

The Remarkable Honey Bee - January 2014

Beekeeping By the Numbers

by Larry Connor

(excerpt)

The concept of the increase or nucleus hive is directly credited to L. L. Langstroth in his original *The Hive and the Honey Bee*. Langstroth's hive was based upon movable frames that honored and respected the bee space—the thickness of two worker bees on opposite combs that allows them to work without bumping into each other—while not wasting space. In the western honey bee this space is about 3/8ths of an inch (9.5-10 mm). Langstroth frames were inserted and removed from the top of a box called the hive body and were not attached to the side or in a drawer configuration as were other hives of the early 1800's. This allowed Langstroth the ability to easily take frames from one hive and put them into another, removing frames of bees and brood from a strong colony, and, adding a new queen to the new unit or allowing the bees to raise a new queen. This created a new colony that he called a nucleus, a colony in miniature or reduced size and bee strength. Frames of bees and brood frames were easily removed from a larger hive and placed into a new hive to form the nucleus. By adding a laying queen, a virgin queen, or a queen cell, Langstroth and his many followers were quickly able to produce many new colonies from their existing colonies to develop new increase colonies.

In reaction to the heavy losses many single colony beekeepers experience we strongly recommend that every new beekeeper start with a minimum of two colonies of bees and attempt the production of at least one increase colony during their first beekeeping season.¹ As simple as it sounds, not all beekeepers routinely rely on the nucleus increase system in their own apiary operation. Many are afraid to make an increase colony out of their fear of failure. Others may have failed in earlier attempts, and are reluctant to try making increase nuclei again. We will address some of the key factors and concepts of all colonies, and how these apply to our making an increase nucleus. Before we get into the nucleus making process, first we must understand the essential basic parts of a healthy have.

The Remarkable Honey Bee - December 2013

Beekeeping By the Numbers

by Larry Connor

One advantage beekeepers have over those who raise or manage mammals and birds is the tremendous reproductive power of the bee hive. While there are huge losses reported in survey results indicating that many beekeepers lose many bee colonies every winter (or their local equivalent, such as a nectar dearth), one unique aspect of bee husbandry is this insect's amazing ability to make a lot of new bees in a short time period. How else can beekeepers who have lost over fifty percent of their colonies take a deep breath and calmly state that they will rebuild their losses, often in one spring buildup season? How else can beekeepers who have 40 colonies predict that they will fill 200 hives with bees within two seasons? Without this numerical reproductive advantage, the bee industry could be in a much more desperate state in light of all the dramatic colony losses that have been reported.

Through evolution honey bees have refined high reproductive rates by combining their egg-laying rate and repeated swarming behavior. These two behaviors are closely linked with each other (a colony with a low egg-laying rate is not very likely to swarm) and the combination of the two produces remarkable results.

In the revision of *Honey Bee Biology and Beekeeping* (Caron and Connor, 2013, Wicwas Press) the authors remind the reader that the primary goal of every beekeeper is to maximize the number of bees in a colony at the same time that the colony has the potential to produce the maximum amount of honey. Or, put the maximum number of pollen collectors into the orchard or target crop for pollination services. There is a powerful numerical effect of keeping large colonies over small. For example, research has shown that four small colonies do not produce as much honey as the same number of bees kept in one hive. This reflects the tremendous efficiency of a large social group. Consider the benefits of a large ant nest or a well-run human community. There are advantages in labor specialization, community protection, food gathering, nest-site creation and maintenance, disease and pest control and even specialized individuals that serve as undertakers for those that die.

At the Mother Earth News Fair in Lawrence, Kansas in October I spoke with many beekeepers who have followed the traditional "Langstroth" method of keeping hives and managing them. But there is a strong mood shift, often observed in young, idealistic non-beekeepers who vocally express that they will soon own bee colonies that will keep themselves—no human help is required for the bees to thrive. Unfortunately, some of these people do not want to have a discussion about the facts-of-life of bee management, or the results of scientific research. Instead, they want to put bees into a container and let the bees keep themselves. These bees cannot be fed, as feeding bees is an act against Nature. These people will not use smoke on the bees, ever. I wonder if they will treat their other animals and small children in the same manner and clench my jaw tightly for fear of saying something inappropriate. I admit I was not always successful.

Beekeepers help bees by the simple acts of feeding starving colonies, of adding frames of honey or brood when the bees need food or of providing young larvae to create a new queen, especially after the replacement supersedure queen was eaten by a dragonfly on her mating flight. We know that swarms in Nature have a low survival rate, that only 16% of all swarms reach their first birthday. Even with the losses we have seen over the past few years, the post-CCD era beekeeper losses are not as low as Mother Nature's huge loss rate.

Population geneticists will tell you that a certain level of mortality is necessary to keep any animal or plant populations healthy. Prior to the appearance of mites, North American beekeepers kept winter mortality at 10% in most years, apparently having found a balance between successful management and minimizing disease and colony loss.

Egg-laying rate

You can calculate an estimate of the number of eggs a queen has produced by using a simple calculation based on of the amount of sealed brood in a hive. I have used a Plexiglas sheet with one-inch grid drawn on it to quickly count the number of cells of sealed worker brood. Or you can use a ruler, kept in your back pocket or tool bucket, to roughly calculate the width and depth of each side of each frame of brood. Add this up and you have an approximate number of square inches of sealed worker brood.

Use your ruler and you will probably come up with the following observation—there are about five worker cells to one inch, so a square inch of sealed worker brood contains about 25 developing bees. If you multiply 25 times the square inches of brood, you can estimate the number of bees in the sealed stage.

European honey bee races spend twelve days in the sealed brood stage (3 as egg, 6 as larvae and 12 as sealed, for a total of 21 days for development). This gives us a simple method to complete the eggs-per-day calculation: simply divide the number of sealed brood cells by 12 and you have an estimate of the number of eggs a queen has produced in a 12-day period ending 9 days prior to the measurement, the time for egg and open larvae. Of course, this is a low estimate, but a useful one nonetheless.

While this system is not 100% perfect, it does allow you to compare hives and see which colonies are producing the greatest amount of brood in the same time period. The Dadant-Genetic Systems Starline and Midnite Hybrid bees were based on these back-breaking, intensive observations, as it was a powerful method of comparison to show how bee numbers and honey production (and also pollen collection) were highly correlated statistics. The key is to make the brood measurements about six weeks prior to the start of the nectar flow. Why? Because the bees you measure as sealed brood are the bees that will actually gather the nectar that will become the honey crop. These data suggested that there is an ideal egg-laying rate for a specific area; you may find brood counts that are too little and others that are too high. Colonies that failed to produce the eggs were poorer honey producers, but colonies that produced the maximum brood did not produce the greatest amount of honey, probably because it took more honey to feed these hard-working, but overly abundant and hungry bees!

Based on a few home-apirary observations I have recently made at the farm, I am willing to state that a colony changes its egg-laying rate frequently during the season, and perhaps even during the height of the season. Obviously, colonies have much reduced egg-laying rates in the winter and early spring—until the abundance of pollen and nectar stimulate the colony to collect more food and produce more brood. Certain races, like the Carniolan bees, and queen families like the USDA Russian bees, hold back on buildup during the late winter and early spring but then explode. In a queen rearing course I taught in the Lansing, Michigan area we measured second-year Minnesota hygienic colonies that appeared to be producing 2,200 eggs per day, using the method discussed above. I say ‘appeared’ because there is always the chance that there is a second queen in a hive working in a mother-daughter supersedure behavior that has been described by several groups of queen breeders.

This big push reaches the objective of maximizing the number of field bees for the nectar flow as described by Caron and Connor. While Italian-American stocks are known for early brood rearing that is sustained as long as there is food coming into the hive (even in December in temperate areas) other strains and queen families are more conservative, but then explode to generate huge bee populations for the flower-blooming period.

The challenge is to find the bee stock that provides the proper ‘fit’ for the plant community and the climatic conditions that are found in each colony’s specific ecosystem. I argue that there can be as much variation between colonies within my home county of Kalamazoo County, MI as found among colonies in different parts of the state of Michigan. Local variations are often huge! Successful, locally adapted queens and bees undoubtedly are the ones that have the right buildup rate for specific areas. Add to this the variations from season to season and no wonder beekeepers are bee-wildered about what stock to keep in each area.

Bees per frame

Using the 25 bees per square inch statistic, it is possible to determine the number of bees found in the developing frames of brood of a colony, and to predict the number of bees that will emerge from such a frame over the next few weeks. In a standard deep Langstroth frame, about 19 inches wide and nearly 8.5 inches deep, there are enough cells to produce 3500 or more bees per side of comb, or 7000 adult bees per frame. At 3500 bees to the pound, a full, corner-to-corner frame of brood will produce two pounds of bees, and combs with reduced brood areas will often produce 1.5 pounds of bees once all the worker brood emerges. This provides the beekeeper with a fundamental tool to move frames of sealed brood to weaker brood to boost bee populations (and often reducing the swarming pressure in the donor hive). If a queen lays an average of 1500 eggs per day, the production of 1.5 to 2 pounds of bees in brood represents a queen’s efforts for 3.5 to 5 days. This equalization of bee populations between colonies in an apiary is a standard method of boosting production of all colonies in an apiary. The use of these same bees to make increase nucleus colonies, aka splits and nucs, is a fundamental method beekeepers use to make up colony losses, as well as methods of producing bees for sale to local beekeepers, bypassing the need to purchase package bees. This is the key to a sustainable approach to beekeeping—maintaining and increasing colony numbers within the apiary.

Colony reproduction through swarming

The second part of this colony number story is the profound swarming behavior of bee colonies. This past summer and fall I've been working with Pittsburgh beekeeper and EAS Master Beekeeper Steve Repasky on a new book titled *Swarm Essentials: Ecology, Management and Sustainability*. Steve has been looking at the entire swarming event. Steve is a swarm catcher. He does cut-outs and promotes swarm capture among new beekeepers.

