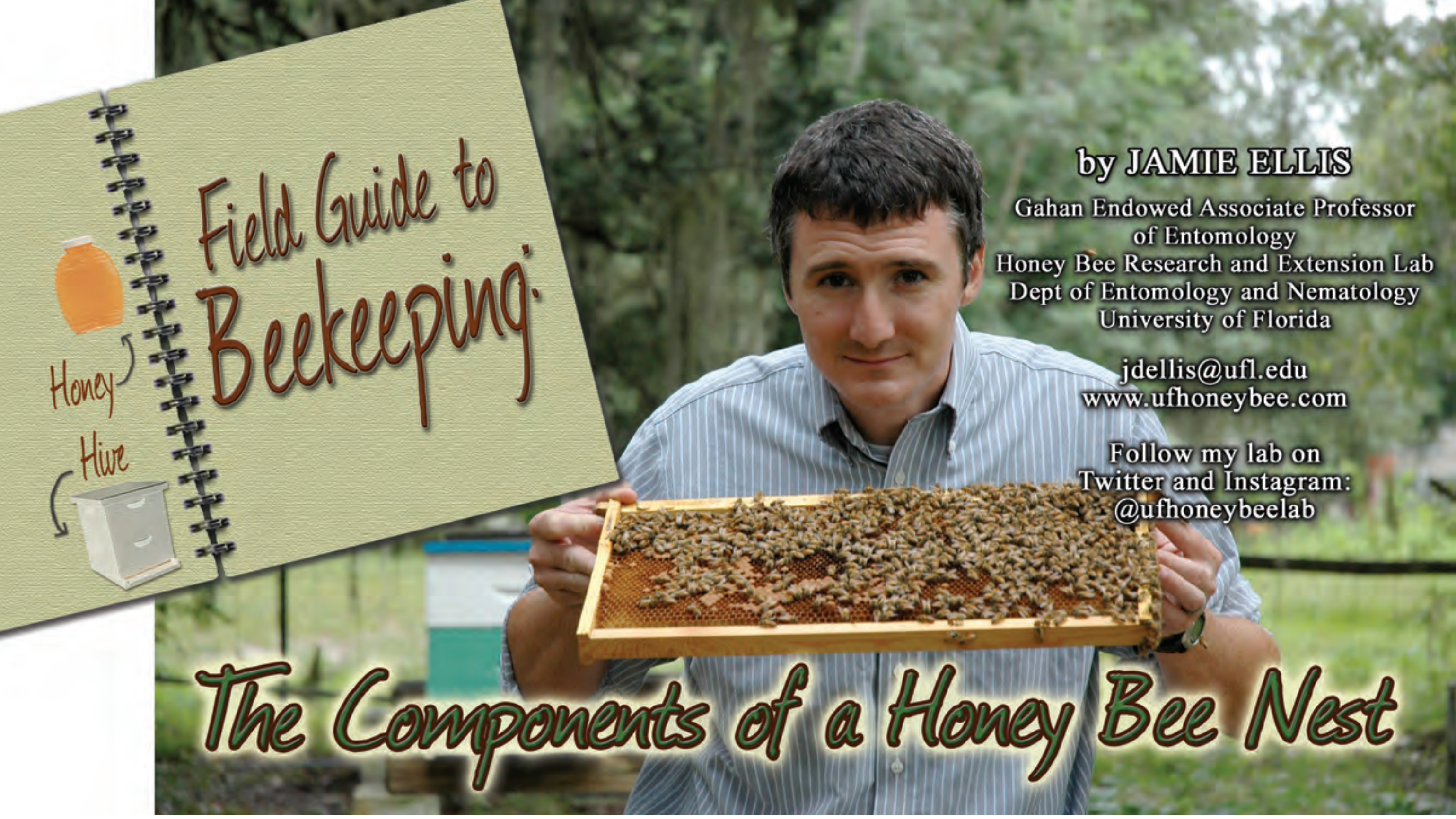

Field Guide to Beekeeping

The Components of a Honey Bee Nest

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In my column last month, I discussed the terminology associated with the members of a honey bee colony. In the present article, I am going to introduce you to terminology associated with the hive and its various components. I put the important new terms in bold font so that you know exactly what I am trying to define.