In Nature swarms issue from most colonies starting their second year. Following the early spring buildup, a combination of factors combine to stimulate swarming in healthy bee colonies. When bees swarm, between 40 and 60% of the adult bees leave with the swarm in a dramatic rush to the entrance that is quite fascinating to observe. Colonies produce multiple queen cells prior to this, and drone brood prior to swarming, in a complicated serial progression ending up with daughter colonies living in nearby nest sites.

What has come out of this book project for me has been the realization that colonies are tremendous risk takers. They put enormous resources into the bees and honey that leave with the prime swarm, along with the mother queen, and then multiple secondary swarms containing one or more virgin daughter queens. The risks are great for the parent hive—will there be enough bees left in adult bees and emerging brood to produce a crop of honey so it can survive the winter? Also, will a daughter virgin queen be successful — to mate and return to the hive without being eaten by birds, dragonflies and other predators? Or will the colony be weakened too much that it will fall prey to robbing by other bee colonies and wasps?

For each of the new hives the risks are also profound—as the 16% feral success rate clearly indicates. These bees must find a suitable home (see Tom Seeley's *Honeybee Democracy*), construct comb or retrofit 'found' comb in an old bee tree, collect adequate amounts of pollen and nectar for winter survival. And, if the old queen left with the prime swarm, will her replacement daughter be successful in her production and mating?

Bee colonies are tremendous risk takers. Humans help bee colonies by providing food, space, comb, and intensive management (such as by making increase nucleus hives to reduce bee population pressures). All beekeepers should keep a minimum of two colonies throughout the season as a means of pulling bees, brood, honey, and pollen—whatever is needed—from one hive to place it into another to keep the second colony alive. All beekeepers should keep one or more nucleus colonies year-round as a means to increasing survival percentages and providing the bees the ecosystem needs for pollination, while at the same time ensuring the beekeeper with honey and other hive products for personal use and for the marketplace. Active beekeeper participation is good for the bee colonies as well as the beekeeper. It is a wonderful synergistic relationship that has worked for centuries.

If you missed the not-so-obvious plugs for Wicwas Press titles, plus one for Harvard University Press, check out the newly revised and continuously revised website www.wicwas.com. In January Wicwas Press will be at both trade shows of the American Beekeeping Federation Conference, as well as the American Honey Producers Association Convention. The same week. Clearly bees communicate better than beekeepers do—it's called a calendar!

The Remarkable Honey Bee - November 2013

Sustainability In Beekeeping

by Larry Connor

(excerpt)

More and more beekeepers worry that beekeeping is no longer sustainable, a concern reinforced by a multitude of media reports and survey results showing high colony mortality, reduced bee viability, and some tantalizing data that indicates that beekeeping globally is undergoing tremendous change. Beekeepers report that fewer of their colonies are able to survive the many insults they face from modern agriculture in terms of monoculture and new pesticide utilization, as well as from climate changes and increasingly unpredictability of the ability of colonies to produce surplus honey and survive to the next reproductive cycle. Will their colonies be alive next spring? Too often this is the primary question beekeepers ask, regardless of their years of experience or size of operation. To sustain both the bees and the beekeeper, bees must survive in larger numbers.

Sustainable apiculture, that which is able to maintain itself at its certain rate or level, clearly depends on our ability to manage population levels. In the revised edition of *Honey Bee Biology and Beekeeping*, Caron and Connor describe the Essence of Beekeeping as “the relationship between time of the season and the number of bees” (Chapter 1, Figure 1-2). They go on to state that the goal of all beekeepers is to reach the peak population of bees with the peak availability of nectar and pollen needed to make a honey crop and sustain bee populations for the rest of the season.

While this seems to be a simple concept, it is harder and harder for beekeepers to achieve. Beekeepers report that their colonies fail to build up in time to be productive. Colony populations do not reach their peak until AFTER the primary nectar flow is over for their area, if they grow at all. This may be a combination of a variety of factors—a shift in the genetic composition of the bees due to heavy varroa mite predation—earlier blooming times for plants as impacted by global climate change/global warming—and sharply reduced new colony viability. Especially with package bees, in 2013 some beekeepers report failure rates approaching 100% due to queen problems and a general failure to grow, combining to result in some pretty pathetic colonies. Or dead hives.

Beekeepers who have success with new colonies tend to be those who are using locally produced queen bees installed into colonies that were produced from local bees, those that survived winter or periods of extreme stress. Any step toward localization of genetic stock

and bees tends to move the beekeeper to a higher level of success. Various state programs have clearly shown the value of local bees, local queens, and local training as a method of ensuring better results in the colony.

This leads me to consider the sustainability concept and show how many beekeepers are surviving while others are failing. For the point of generating a label on these practices, I will refer to them as the New Sustainability Practices.

New Sustainability Practices

The sustainable beekeeper is one who keeps extra bee colonies in production at all times, usually as growing nuclei colonies established during the peak of bee population, from swarm prevention practices (making nuclei) or by catching swarms and removing bees from buildings. Some sustainable beekeepers consider only the third concept as the limit of their operation, and I disagree. Making and using nuclei (call them what you want, a nucleus is a miniaturized version of a full-sized hive) has become a dominant change in many beekeeping operations over the past decade or two, with beekeepers attempting to overwinter one or more nuclei hives for every full-sized colony in the operation. This maintains colony numbers when some of these colonies die, or are killed by a multitude of factors but concentrated on queen failure and pesticide-disease interactions. Progressive northern beekeepers are keeping nuclei alive during the winter, and using them as brood and bee banks to strengthen full sized colonies during colony buildup and just before honey production, and to make further increase to replace colony losses or make new colonies for sale to area beekeepers in line with the local bees' attributes.

The Remarkable Honey Bee - October 2013

Integrated Pest Management of Varroa in North America

by Larry Connor

Last month we reviewed some of the history of Varroa destructor in the United States, as well as some of the mite-tolerant stocks available within the country. In this article we will review some of the integrated pest management (IPM) concepts in current use in the Americas. IPM is not a new concept, since it became widely accepted in the early 1970s in general agriculture, but the use of IPM is relatively new for beekeeping since the introduction of tracheal and varroa mites into the Americas.

IPM is often offered as a alternative or replacement to the pre-IPM chemical recommendations that governments and the extension services generated using chemical controls. My father routinely used the Michigan State University spray calendar to apply many, many applications of insecticides, miticides and fungicides to our apple trees. The calendar was often based on the plant and flower cycle. Applications were timed to plant growth, which roughly approximated pest growth. It was not an easy schedule to follow, but it did essentially turn pest control into a cook-book operation and he would rush home from the machine shop to apply a fungicide within a certain time period to prevent scab on the apples. He would also listen to the 5:30 a.m. farm show on the local radio station to find out about new pests—and there were always new pests—as county and state specialists were interviewed.

IPM was a result to the strong reaction to over-treatment of crops, which is often considered to have started with the publication of Rachael Carson's Silent Spring, and by 1970 was met with a strong natural food movement much like we are experiencing now. Entomology departments, like the one at MSU where I was a student, took great effort to change the way they operated and made pest control recommendations. This also mirrored the Federal movement, the formation of the Environmental Protection Agency, and a growing political distaste for excessive pesticide usage.

IPM programs are often represented by a triangular image showing four or more components of pest control. These were Cultural (the base), with Physical-Mechanical second, Biological Control third and Chemical Control fourth. The true brilliance of IPM methodology was the insistence that growers actually determine the pest level in a crop or animal population PRIOR TO chemical treatment. This led to the entire survey-sampling methodology widely used by many growers. The logic was simple and worked—only treat for pests when they are present and in numbers that are large enough to cause economic harm to the crop. One apple maggot in a large bin of apples was acceptable, but a maggot in each apple generally was not suitable for the marketplace.

When we look at these parts of a pyramid, we start with Cultural Control in the bee colony. Two of the biggest cultural control methods for mite management include apiary location and genetic stock. Both of these methods focus on prevention of mite buildup at zero or nearly zero toxicity to the bees.

Apiary location impacts the temperature and ventilation of a hive. When I started keeping bees we routinely put colonies in a line along a shady fence line facing south or east. Of course, the cool location kept the beekeeper cooler, and it was widely thought the bee colonies did best in the shade. With the appearance of varroa mites, it was discovered that colonies in full sun generally had a lower varroa mite population growth, apparently because the mites themselves were more sensitive to very warm temperatures. Today many beekeepers now keep their colonies in the full sun, without shade. Where Small Hive Beetles (SHB) are a problem, it has been shown that the beetles also do not reproduce as quickly in hot, dry conditions. Small-scale beekeepers often put water into entrance feeders (no sugar syrup) or put bright children's wading pools filled with large stones and water, to provide a water source.

Mite tolerant Genetic Stock in a hive will help determine the colony's ability to counter the high reproductive rate of the mites. As we discussed in last month's article, there has been a widespread effort to develop tolerance against the mites. Unfortunately, the multiple mating behavior of honey bee queens makes it extremely difficult to keep the stock concentrated enough in open mating systems so that the genetic stock is sustainable. Only when a stock is propagated in an isolated mating area or via instrumental insemination is

sustainable stock maintenance successful. In areas of the world where all beekeepers use mite-tolerant stock, beekeepers experience a lower colony loss due to mites. There are few places like that in the United States because of migratory beekeepers and the widespread practice of purchasing package bees.

The second slice of the Pyramid of Control is the Physical and Mechanical methodology many beekeepers employ. I am not aware of any successful varroa traps, functioning like the many small hive beetle traps, that have been shown to be successful in reducing mite numbers by drawing the mites into them. But the growing use of screened-bottom boards has been useful in all sized beekeeping operations. These screens work in several ways, but the most obvious is the elimination of mites as they fall or are groomed from the worker bees and fall to the bottom of the hive and through the hardware cloth screen. Many beekeepers leave their screened bottom boards open year-around, while others insert a tray on the bottom during the fall and leave them there for winter. I think the most useful aspect of the tray in the screened bottom board is to give the beekeeper the ability to sample mite numbers, as well as initiate a low-level chemical control of the mites via repeated powdered sugar treatments.

Calendar-related events are put into this category as well, especially with the production of increase colonies after the summer solstice and requeening colonies during the late summer. Many commercial pollinators routinely make up new colonies from existing colonies returned to their southern base in August and September by reconstituting colonies into new colonies or nucleus units, installing a queen cell, virgin queen or mated queen, removing some of the oldest combs and any residues of pesticides or pathogens, and providing a significant break in the brood cycle to reduce varroa mite population numbers.

Physical and Mechanical control systems in IPM do not use chemicals and pose no toxic impact on bee colonies. They may add stress to weak colonies, such as a small colony in a large hive body with an open screened bottom board, causing the colony to use more of its stores to regulate hive temperature and humidity. There is a great deal of invention to be encouraged within the bee industry to examine other hive designs and arrangements that promote the warm and dry conditions that reduce mite buildup, as well as efficient insulation systems that optimize colony stored food utilization.

The third slice of the IPM triangle is the use of biological control agents to control pests. There we have a long way to go before we have a bio-control agent that controls varroa mite numbers and does not increase the mortality of the bees themselves. As Dr. Dewey Caron states in the revised edition of *Honey Bee Biology and Beekeeping*, beekeepers lack a Lady Beetle-type organism for bio-control of varroa mites in the bee hive. Attempts to find control agents have focused on fungi and other microbes that must kill mites and not negatively impact bees.

The fourth slice is for Chemical control of mites. We will divide these into two groups, the miticides and a general group of lower-risk materials that includes the essential oils, powdered sugar, repellents and desiccants. Here there is a trade-off between prevention and various levels of toxicity. The miticides are often considered the most toxic, but this does not necessarily follow true with all chemicals. Theoretically, there could be a chemical miticide that controls only varroa mites, but does not have a negative impact on the bees or leave residues inside the hive, the honey, beeswax or propolis. Unfortunately, that miticide has not been found.

Resistance develops against many chemicals when the mites are subjected to the molecules for a long period of treatment. Eventually, the small percentage of mites that are not controlled by the chemical reproduce and grow in numbers, leading to the eventual replacement of susceptible mites with chemically resistant ones. Certain miticides have had high levels of resistance develop to them. One solution is to use these chemicals in rotation so that different molecules are used in alternative treatments. As long as the miticides are not closely related chemically, different populations of mites are controlled and die with each treatment, prolonging the use of the chemical in an operation.

Certain miticides have been shown to contaminate combs, pollen, propolis and even honey. This has led to the routine replacement of comb by many beekeepers. Recent studies have shown that miticides in combination with other agricultural chemicals, like fungicides, increase the risk to colony health through a synergistic reaction, where 1 plus 1 produces a result greater than 2. The same has been shown with miticides and various organisms, such as Nosema and chalkbrood. It seems clear that we are just starting to understand the impact of these synergistic effects on bee colonies.

The key to any IPM methodology is the acceptance of a sampling method to evaluate the mite levels and develop enough of a relationship with the pest to understand what certain mite levels really mean. A sampling method may show you a certain level or number of mites in May, but the colony still dies over the following winter. What do those numbers mean? How do you employ the IPM methodology to manage these parasites. Unless the numbers are put into the context of other control methods (cultural, physical and mechanical), along with chemical treatments (time of year, material selected, miticides in rotation and dosage), mite numbers will be difficult to assess. As we discussed in last month's article, some mite strains demonstrate a combination of higher mite numbers combined with productive colonies. Have these mites and this strain of bees worked something out that allows for less feedings, but more alive mites, as varroa did on its native host, *Apis cerana*? It so quickly becomes enormously complicated.

Most beekeepers who actually do sample seem to prefer the use of powdered sugar in a shaker jar as a means of sampling mites without killing the bees. Systems using ether, windshield fluid or alcohol, and other methods kill the bees. The lethal methods are great for collecting a sample of bees—about 1/2 cup or 300 worker bees from brood combs—so that the bees may be further sampled to see how effective the sampling technique really is. But this is a research focus.

For most beekeepers a sample of 300 bees from the brood nest bees (where the feeding or phoretic mites accumulate when they emerge from the cells) shaken with a few tablespoons of confectionary (powdered) sugar following a standard technique, should provide a successful comparison of mite population trends for that one colony, the trend for the entire apiary or operation, and the response to the mite level following any of a number of management manipulations: Replacing the queen; removing three frames of bees and two

frames of brood to make a new nucleus or increase colony; a biological pesticide treatment such as powdered sugar dusting (entire colony); or an essential oil application (entire colony) or other manipulation.

For any IPM process to work, sampling is advised. The sole use of one component, such as screened bottom boards or resistant bee stock, may provide benefits to the colony and the entire operation, but without data, how do you really know?

October will put Dr. Connor in Kansas for the Kansas Beekeepers meeting (Oct 18-19), and the British Columbia Beekeepers (Oct 25-27). In November he will be at the Joint Wisconsin-Illinois meeting (November 1 and 2), the Texas Beekeepers Nov. 7, the Massachusetts Beekeeping Federation (November 18) and the Southern New England Beekeepers Assembly on November 23. In December Dr. Connor hopes to be recovering under a palm tree somewhere. For the latest, check in at the newly redesigned website www.wicwas.com.

The Remarkable Honey Bee - September 2013

Varroa Control Past and Future

by Larry Connor

(excerpt)

History of Varroa in North America

The first discovery of *Varroa jacobsoni* (later renamed *Varroa destructor*) in the United States was made on Sept. 25, 1987 in Florida on colonies owned by a Wisconsin beekeeper. This beekeeper, Gary Oreskovic, was a supplier of package bees that were combined with packages from other beekeepers and sold to companies and individuals in Wisconsin. The initial infested hives were depopulated (killed). Yet by October 20 of that same year 19 of Florida's 67 counties had positive finds for the mites, and within two years the mites were found in 19 states within the United States. They are now found in every part of the Americas where bees are kept.

Cornell Prof. Roger A. Morse reported that the source of the queens that introduced the mites into North America was somewhere in South America, imported illegally by a commercial beekeeper. Between beekeeper movement of hives and packages by beekeepers and the natural interchange of bees from one colony to another, mites were efficiently distributed. It has been shown, for example, that bees foraging on flowers will join a swarm as it moves through the air. The foragers are apparently attracted to the pheromone odor of the swarm and the swarm's overall behavior. This is one method mites could be spread from colony to colony in nature. Drones, migrating from colony to colony during their reproductive flights, also provide a critical vectoring of the parasite. Also, when a colony eventually dies from the mites, remaining workers carry mites to other colonies, a notorious behavior often called the 'varroa bomb'.

Because European beekeepers had experienced the wave of varroa across that continent, there were pre-existing chemical control methods in production that were easily adapted within the United States. A compound called Apistan (fluvalinate) was impregnated into wooden strips in initial treatments in Florida and elsewhere. These were replaced by the availability of plastic Apistan strips that were widely sold to control mite numbers. There was little discussion about 'should we treat', but rather the driving insistence that we develop treatment methods that were cost effective and relatively inexpensive. This did not stop the wide-scale use of home-made delivery methods to administer fluvalinate (tau-fluvalinate is sold as Mavrik and Klartan for insecticidal and acaracidal action on aphids, trips, leafhoppers, whitefly, beetles and spider mites). Fluvalinate is a pyrethroid that acts on the insect nervous system. Because it was available for purchase by agricultural producers, many beekeepers developed their own control methods using the agricultural preparation of the compound. In doing so they both over- and under-dosed the colonies where they were attempting to achieve mite control. Over-dosing provided evidence of toxic effects to queens, drones, workers and lead to widespread comb contamination. Where lower than recommended levels were used, there were a larger number of mites that survived the treatment, ultimately leading to mite resistance to the compound. Because of the wide-spread resistance, the compound is now used only when in rotation with other mite control molecules.

Finding Tolerance Against Varroa Mites

Untreated colonies suffered horribly as the mites swept across the country. Beekeepers reported the deformity of worker bees at the time they should emerge from their cells, and the appearance of damaged wings as a result of the mites feeding on the bees. The eventual outcome was the death of the colony. Within a few years there were reports of colonies that were still alive after the mites had destroyed the rest of the colonies in the apiary. Feral bee colonies died from the mites as well, and gardeners and naturalists quickly noticed the lack of honey bees on vegetable and flower gardens, as well as a decline in the natural food bees pollinate for birds and wildlife. With the absence of completion from honey bee foragers for the same food supply, many naturalists and scientists noticed an increase in the number of bumble bees and other native pollinators. It was an interesting exercise to observe the change in the ecosystem as honey bees were somewhat suddenly removed.

The survival colonies were of interest to many beekeepers, and many small-scale producers used these few remaining colonies as the basis of their slow rebuild of bee colony numbers. The progress was slow. Researchers noticed too, and Dr. Roger Hoopingarner (Michigan State University) and Dr. John Harbo (USDA Honey-Bee Breeding and Physiology Lab, Baton Rouge) sent out a call for

beekeepers to ship them their queens and they started a stock of survivor queens. With Hoopingarner's retirement Harbo maintained the program, developing the Suppressed Mite Reproduction or SMR strain of honey bees.