I will begin my discourse of nest components by discussing the difference between a honey bee *colony* and a honey bee *nest* (or *hive*). In the loosest sense, a honey bee **colony** is a group of bees, usually sharing the same or a related mother, that together function as a single unit. This "togetherness" confers certain, mutually beneficial attributes that are otherwise absent in a single bee. In laymen's terms, a colony is the sum total of all the bees that live in the nest. The **nest**, or **hive**, on the other hand, is the physical space occupied by the colony and is the sum of the components that together, comprise the nest.

Why make the distinction between nest/hive and colony? Quite frankly, it is because we often use the terms incorrectly or interchangeably. It is very common to hear one say that bees live in a colony or that the bees are a hive (i.e. a hive of bees). However, it is important to distinguish between the two since they do not mean the same thing and conversations become confused when using the words incorrectly. Bees do not live in a colony, neither are they a hive, though the latter use is accepted increasingly. I prefer to use the word *nest* rather than *hive* because I believe it is less ambiguous and less likely to be used incorrectly.

With that background, I am not writing about the components of a honey bee *colony*. That would produce a discussion of the colony members, which I covered in last month's column. Rather, I am focusing on the components of a *nest*, the bees' living quarters. I also am not discussing the parts of a managed hive (the lids, frames, bottom board, etc.). Instead, I am focusing on those parts that are common to all hives, whether managed, wild, or feral.

The honey bees we keep prefer to nest in cavities that are about 40 L in volume and 10 or more feet above the ground. We know this from the work of L.L. Langstroth and Tom Seeley, among others, who conducted elegant studies to determine honey bee nest site preferences. Furthermore, there likely is a number of nests that honey bees will establish per unit area (# nests/unit area = nest **density**). Notably, honey bees in the wild rarely nest in the densities that we as beekeepers create in our overcrowded apiaries. Bees seem to nest at much lower densities, likely based on the amount of resources available in the environment.

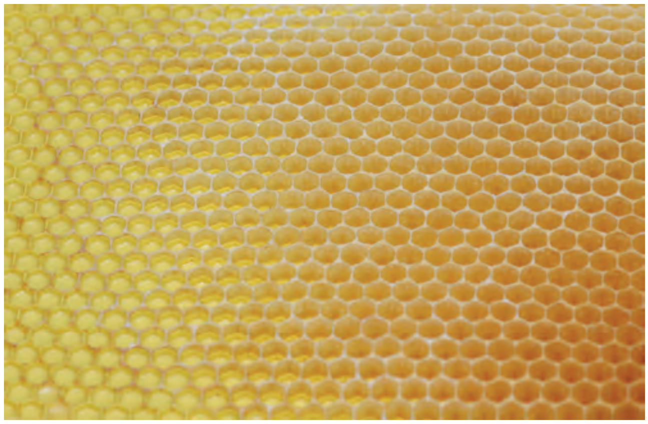
The nesting sites that honey bees choose to inhabit usually meet stringent criteria that the bees desire. I will not discuss those criteria in depth here, but it is worth noting that Tom Seeley, in his book *Honey Bee Democracy*, covers this topic in considerable detail. I also want to share that Randall Hepburn and colleagues published a book entitled *Honeybee Nests: Composition, Structure, Function*. The authors of both books more than adequately cover the topics of nest site choice (Seeley) - what honey bee colonies desire in a nest site - and nest components (Hepburn et al.), i.e. the parts of a nest. I recommend reading both if you remain interested in this topic after you finish reading this article.

Nest components

All honey bee nests have an **entrance** (Figure 1). In managed hives, the entrance is at the base of the nest and occupies a space that is the entire width of the face of the nest. For nest sites occupied by wild or feral colonies, the nest entrance may be as small as the diameter of a dime, though the entrance most commonly is a few inches in size. Some wild and feral nests even have multiple entrances.

The nest entrance is the exit and entry point for bees leaving and entering the hive. All of the colony's traffic is directed through the nest entrance. It also serves as the point of entry for would-be colony pests, parasites, and predators. Consequently, the bees work hard to defend the nest entrance against colony invasion and other threats to the colony.