Harbo was joined by Jeff Harris at the Baton Rouge Bee laboratory (who continued the program until his departure for Mississippi State University) and in 2003 they reported on the project and its results to date. They called this the Suppressed Mite Reproduction (SMR) trait (not a line or stock, but set of genes anyone could breed for). They established that they had identified a heritable trait of the honey bee showing that by selective breeding they could bring the mite reproduction rate to zero in worker brood. They established that the trait is additive, so that a SMR queen mated to non-SMR drones resulted in an intermediate level of mite reduction. They showed that once a colony was given an instrumentally inseminated SMR x SMR queen, the colony had normally reproductive mites for a period of about two months. Then, the level of mite reproduction was reduced. They also reported "Sometimes brood production is poor in colonies with artificially inseminated SMRxSMR queens, even though a queen may produce a very solid brood pattern in her first brood cycle. This does not always happen and we don't know why it happens. Consequently, a colony with an SMR breeder queen may not grow rapidly enough to become a productive field colony. Free-mated daughters of these SMR breeder queens have not had this problem, for tests have shown that colonies with free-mated SMR queens produced as much brood and bees as colonies".¹

Later it was shown that the SMR trait is a form of hygienic behavior, and the SMR trait was renamed the VSH trait. The mechanism explaining the SMR trait has not been described, but Ibrahim and Spivak (2003, ABJ 144: 406) found that bees with the SMR trait were very hygienic and were able to remove varroa-infested pupae from capped brood cells. They also suggested that SMR bees may selectively remove pupae having reproductive mites. It was shown that the brood cells with reproductive mites were opened and removed by the bees with the hygienic trait, while the single foundress mite that is nonproductive) was not removed, and was assumed to emerge from the worker cell when the worker bee emerged. Because she had not produced offspring, she was not removed from the cell by hygienic bees. There is a group of VSH bee breeders that may be reached through VSHBreeders.org. However, beekeepers may want to place orders for VSH breeder queens through Adam Finkelstein of VP Queens (in Maryland) at www.vpqueenbees.com.

The Remarkable Honey Bee - August 2013

Beeswax

by Larry Connor

How Bees Use Beeswax in the Beehive

A Swarm's Rapid Beeswax Production

When a swarm leaves the parent colony, the individual worker bees engorge with honey to carry with them to their new nest site. While this honey serves to keep the swarm alive during the move to the new location—a period of a few hours to several days—any remaining honey is digested and used to produce beeswax and construct essential honeycomb. Swarm bees are uniquely qualified to produce new beeswax. They are primed to convert the carbohydrates in the honey to liquid beeswax they secrete from the four pair of wax glands on the ventral (bottom) side of their abdomens. There is one pair on each of segments 4 to 7. They hang in chains of bees as secretion occurs. As it is secreted, the liquid wax immediately solidifies when it hits the air and forms a wax scale, and the scale is like the rings of a tree, under the microscope they show the layers of wax as it is secreted.

Spines on the bee's legs move these scales to the mouthparts where the bee can chew the scale with their mandibles and adds saliva to soften the wax so it can be worked by this and other bees in the hive. Wax is deposited along a line to form the midrib of the comb and additional wax is placed on it to build out the comb. Natural-comb beekeepers deposit a bead of hot beeswax to establish the desired pattern for the eventual comb. Other beekeepers put in starter strips for the same reason. These are usually about one inch strips of pure beeswax foundation that the bees are encouraged to use as a starting point for comb construction.

As the comb is produced, the weight of the bees may cause the comb to distort somewhat, forming irregular comb shapes. Bees use gravity as the stimulus for vertically straight comb building, building the comb in alignment to the pull of gravity, so any hive that is placed on an unlevel location will produce asymmetrical or oddly shaped combs. While many beekeepers are familiar with the concept of the bee space, it needs to be expressed as a behavioral aspect of bees—it is the space where to bees, on opposite combs, can pass without interference. Thus, bee species of different sizes have a different bee space measurement. Biologically the bee space is the thickness of two worker bees. Irregular comb will be created wherever this relationship is challenged.

Worker bee production

New swarm colonies store fresh nectar and pollen in newly built honey comb, expanding the amount of comb rapidly during the first few days in the new domicile. The queen is fed to re-start (if she really completely stopped) her egg-laying behavior, and very soon the fresh, delicate comb contains an area of worker eggs surrounded by pollen and ripening nectar. The queen will lay eggs into the cells as long as the nectar stimulates further wax production; once the original honey carried from the parent hive is consumed, the new colony must rely upon incoming food sources. Fortunately, spring and early summer swarms are characteristically blessed with abundant nectar and pollen, so most of the comb the colony will need will be produced within the next two to three months. The timing of swarm production is no accident, for it allows the colony to build rapidly on the first weeks of the spring and engage in swarm production when queen pheromone levels decline, there are few cells for the queen to lay into (these two factors seem to be related), and the queen places eggs into the pre-existing queen cups in the colony.

Honey storage

Once the brood production area has been established in a bee tree or other cavity, the bees will build more combs above and beside the brood nest. These cells are all worker-sized cells during the initial establishment of the colony. Some of the initial honey storage cells will be given up for brood rearing, and retain a dynamic relationship between the two different colony needs as the colony expands and

contracts bee population in the future.

Drone production and honey storage

It is not expected that a new swarm will itself swarm the same year it is produced. Especially if the old queen from the parent colony flew with the swarm, there will be strong pressure to replace the old queen once the colony has been built in size and strength, and there is a good moment for a daughter queen to take over her duties. We generally consider the queens in primary swarms to be older queens, and subject to a variety of factors of aging. A month or two after the new swarm has become established it is not unusual to find queen replacement or supersedure cells, in the relatively new colony. This is also associated with the production of drone-sized cells along the sides and at the bottom of the worker brood area. The failing queen may deposit many unfertilized eggs in these larger cells and provide a drone supply for other colonies experiencing a similar build up after swarming.

Examination of natural colonies show that 15 to 20 percent of the cells in a 'mature' natural colony will be drone sized, but rarely are there more than 3 to 5% of the drone cells filled with developing drones. What can be the explanation for this inconsistency? It has been shown that drone-sized cells, which begin noticeably larger, will provide the most efficient honey storage for the amount of beeswax used.

Colonies given inflexible worker cell-sized templates for cell production almost always end up with some drone comb built perpendicular to the line of the frames, usually attaching them to the plastic or wax templates. While there may be some comb stability advantages to this behavior, it is simply the bees' way to adjust the worker cell domination to accommodate some drone cells. These cells may or may not be used to produce drones during the first season, but I have noticed that large primary swarms produced early in the season have more time to develop drones that same season, much the way any early nucleus colony will produce drones by the time it is filling the second hive body and the food supply is abundant.

What Is Beeswax?

Chemical composition

As beeswax is the primary construction material of the beehive, its chemical composition is integral to how the hive functions. This same material, the storage location of food resources and developing brood, must be relatively non-reactive, so beeswax's neutral pH (7) suits the need perfectly. A product of organic processes, this product is created from carbon, hydrogen, and oxygen—three elements taken from the honey and nectar the bees collect, which are arranged into long carbon chains of fatty acid esters and aliphatic alcohols. These compounds and their ratios vary from species to species, but retain similar chemical properties including a low melting point which, from a human perspective, makes it very useful for sculpting and shaping once it has been harvested and cleaned.

How bees produce beeswax

Bees produce beeswax by converting their nectar and honey stores into the compounds that become beeswax. The constituents of beeswax are synthesized in the oenocytes and fat cells of the bees when stimulated by an esterase enzyme. These compounds are secreted through the special glands on the underside of the bee, which were mentioned earlier. This task, performed exclusively by worker bees, is most easily accomplished by worker bees younger than 17 days old. The wax glands of older bees atrophy after they begin daily foraging flights.

Role of color in beeswax

New beeswax is lighter in color because of its lack of impurities. As beeswax gets used, particles from the environment become lodged in the wax and it becomes stained with use. Some bees use the bee glue, propolis, to line cells with in order to take advantage of its medicinal properties, a process that also alters the coloration of the wax. Certain nectar sources have natural pigments that seem to be incorporated into the wax, and many beekeepers associate certain wax colors in their operation with specific nectar sources. For example, I consider the wax produced from goldenrod flowers to have a deeper yellow and brighter hue than wax produced from the nectar of other plant species.

Harvesting Beeswax

Separation from honey by crushing or pressure

In most Human cultures that developed with honey bees in their environment, honey was harvested by the partial or complete destruction of the bee nest, depending upon the culture. Brood combs were used for immediate consumption, since the food value of the fresh larvae and pupae decline rapidly once they bees are removed and secondary bacteria start a decomposition of the bodies of the dying bees. Most of the brood comb, which contains wax, is eaten and the wax passes through the digestive system as an inert material. There is no food value for humans in beeswax.

But the honey can be stored in natural and human-made containers and either stored in pieces of comb, or crushed by hand to drain off the honey. From the mediaeval housewife to the contemporary small-scale beekeeper, the easiest way to harvest honey from a few hives is to crush and drain the liquid honey from the beeswax combs. Some beekeepers still use comb presses to remove honey. Once the majority of the honey has drained off the wax, the traces amounts of honey still need to be removed. Some use heat in double boilers, or carefully watch small batches in the microwave to separate honey from wax. Once most of the honey has strained off, many take fresh water and mix the honey-beeswax combination to wash the honey off the wax. The liquid is saved for use in cooking (great on vegetables), in canning as the sweetener around fruit, and is often adjusted for sugar content for brewing into honey beer or mead. I bring in bits of honey scrapped from frame tops and bottoms, off the inner cover, etc., and put them into a colander, crush and drain the honey, and rinse the smashed wax with a small amount of water and use this water on the next batch of carrots or sweet potatoes I make. It can also be used in summer cold beverages as a sweetener (honey sweet ice tea) and hot beverages in the fall.

Cappings pose special issues

A side aspect of large honey extracting operations is that they generate large volumes of wax cappings infused with honey. Various commercial devises using resistance-wire heat, infrared lamps and other techniques liquefy the wax, but at a low enough temperature that the honey is not burned. Honey from commercial capping melters is often overheated and must be kept separate from the bulk of the honey harvest. Capping melter honey is usable in commercial and home baking in recipes able to handle the partial caramelization of the honey that the heating generates.

Filtering beeswax

Beeswax may be heated in a double boiler or commercial wax melter following standard safety recommendations. The wax may be poured through a heavy fabric, like that of an old sweat shirt, that is securely clipped or fastened over a container. The liquid wax may be poured through the simple filter to remove bits of dirt and hive contamination that naturally occur in the hive. This process may need to be repeated more than once, depending on the eventual use of the wax. A single filtering is adequate for beeswax that is being sold to a wax processor for reworking into wax foundation or other products; this wax will be further refined. For craft wax (Batik, encaustic painting, lost-wax sculpturing) make sure the wax is ultra clean of any trace of honey and any evidence of other contamination.