When entering the colony through the nest entrance, one quickly encounters the **wax combs** (Figure 2) that provide the internal framework for the colony. The honey bees we keep construct multiple layers of



(l) Figure 1. The nest entrance. Multiple worker honey bees can be seen flying toward the nest entrance. (r) Figure 2. Pulled comb or virgin comb. The progressive growth of wax cells can be seen in this photograph. Beeswax-coated, plastic foundation is seen on the left of the photograph. Bees have begun to add wax to the foundation and the cells grow in height from left to right. *Photographs by Mike Bentley*.

wax combs, arranged vertically in sheets in their nests. The bees suspend these combs from the ceiling of the nest and affix them to the nest walls to provide added structural support to the combs.

The combs are made of wax that bees secrete from special glands, the wax glands, located on the underside of their abdomens. Wax production is greatest during a nectar flow because the incoming sugar source provides the energy the bees need to secrete the wax and the incoming nectar needs a place to be stored, thus creating a demand for comb. The bees remove the wax scales from their abdomens and use their mandibles (their chewing mouthparts) to manipulate the wax and place it on the growing comb.

Beeswax, the term for the wax produced by the bees, is an interesting substance itself. New wax is white and its chemistry is fairly well known. The major compound families in beeswax include alkanes, alkenes, free fatty acids, monoesters, diesters, and hydroxymonoesters (Hepburn et al. 2014). Fatty alcohols and hydroxydiesters are minor constituents of beeswax. Hepburn et al. (2014) note that beeswax is a viscoelastic, thermoplastic material. This simply means that beeswax "flows" at normal hive temperatures, though to the naked eye, it looks as if nothing changes. In this sense, it is somewhat like glass, which behaves like a "liquid-solid."

In managed hives, bees are encouraged to build their combs within the wooden frames in the nest by securing a sheet of **foundation** (Figure 2) within the walls of the frame. Foundation serves as the **midrib** or **base** of the comb as it is a sheet of wax or plastic on which the bees construct their combs. Historically, foundation was made of pure beeswax, but it increasingly is made of plastic and coated with a thin layer of wax. Foundation is milled, imprinted, or molded to contain thousands of tiny, slightly raised hexagons on which bees start constructing their combs. Foundation is not a natural part of the bee nest since bees naturally build comb without being provided sheets of foundation. Instead, foundation is provided by the beekeeper to coerce the bees to build combs where he or she wants the combs to be constructed. In the wild, the midrib of the comb is built as the walls of the **cells** develop [a cell being the wax cylinder that is permanently closed on one end (the base constructed on the comb midrib) and periodically opened/closed on the other (the opening); a group of cells compose the comb]. This simply means that bees do not first make the comb midrib and then build cells on top. Instead, all parts are made simultaneously.

Many believe that bees shape wax cells into hexagons, and in fact are famous for so doing. However, there has been some recent debate on the actual shape of the wax cells made by bees. Notably, Hepburn et al. (2014) stated:

> "At the onset of comb-building, nascent cells are circular but soon after acquire a more crystalline structure; regular hexagons appear that are products of the physical properties of wax, equal pressure from adjacent cells, and the flow of the visco-elastic wax. The structure and formation of cells result from wax being a thermoplastic material, while the hexagonal structure is the result of the wax reaching a liquid equilibrium…"

This simply means that bees do not build hexagonal cells but rather build circular ones. The physical properties and "flow" of the wax ultimately produce the hexagonal cells that beekeepers and scientists celebrate. Thus far, my favorite quote from Hepburn et al. (2014) on this topic is:

(l) Figure 3. A brood comb composed of multiple worker cells. One can tell that brood has been reared in the comb because the comb is brownish-black in color. (r) Figure 4. Drone comb. These capped drone cells protrude further out than do the worker cells that surround them. *Photographs by Mike Bentley*.

(l) Figure 5. Queen cup. When properly oriented, the opening of the queen cup in this image will point downward. (r) Figure 6. Queen cell. A queen emerged normally out of the cell on the left. This can be assumed because the capping of the cell is missing in a manner consistent with the emergence of a queen. The queen developing in the cell on the right was killed before she emerged, this being evident by the remains of the cell capping and missing side of the queen cell. *Photographs by Mike Bentley*.

> "The shape of the honeybee cell does not have its celebrated regularity; its economy is a teleological myth. The entire history of the honeybee cell in natural history, geometry and philosophy is the story of centuries-old misconceptions."

Stated another way: most of what we were taught about hexagonal cells was wrong.