For show wax, you may need to resort to filtering the wax several times to remove even a hint of dirt. One person I know uses a low setting on an electric oven and melts small batches of wax over a filter so the wax drips into a clean glass or metal mold below. Once the wax is all melted and filtered, it is allowed to cool slowly in the oven to prevent any rapid cooling, cracking or unusual effects in the wax blocks. This person always seems to win the top prize in wax competitions, both as a block of wax or poured into a mold.

Written with the assistance of Robert Muir.

The fully revised 2013 edition of Dewey M. Caron and Lawrence John Connor's *Honey Bee Biology and Beekeeping* is available at www.wicwas.com and selected bee book sellers. Copies will be available for sale and to receive the authors' autographs at the Eastern Apicultural Society meeting in August.

The Remarkable Honey Bee - July 2013 Pollen and Bee Bread

by Larry Connor

While there is no way we can precisely know when it happened, it is thought that sometime about 200 million years ago, ancient plants produced the first pollen—the flowering plants' highly portable male sex cell transport structure. Rich in amino acids, minerals and other components important both to pollen tube growth and to the development of young bees, the flowering plants (the angiosperms) developed a close relationship with pollinating insects and other animals. The first bees appeared between 65 and 144 million years ago and primordial honey bees appeared at least 35 and 65 years ago. *Apis mellifera* appeared about two million years ago. This co-evolutionary relationship is critical to the success of both flowering plants and pollinators, and is expressed as an amazingly diverse and remarkable array of floral types, bee behaviors, and intricate relationships.

Honey bees have been known from the Eocene, first with the appearance of *Apis dorsata* and *A. florea*, the single-comb nest bees, built in the open. Not until the late Pliocene did *A. mellifera* and *A. cerena*, the first two cavity-nesting hive bee species arise, along with the ability to produce a number of parallel combs. Comparing the relative time frames, the cavity nesting bees have only been existence for about ten percent of the time of the open-nesting species, but during that period they extended their distribution throughout Africa, Asia and Europe. They modified their tropical brood nest by developing the behavior of a cold-weather cluster within the confines of the nest cavity (Crane, 1999). The various contemporary races of honey bees were formed as the species spread and were subsequently isolated by geography and climate changes during the Ice Age. The most recent glaciation reached its greatest extent about 10,000 years ago, correlating with the time when humans moved from hunter-gatherer cultures to those of land-based agriculture in various parts of their dispersal range (Wells, 2010).

Pollen is produced in a flower's anthers, at the end of a long stamen—the male sexual organ of the plant. As it develops, the flower releases pollen through a process called dehiscence, when the anther wall opens and the pollen is released. Dehiscence may occur before, during or after nectar secretion, when carbohydrate-rich rewards attract and established fidelity by pollinators. Visual and odor components also help animal pollinators find flowers.

Bees collect both pollen and nectar. Pollen provides the amino acids (the molecules that are the building blocks of proteins) that supply developing immature bees with the nitrogen (N) they need for growth. The use of nectar to attract insect visitors, such as ants for insect control, or for pollination, arose about the time of the first angiosperms, or some time before that event. Nectar becomes honey in a chemical conversion by the field bees and the nurse bees that break 12-carbon sucrose into the two 6-carbon molecules fructose and glucose.

The end result of the co-evolutionary relationship between angiosperms and pollinating animals is clear. In exchange for food, the plant produces food for bees in the form of pollen and nectar, while the animal provides critical pollen-moving services, or pollination, for the plant. The plant benefits by avoiding self-pollination that would result in genetic inbreeding.

Nutritional value of pollen

Pollen has a greater attractiveness to bees than other protein foods (Johansson, M.P. and T.S.K. Johansson, 1978). The protein content of pollen ranges from 7 to 30%, and the amino acids making up the protein are also highly variable (Weaver, N.). Insect-collected pollen from flowering plants contains the highest protein levels (but with variation—almond has 26% crude protein, while canola has 23%. Raspberries and blackberries have 19% while willow has 17% and sunflower 16%). Wind-pollinated plants like poplar and elm that are sometimes visited by bees have a significantly lower protein level. Other wind-pollinated plants of minor interest to bees like alder, birch and hazel generally have very low protein levels. Pollen from *Pinus* and the rest of the conifers have very low (7%) protein levels; so low that they will not sustain bee colony growth. *Pinus* species also contain 29.2% crude fiber, while 13 angiosperm species contain 3.3% fiber (Peng et al 1985).

When bees feed on the amino acids in pollen, their hypopharyngeal glands are activated. These glands are responsible for the secretion of brood food used to provide food to developing bee larvae, and royal jelly for queen larvae. Also called brood food glands, they are the largest of three secretory glands located in the head of the worker honey bee (Stell, 2012). The brood food glands are in the front of the head, above and below the bee's brain. Under close examination the brood food glands look like a cluster of grapes, which are linked by a common duct ending in a plate in the bee's mouth. Queen and drone bees do not have hypopharyngeal glands.

The second head glands are the two salivary glands, also called the post-cerebral glands, which produce saliva that is mixed with ingested food, including the enzyme invertase, which splits sucrose into glucose and fructose. The third head gland of the worker bees are the mandibular glands, located in the sides of the lower part of the bee's face, or gena. These are sac-containing glands whose secretions are exchanged between bees within the hive. In the queen, these glands produce the queen substance that is so important to colony organization.

A mixture of pollens (collected from different plant sources) provides a higher level of minerals, including manganese and zinc. (Nation, J.). In Michigan, bees collected pollens from 20 or more species of plants at one time. No one plant species produced more than five percent of the pollen collected at one time except for corn pollen, produced during a July dearth, and aster species in the late summer and early fall, when little else was in bloom (Olsen, Larry, personal communication).

Pollen conversion by bees into bee bread

Bee bread is pollen that the bees have stored in the comb and allowed it to be converted, by lactose fermentation, into a more stable

form. Returning foragers enter the brood nest and combs immediately adjacent to areas of active brood rearing and remove the pollen pellets from the spine on the corbiculae of their hind legs by rubbing their legs in the opposite direction of pollen packing. This removes the pellets from the legs and into the wax cell. Even bees that pass through a beekeeper's pollen trap will duplicate this behavior, even if the pollen pellets were removed by the trap mechanism. During foraging bees add honey stomach contents to the pollen as they forage—this moistens the pollen and makes it easier to pack. It turns the often dry, dusty pollen found in most flowers into a cohesive pollen pellet. In the process, it inoculates the pollen with microbes, especially yeasts that occur in the stomach of bees. These include various agents of fermentation that convert the pollen into bee bread. Once in the cell, the bee pollen is compacted by the bee—she pushes with her head to increase pollen storage by 2.5 times than if loosely filled. The angle of a bee's head, in the eye area, is approximately the same angle as the hexagon wax cell, which turns the bee and her head into an effective packing ram (Alphonse Avitabile, personal communication).

Pollen placement in the hive is quite organized, with many bees placing the material into a small area of comb in and adjacent to the open brood, rather than spreading the pollen over a less concentrated area. Beekeepers recognize stored pollen and bee bread as a part of the normal perimeter of the brood nest in an undisturbed and natural comb. They see a transition from the center of a developing brood frame, showing sealed brood in the center of the frame. Moving to the sides and top of the frame, one sees a biologically logical progression of open brood (larvae), to eggs, to pollen and then to open honey cells. If there are any capped (sealed) honey cells, they are at the outside perimeter, forming what some call a crown, or cap, of honey.

Bees compete for empty cells. Nectar ripeners are looking to add cells of honey to the crown or cap of honey surrounding the brood and pollen area. Nurse bees seek some of these same cells for a location for the queen to lay eggs in the urge to expand the colony's size.

Pollen bees establish a pollen-storage region in the middle of this contested area, and often store pollen in cells that have just emerged. Such close proximity to the brood area is quite logical as it provides fresh protein to the nurse bees that occupy that region of the hive. Beekeepers need to remember this when they try to help bees by feeding protein patties as these must be placed immediately on top of or beside the active brood area. Even a separation of several inches will reduce the attractiveness of the food to nurse bees and render the feeding useless.

Yeasts occurring naturally in the hive and living in the gut of the bee are regurgitated with nectar and honey when the forager adds it to the pollen. This leads to fermentation and the production of lactic acid in much the same way that farmers produce silage (fermented, high-energy green forage plants used for animal feed). Bee bread has a higher nutritional value to bees than fresh pollen, but this value declines when stored. This is shown in the results of a study that compared fresh bee bread with that which had been stored for one year at 0-16° C or at 18-26° C. The results show the importance of fresh pollen to a bee colony. When a group of 1,000 bees were given a diet of the fresh bee bread, they were able to feed 142-306 worker larvae. The 0-16° C bee bread produced only 49-75 larvae, while the third sample of bee bread stored at 18-26° C, failed to feed any larvae. This emphasizes two things: first, that beekeepers must find apiary locations that support a continuous and diverse supply of fresh pollen. Second, beekeepers who store bee pollen (not necessarily bee bread) must freeze this material in order to preserve its nutritional value. It also questions the somewhat standard procedure beekeepers use to store pollen at room temperatures (although, perhaps, in unheated conditions during the winter) to make bee feed for spring stimulation. While this pollen may have some value as a feeding stimulation (phagostimulant—something that entices a being to eat—like the smell of bacon frying or French fries hot out of the deep-frier), regardless of nutritional content, the value of the product is most certainly inferior as a protein food.

Bees do not hoard pollen and bee bread to the same extent that they do honey. They respond best to fresh pollen for the stimulation of egg laying and further brood rearing. During the active spring development cycle of hives, colonies may store what seems to be a great deal of pollen, but they need large amounts of pollen during this time period. If we figure that it takes one or more cells of freshly collected pollen to produce one worker bee, at least one frame of stored pollen must be consumed to produce a frame of sealed worker brood. This does not take into consideration the carbohydrates needed to feed bees and brood during this process.

When corn and other grasses, pines, and other low-protein pollen sources, like ragweed, dehiscence, it is often when little other pollen is available in other flowers, so the bees at times collect huge amounts of low-quality pollen that they store in cells. If higher protein pollens are later found, the bees would ignore the low-value pollen/bee bread. Some of this may be seen being pulled out of the comb as the bees chew the combs to the midrib to remove the low-grade pollen, and then rebuild the comb. In terms of food value, it will take three or four more times the amount of low-grade pollen to produce the same number of cells of brood and bees that a higher pollen source will require.

When overwintering colonies begin brood rearing during the depths of winter in northern climates, they rely upon a combination of pollen stored in the brood nest during the previous season (as bee bread, usually sealed under a thin layer of honey) and the stored food in the body of overwintering “fat bees” (Somerville, D. 2005). Winter and early spring brood rearing drains the stored bee bread supply and the physiological resources of the workers as the brood is produced. This physiologically ages bees, and shows the impact of a late spring on the systemic nutritional decline of colonies as they wait for temperatures, rainfall breaks and plant development to cooperate to allow the bees to find and collect food.

Seeley (1995) describes the pollen-collecting patterns of the average colony. He reports that, during the average foraging trip, the worker bee carries home about 15 mg of pollen, contributing, bee by bee, to about 20 kgs of pollen per season. Most of this pollen is consumed during the spring; summer and early fall while brood rearing is most active. A single bee requires about 130 mg of pollen and an average colony produces about 150,000 bees per season. From this Seeley calculated that a colony requires 20 kg of pollen requirement per year. He does not allow for differences in the protein levels of different pollen sources, but apparently provides for an average protein level. A larger protein need was reported by Ellis et al (2012), who state, “A colony's annual requirement for pollen has been estimated to range from 15 to 55 kg.” They also state that a single worker larva has been estimated to require 124-145 mg of pollen, with a protein level of 20-25% crude protein.

What happens if bees do not receive adequate protein from pollen? Winston (1987) reviewed key aspects of this question. He reported on research that indicated that a lack of protein during the adult bee's first 1 to 8 days resulted in a shorter lifespan and poor development of the hypopharyngeal gland and fat bodies. The source of the pollen was also important. There is reduced longevity when bees are fed only dandelion pollen. In general, ten amino acids are essential for proper bee growth. These are arginine, histidine, lysine, tryptophan, phenylalanine, methionine, threonine, leucine, isoleucine and valine. To acquire all these amino acids, bees require varied pollen sources to compensate for any one species pollen deficiencies. Various vitamins are also needed for hypopharyngeal gland development.

In drone bees, the larvae require more food due to their larger size. This food has more diverse proteins than worker brood food. They are fed a diet of more pollen and honey as older larvae. Workers feed drones for the first few days of adult life, but then feed themselves from honey cells. When fed by worker bees, young drones receive a mixture of brood food, pollen and honey; they may also receive regurgitated honey stomach contents as food. The level of drone bee brood food and protein feeding is directly related to how long the drone lives, how successful it will be during mating, and the number of viable sperm it will develop. Older drones feed themselves honey from comb for energy for mating flights. Flying drones require 14 mg of honey per hour of flight.

Queen adults are apparently fed brood food with some honey. The level of queen feeding is linked to her egg-laying rate—more food is consumed when queens are actively laying eggs. Queens will lay between two and 26 eggs between feedings, usually from one worker bee, but more at times.

Written with the assistance of Robert G. Muir.

Literature cited

- Crane, E. 1990.** *Bees and Beekeeping: Science, Practice and World Resources*. Comstock. Ithaca, NY
- Ellis, A., J. Ellis, M. O'Malley and C. Nalen. 2012.** *The Benefits of Pollen to Honey Bees*. Publication #ENY 152. <http://edis.ifas.ufl.edu>.
- Johansson, M.P. and T.S.K. Johansson, 1978.** *Some Important Operations in Bee Management*. IBRA, London
- Somerville, D. 2005.** *Fat Bees Skinny Bee-A manual on honey bee nutrition for beekeepers*. A report for the Rural Industries Research and Development Corporation, NSW Australia
- Nation, J. 1974.** Nutrition of honey bees. 20th A.E. apic. Soc. Conf., Guelph, Ont.
- Peng, Y-S. et al 1985.** The digestion of dandelion pollen by adult worker honeybees. *Physiol. Ent.* 10(1): 75-82
- Seeley, 1995**
- Stell, I. 2012.** *Understanding Bee Anatomy: a full colour guide*. The Catford Press.
- Weaver, N. 1964.** A pollen substitute for honeybee colonies. *Glean. Bee Cult.* 92(9): 550-553.
- Wells, S. 2010.** *Pandora's Seed: The unforeseen cost of civilization*. Random House, NY.
- Winston, M. 1987.** *The Biology of the Honey Bee*. Harvard University Press, Cambridge.

The Remarkable Honey Bee - June 2013 Propolis Rx

by Larry Connor

New beekeepers quickly learn that propolis is the glue bees use to bind hive parts together, making the manipulation of frames and other hive parts a growing challenge as hive equipment is increasingly coated by the bees. At warm temperatures fresh propolis is incredibly sticky, while at low temperatures it serves as a solid binding agent, making frames difficult to extract. Gathered by bees as plant resins, the complex material has been considered a form of medicine dating back thousands of years. Various studies have shown propolis to be antimicrobial in nature, with studies on herpes simplex virus, influenza virus and most recently as a potential inhibitor of HIV-1 expression (Gekker et al 2005) as only a few examples of U.S. testing. The HIV study, done in vitro (a study made to occur in a controlled experimental environment rather than within a living organism or natural setting), found that propolis has powerful antiviral activity, in lab tests, against X4 and R5 variants (two categories of HIV strains, distinguished by their different approaches to infecting a cell) in the major cell types that this virus infects. The study indicated that, though the tested propolis samples were from various parts of the world, each variation of the material functioned as a viral entry inhibitor.

Dr. Nicola Bradbaer of Bees for Development (2009) reports that it was long thought that bees collect the plant resins without altering their composition, but “recent work has shown that bees’ enzymes do indeed transform some components of propolis.” There is no clear and chemically standardized definition of propolis, although all experienced beekeepers know what it is. It is a beekeeper term, not based on plant botany—the precursors of propolis are the “sticky material on leaf buds” bees collect. Dr. Eva Crane, the late director of the International Bee Research Association, reported that propolis is “material that honeybees and some other bees can collect from living plants, and use alone or with beeswax in construction and adaption of their nests” (Crane, 1990). To confuse matters further, Crane adds that some authors consider the material that beekeepers scrape from their hives to be propolis, even though it may contain a large percentage of beeswax and a small amount of bee-collected pollen and honey. The propolis part of this is sometimes called balsam. Stingless bees use propolis and wax to produce a material called cerumen, which Crane suggests may be a more precise term to describe what honey bees use in their hive.

Bees use the propolis to keep their homes dry, free of drafts and hygienic. The inside walls of bee trees are remarkably smooth with a varnish of propolis, sealing cracks where microorganisms may develop. The volatile components of propolis are thought to serve as an antiseptic air-freshener. The thin layer of propolis varnish inside the brood cells strengthens the comb and establishes a more hygienic space in which eggs, larvae and pupae complete their metamorphic processes. The space within the brood nest is dark, humid from honey processing and filled with the microbes associated with pollen conversion to bee bread. The thin propolis layer on much of the wood surface, as well as on the wax comb, apparently helps the bees maintain colony in healthy homeostasis (a relatively stable equilibrium among diverse elements inside the hive).

Propolis contains over 180 components (Burdock, 1998) and the exact molecules involved in this inhibitory role are unknown. Many researchers suspect that various flavonoids (organic compounds that appear as pigments in plants), moronic acid derivatives and caffeic acid (present in at least some plant resins) are contributing to the anti-HIV-1 activity.

In this article, we explore some of these chemical and medical properties, starting with the use of herbal remedy for over three thousand years, as well as recent evaluations of the substance’s toxicological properties.

History of human medical use

As many cultures interacted with beehives in earlier times, the advantages of propolis were widely accepted. While the exact sources of illnesses were as poorly understood as their cures until relatively recently in contemporary history, there is a void of solid research on the medical application of propolis since Western medicine has only been conducting research in this area for approximately 40 years. This task has proven to be highly challenging because of the variance in propolis’s composition, and the lack of a standard propolis product.

But we are making headway. We are finding strong evidence of mechanisms that underlie the substance's historic reputation as a medicine. Crane collected some of the traditional uses of propolis in her book, *The World History of Beekeeping and Honey Hunting*. She cites Aristotle's *Historia animalium*, which points to propolis as a cure for bruises and suppurating sores. According to scholarly texts surviving from ancient Rome, propolis was a component in many physicians' poultices. Crane cites Arabic physician Avicenna's claims that propolis was "capable of expelling the tip of an arrow or thorns, cleans and softens the skin". Records from 12th century Europe describe medical preparations using propolis for the treatment of dental cavities and with mouth and throat infections. Even the Incans—who had access to stingless bees (*Genus Mellipona*) before the western honey bee, genus *Apis*, was brought to the Americas by Europeans—adapted propolis as a treatment for inflammation accompanied by fever. As honey bees thrive in most habitats also occupied by humans, propolis has, historically, been an available resource. Propolis has been used in dental work, serving to both seal and clean the work site; it is readily available in health food stores as toothpaste and other personal grooming products. Inspiration for modern research of propolis as a possible agent against HIV came when researcher Genya Gekker, who received her formal training in the Ukraine, sought propolis as a traditional remedy for her own cold.

Some recent investigations include:

Anticancer effects—Ethanol extracts have been tested on human liver and uterine carcinoma cells in the laboratory and shown to inhibit their growth; one of the components of propolis is clerodane diterpendoid, which shows a selective toxicity to tumor cells. Using hamster ovary cells and mouse sarcoma-type tumors, propolis killed cell growth and prevented further cell development.

Antioxidant effects—Propolis flavonoids are thought to be powerful antioxidants, affecting free radicals and protecting compounds like Vitamin C from being destroyed.

Wound healing and tissue repair—Propolis is thought to stimulate circulation, enzyme systems and cell metabolism in burn wounds, perhaps due to the arginine in propolis.

Cardiovascular effects—Tests with mice showed that propolis reduced blood pressure and produced a sedative effect. There may be other benefits as well.

Dental caries effects—When rats were given water containing a propolis extract they developed fewer dental caries when also exposed to one of the decay microbes. It has also been used as a secondary treatment to gingivitis, plaque and pulp gangrene.

Human tests—A wide array of tests with humans (with different sample sizes and control conditions) suggest that propolis has some benefit in throat and lung infections, plaque and gingivitis, deep-growing fungi, ringworm, skin ulcers on the tibia, burns, external ear infections, vaginal and cervix inflammation and giardiasis. We mention these with caution because they are not widely approved treatments in the United States, and require further investigation by both the medical community and potential users.

Perhaps the most remarkable part of all of the range of applications of propolis is the rate at which its purported properties are finding underlying support. Even with its inconsistent composition, it seems highly probable that the wide-range antibacterial, antiviral and antifungal properties of propolis would benefit everything from 'suppurating sores' to low-cost dentistry. Perhaps, if the traveling salesmen, who coined the phrase, had been selling 'bee oil' instead of snake oil, they'd never have sullied their reputations!

Uses of propolis by humans

Though the historical properties of propolis have been widely established and the progress of science in the past 40 years of research has been promising, the reality of U.S. regulatory requirements demand rigorous testing and strict definitions before such substances can be marketed with any specific health claims. This is a challenge because the composition of propolis varies by region (which makes it particularly remarkable that all propolis samples appear to be generally effective) and the abundance of corroborating data required can be quite high.

Of particular interest, considering the range and impact of human immunodeficiency virus (HIV) on the global population, a report published in the 2005 *Journal of Ethnopharmacology* detailed the effects of propolis on specific cell bodies targeted by HIV type 1. To address the variance in chemical composition, the team tested substances collected from various local and global regions, specifically studying the effect of different concentrations of propolis on CD4+ and microglial cell cultures, two types of cells vital to the human immune system, when exposed to HIV type 1. Without apparent negative impact to the cells, this study suggests that a concentration of 66.6 micrograms of propolis per milliliter is sufficient to suppress the virus at over 85-98%, maximally, depending on the cell type. Even with regional variance in composition, the results reached similar levels for each type, leading the researchers to conclude that clinical trials of the substance (or one or more of its components) should be performed in the treatment of HIV-1 infections.

Stefan Bogdanov, a former researcher at the Swiss Bee Research Center, wrote a paper entitled "Propolis: Composition, Health, Medicine: A Review" in 2012 which documents dozens of uses and studies from around the world, ranging from simple antibacterial, -viral and -fungal uses to specific applications for conditions of many varieties. Propolis has been tested in vitro and in animal experiments for properties that are anti-diabetes, anti-tumor and chemopreventive, and as an anti-inflammatory agent, all of which underscores contemporary interest in utilizing this natural product. As Dr. Crane indicates in her own writing, a standardization of propolis composition and further study on their components is required, and it seems clear that such an effort would be well rewarded.

Caution is needed

The perceived medical promises of propolis aside, there are good reasons to temper expectations about widespread propolis use in medicine. For starters, one must always consult a medical professional before consuming this (or any) substance for medicinal

purposes. As amazing as propolis seems to be, there are side effects from its use, both externally and internally. To people who are already predisposed towards bee-product allergies, propolis may have a higher rate of triggering an allergic reaction. Persons with dermatitis, according to some European studies, are susceptible to outbreak from propolis contact.

In September 2010, New Zealand's Medsafe: Information for Health Professionals, Prescriber Update Articles, issued a prescriber update that warned of hypersensitivity reactions, as well as cases of renal failure linked to propolis use. "This advice follows a review of international adverse reaction reports that identified several cases of hypersensitivity reactions in people using complementary medicines containing propolis. Patients with a history of allergies appeared to be at particular risk of these reactions. Propolis has been implicated in cases of acute renal failure." Unfortunately, this advisory referenced only a few isolated cases of caution, neglecting a statistical analysis that might suggest how much or which parts of the human population may be affected. How frequent are these events within the general public? It seems logical that individuals with known allergies should be sensitive to the use of any natural product from the beehive inasmuch as the exposure to bee-collected pollen is an ongoing concern to pollen marketers.

As of the beginning of 2012, the National Institutes of Health was only willing to rate propolis as possibly effective for cold sores, genital herpes, and improving healing and reducing pain and inflammation after mouth surgery. The MedlinePlus® entry on Propolis goes on to state that there is insufficient evidence to address claims of effectiveness on general inflammation, wounds, and any of the dozens of other claims that have come from history. Certainly, if you are a producer of propolis products, you will need to consult with FDA guidelines to ensure product compliance on medical claims and how propolis products can be marketed. A simple search of the FDA's website on the subject returns numerous citations by the FDA against even well-established bee product companies regarding their compliance with advertising and sales.

So, is propolis worth getting excited about? Absolutely. With the availability of knowledge at every corner of the globe, the threats facing bees today and the growth of the human population, the pressures of sustaining our populations with all of our resources has never been greater. It is important that we all take an interest in advancing our understanding of these simple-yet-mysterious things that come from the most unexpected places. Research only goes as far as interest and support allows, so it falls to the global community to encourage the development of this knowledge base. The next time you find yourself grumbling as you try to pry open a hive, glued shut with propolis, consider the opportunities you may be missing!

Literature cited

Bradbaer, N. 2009. Bees and their role in forest livelihoods: A guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products. Non-wood forest products 19. Food and Agriculture Organization of the United Nations, Rome

Crane, E. 1990. Bees and Beekeeping: Science, Practice and World Resources. Cornell University Press, Ithaca NY.

Gekker, G. 1995. Journal of Ethnopharmacology. 'Anti-HIV-1 activity of propolis in CD4+ lymphocyte and microglial cell cultures'. www.beelab.umn.edu/prod/groups/cfans/@pub/@cfans/@bees/documents/asset/cfans_asset_317691.pdf. Accessed 19 April 2013.

Bogdanov, Stefan. 2012. 'Propolis: Composition, Health, Medicine: A Review'. www.bee-hexagon.net/files/fileE/Health/PropolisBookReview.pdf. Accessed 19 April 2013.

MedlinePlus®. 'Propolis: MedlinePlus Supplements'. U.S. National Library of Medicine NIH National Institutes of Health. <http://www.nlm.nih.gov/medlineplus/druginfo/natural/390.html>. Accessed 19 April 2013.

Medsafe. September 2010. Prescriber Update Articles. 'Complementary corner: Propolis – reports of hypersensitivity reactions'. <http://www.medsafe.govt.nz/profs/PUArticles/ComplementaryCornerPropolisSept10.htm>. Accessed 19 April 2013.

For information about other work by Connor and Muir, consult the www.wicwas.com website.

The Remarkable Honey Bee - May 2013 Propolis

by Larry Connor

(excerpt)

Propolis is a plant product collected by bees from plants within their normal foraging territory. The substance, understood to be largely unaltered by the bees, is comprised of resin from various species of plants, the exact sources of which are difficult to determine due to logistical reasons. However many of the North American propolis samples are collected from the tree genus *Populus*, commonly known as poplars. Propolis sources from other parts of the world appear to possess properties directly related to the available plant forage visited to obtain the material. Not all plant resins are identical.

Plant bud resins and their functions

Plant resins are believed to protect a plant's buds and leaves from water loss and have a component of insect repellency. The resins are found in trees like the poplars and cottonwoods, trees that form new buds in the summer and early fall. The primordial tissue inside the bud does not produce propolis, but the stipules that form the bud scales secrete a resin that fills the bud. As the leaves grow and unroll in the spring, they produce glands that secrete resin. There may be extra floral nectaries located near the resin glands that are responsible for the guttation of sap (seen as drops of water at leaf edges, often exuded when there is high soil moisture) and nectar secretion¹.

Humans use poplar buds for medicine, and continue to make poplar bud oil from cottonwood poplar buds, especially from *Populus trichocarpa*. They collect winter buds, macerate them and cover them with water and oil. This may be heated at a low level for several

days and then stored for a month or more. Then the oil is carefully removed from the mixture and bottled. Any medicinal properties are attributed to the plant bud resins and salicylates in the bud tissue. Some people are allergic to this solution and may develop anaphylaxis².

As a group, plant resins are known to be powerful chemicals. They are the source of the greasy build-up that forms when burning buds of cannabis, or while smoking leaf tobacco. As insect repellents, plant buds must contain powerful molecules to successfully minimize leaf feeders, either by a repellency (by an odor or tactile reaction) or toxic effects when ingested.

How do bees collect and use propolis?

Bees collect propolis in the same manner as pollen, packing it into their corbicula (pollen basket) and flying back to the hive. Upon arrival, the forager bee is assisted in the removal of the sticky substance that is then applied to the sides of the nest chamber, on the top of the wax brood comb (apparently to strengthen the hexagon-shaped wax to withstand bee foot traffic) and wherever a hole or crack needs to be filled. Beekeepers are all too familiar with propolis, especially when the bees have fastened combs together with the material (to keep them from moving in the wind?), securing the nest. Bees of certain races use large amounts propolis to reduce the size of the entrance of the hive, blocking potential intruders and cold winds. Hive invaders that die within the hive, and are too large for the bees to remove, are encased in propolis to arrest their decay and prevent the byproducts of decomposition from affecting the population of the hive. Beekeepers have found mice and large insects preserved, mummified in effect, in propolis.

Distribution, where and possible functions

The most apparent use of propolis is the patching of small holes, cracks and spaces less than 3/8 inch in the hive. Bees tend to use beeswax to fill spaces larger than 3/8 inch. While reducing the hive entrance is somewhat useful in deterring pests and predators, hives require ventilation to thrive, which brings our focus to another consideration: propolis and colony health. Propolis serves as an anti-fungal and anti-microbial agent, effectively working as a prophylactic tool used against a number of non-specialized threats to the bees' health.

In feral bee colonies, in tree cavities or rock outcroppings, bees coat the top and sides of the structure with a thin layer of propolis. In addition to the anti-microbial action of the resin, the layer serves as a water and vapor barrier. This ensures that the dankness of a rotting tree or a rock cavity does not promote unhealthy conditions in the colony. The resins thwart the growth of fungi, bacteria and viruses. The propolis is like an envelope or biological shield that provides colonies with a more stable environment in which to grow. Bees also scrape the entrance of the nest to remove loose bark or dirt and coat the hive entrance with propolis. This may provide the bees with a smoother surface for takeoff and landing activities as they forage.

Propolis is used in the comb area of the hive, as evidenced by thin layers of resin on the brood comb and between comb and their attachment to the tree or rock homesite. In managed bee colonies, the bees' use of propolis is considered an essential part of colony health. Within the first season of use with new combs, most colonies add abundant propolis along the frame ends, where the wood parts of the frame contact the frame rest. With additional beekeeper manipulations, there will be additional layers of propolis added to the initial layers, used to re-secure the frames.

The Remarkable Honey Bee - April 2013

The Queen's Life

by Larry Connor

In what season does a queen start her life?

We might assume that the majority of queens are reared during swarming. This is a major colony event during of the spring buildup period of the season. Swarms may first appear in February in Florida, Georgia and south Texas, but not until May or later in the northern reaches of the North American continent. Each area has a peak swarming period of about six weeks, and this peak swarming season moves north as the calendar progresses, influenced by cold fronts, heat waves, drought conditions, and floral abundance. If bees are unable to forage, the swarm season is delayed and its intensity may be diminished. If there is abundant food, good foraging conditions, then the season arrives early, there may be many swarms, even from each colony. The first swarm is called the prime swarm, and is usually the largest, and often carries with it the old queen. The parent hive that issues the prime swarm will have queen cells in production when this occurs, in fact, this swarming business happens quickly, and the swarm cells may not yet be sealed. Many beekeepers miss the signs of swarming, and the beekeepers never know their colony has swarmed.

Incoming resource abundance is clearly a major key to determining the time of the production of natural queen cells by colonies outside a beekeeper's manipulations of feeding and colony division. Nectar and pollen abundance determines the speed of colony development, for both plant and colony development rates are directly influenced by increased spring warming. Colonies on a spring nectar flow are stimulated to expand the brood nest, while incoming pollen stimulates brood production with the engorgement of the hypopharyngeal, or brood food, gland of young worker bees. Because royal jelly cannot be stockpiled like honey or pollen, it must be fed to developing larvae, as there are no cells filled with surplus royal jelly. It takes food abundance to produce abundant bees, and these numerous bees are necessary for production of queen cells during the swarming season. The queen receives this food during her entire larval life; ordinarily she is unable to consume it as fast as the nurse bees provide it, so there is unconsumed royal jelly inside the cell of each developing queen cell.

What triggers queen cell production?

During buildup, healthy queens oviposit 1,200 to 1,500 eggs per day to build a colony's bee population to a robust level. With a vigorous queen most of the cells in the colony are filled with developing bees, the brood, or with pollen and honey. Her chemical messengers that control the colony are reduced by a combination of dilution and crowding. Triggered by self-monitoring feed-back mechanism that informs her that her pheromones are diluted, the old queen places eggs into queen cups built by her workers, initiating the production of the daughter queen cells that will ultimately provide her replacement. For an older but vigorous queen at swarming season, the relationship is like this:

Pollen and nectar in abundance - Stimulation of brood production - Dilution of queen pheromone - Queen puts eggs into cups

Compare this to a colony with an old queen, one that is two or three years old, her egg-laying is reduced, with the nectar flows filling the emerging cells in the brood combs. They are not involved in the swarming process, but supersedure, queen replacement. This drop in brood production is associated with a similar decline in the queen's production of queen substance or pheromone.

The supersedure queen replacement process looks like this:

Reduction of egg laying and reduced stimulation of brood pheromones - Dilution of queen pheromone - Queen puts eggs into cups

The process is basically the same, as the outcome is the production of queen cells. The queen lays the eggs placed into these cells. The difference is in the different stimuli: abundance of food and brood in swarming and the decline of egg-laying and brood pheromone in supersedure. Queen cups are available throughout the year for use for queen cell production, but swarm cells are often at the bottom of the comb, or frame. When the brood area is reduced, due to egg-laying reduction, the cells are often on the face of the comb. With a change of colony fortune, a swarm cell may be used for supersedure without swarming. Less often a supersedure cell may be used to provide a queen for a small swarm.

Royal jelly is not fed throughout the life of larval worker and drone bees. There may be a small surplus of royal jelly at the bottom of their cells, but only for the first two days or so. Then the nurse bees switch the larvae to a diet of honey and pollen, a gruel for the masses, while the queen larvae continues her special diet until the cell is sealed by other worker bees. When small, larvae require fewer visits for feeding, but as they grow in size, very rapidly in about five days, the number of feeding visits increases dramatically because the larva is larger and consumes more food.

Theories of abundance

Bee colonies in nature are often sparsely spaced, and the evolution of the mating behavior of bees using drone congregation areas appears to be Nature's way to ensure that queens and drones from different colonies are able to find each other in a otherwise rarefied environment. Increased abundance of food (or water in the desert) may result in more bee colonies in one area, and while this may seem to be counterproductive by increasing competition for finite food reserves, areas with larger colony numbers tend to have healthier colonies. This same result has been shown with goldfish and butterflies, that an increase in mating opportunities produces a healthier population. We do not think of a young, unmated queen as a lone predator, searching great distances for a mate. Instead, drone congregation areas provide abundant mating partners, enough of them to satisfy a queen's need for 20, 40 or 60 sexual partners, as recent studies have shown.

The need for abundant, sexually mature male bees, the drones, at the time the queen leaves for her nuptial flights is met by increased drone production during the spring increase, and many beekeepers use the appearance of the first sealed drone brood as one method of predicting when their colonies are likely to reach their peak swarming.

If a group of colonies are left to themselves, the healthy overwintered colonies will reach a swarming peak in May where I live in Southwestern Michigan. Some will be reported in April and there will be more swarms throughout June and July, but the largest numbers will issue in May on beautiful spring mornings after a few days of showery confinement.

There are two kinds of queens in swarms. The first often carries with it the old queen, the one that helped build the colony, and survived a winter or two with her colony. She may have been a new queen the previous season or longer than that. My experience suggests that three-year old queens are possible, but infrequent. Dr. Joe Latshaw, who produces breeder queens for the beekeeping industry, calls three-year old queens Grand Old Ladies. I agree that selection for queen longevity is an excellent goal. We need to understand how some queens live longer than others.

When the old queen travels with the swarm to a new nest, she is responsible for the colony's rapid growth during the first months of the colony's occupation of its new home. It is usually unlikely that a new swarm will generate another swarm during the same season it swarmed, but will be stimulated to produce a large nest of new honey comb and store resources adequate for winter survival. Nearly all the brood comb the colony will ever build will be constructed during the spring and early summer as the nectar flow provides the raw ingredients for this task. The older queen will have time to serve her colony, but eventually her pheromone level will begin to fall. As the supersedure process begins, she will keep the colony going during the nectar flow as her daughter completes metamorphic development, emerges, matures, mates and starts to lay eggs in the comb. As the old queen fails, her life is over, and worker bees working the role of undertaker bees will remove her body from the hive.

The second swarm queen type is characterized by swarms containing a number of virgin queens that travel with the mass of bees and enter the new nest. As the colony settles in, the virgins fight each other, leaving just one young queen to leave the hive and mate with drones within the surrounding region, in a distance or radius of two or three miles. She too seeks to find and mate with 20, 40 or 60 drones; they are very likely in abundance at this time of the swarming season. When she returns, successful from her last mating, the last drone's endophallus will still be in her median oviduct, and is called the mating sign. She will rest for a few days as hormones stimulate her ovaries to swell and produce ova in 350-400 ovarioles in her abdomen. The new swarm queen is likely to remain in the new location for at least a year, and perhaps two, before the nest becomes so crowded that the colony swarms much like the parent hive. This constant swarming continues the species.

Should a queen fail to mate due to weather confinement, she may become a drone-laying queen. If a dragonfly or kingbird eats her during her mating flight, her death will lead to the ultimate death of the colony. In a broodless condition, the workers are liberated of the queen pheromone that suppresses the development of their ovaries, and, because they cannot mate, will produce unfertilized eggs that will produce only haploid individuals, all drones.

The chart provided summarizes the difference between the two queen types found in swarms.

Perhaps most queens are produced during the swarming period of the spring season, whenever that is where you keep bees. But other queens are produced later in the season, probably during the nectar flow while there are still drones available for mating. This difference in the time of mating is asynchronous, indicating a lack of concurrence of timing of the mating event. Having different times of queen mating reflects the honey bee species' flexibility in adjusting to differing food supplies and the abundance of male bees. Most beekeepers don't spend much time thinking about this, as we think the bees are excellent in deciding when to produce queens and produce a new swarm or replace an old queen. We should be careful to think that this asynchronous mating behavior always works for queen production, and reflect on this when we find a nucleus or colony that has failed to replace its queen, with or without swarming. Look for the new revised edition of Dewey Caron and Lawrence Connor's *Honey Bee Biology and Beekeeping*, due out later this season. Check www.wicwas.com for availability and ordering information.

Interested in a queen rearing course? Dr. Connor will offer one if there are enough beekeepers interested on May 31, June 1 & 2, in