The wax cells start quite shallow in depth, grow in length as bees add more wax, and, when viewed from the side, are slanted up from the base to the opening. Beekeepers call the process by which bees extend the wax cell **pulling comb** (Figure 2). This invokes the image of bees pulling the wax cylinders out from the foundation or cell base. **Pulled comb** is the completely constructed comb, made to the cell depth preferred by the bees. New, white, fully pulled comb is called **virgin comb**, this simply meaning that it has not been used by the bees.

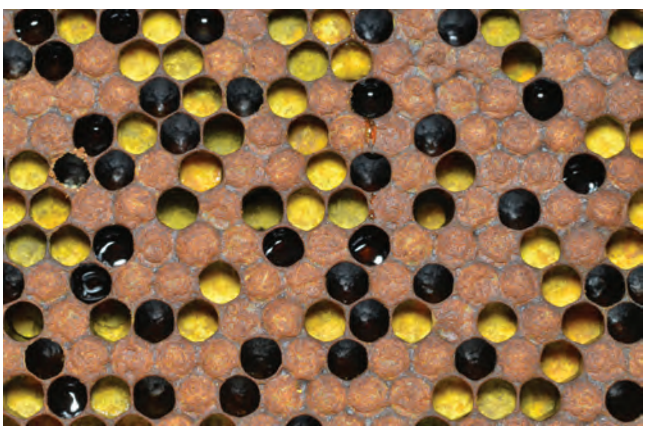
The wax combs have four principal functions, only two of which people often note. The functions of the comb include (1) providing the infrastructure necessary for brood rearing, (2) serving as a place of storage for nectar, honey, and bee bread, (3) aiding in bee communication within the hive, and (4) pathogen, toxin, and general waste management. I discuss first how wax is used for brood production.

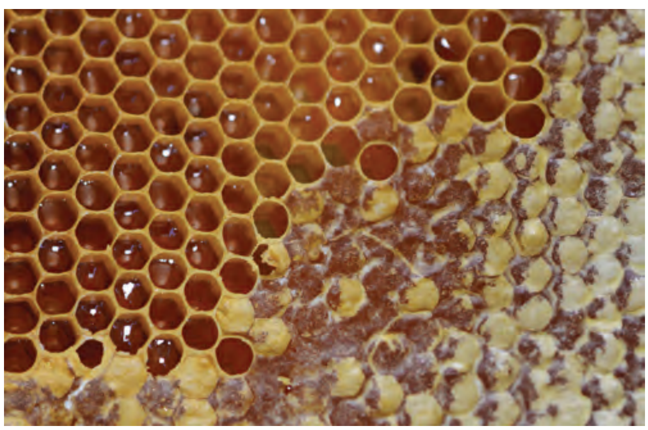
There are three types of bees in the honey bee colony, the worker (female), drone (male) and queen (female). All three develop in different sizes and types of wax cells. Virgin comb is white, but **brood comb** (any comb in which brood has been raised) darkens progressively to be nearly black in color (Figure 3). The comb darkens because the developing immature bees produce silk that adheres to the walls of the cell and normal bee use of the combs stains the wax. As a result, the cells darken over repeated use. One always can tell when a particular cell has been used, even once, as a nursery for developing immature bees because it begins to darken after the first use.

The vast majority of cells that bees construct are sized for rearing worker bees (Figure 3) and are called **worker cells**. Worker cells are the smallest cells in the nest and are arranged horizontally. To produce worker bees, queen bees lay a single egg at the base or back of the cell. A female larva emerges from the egg, is fed hundreds or even thousands of times by her adult worker sisters, and grows to fill the cell. The worker cell remains open while the bee is a developing larva, this because the worker bees feeding the larva need constant access to the larva. After a larva has finished feeding, adult worker bees cap the cell so that the immature bee can develop into a pupa and later emerge as an adult. The head of the worker pupa faces the would-be opening of the capped cell.

Colonies produce more worker bees than they produce either of the other two types of bees. Bees also use the worker-sized cells to store nectar, honey, and bee bread. Accordingly, it benefits a colony to invest in the production thousands of these cell types.

Drone bees also develop in horizontally oriented cells called **drone cells** (Figure 4). Drones are larger than workers and, consequently, develop in larger diameter cells. Drone cells also are deeper than are worker cells since drones are longer bees than are workers. Because the areas of the comb used to rear drones protrudes beyond that used to rear workers, you can hold a comb horizontally and see the areas where bees have developed drone comb because of the rises and falls in the comb. The capping of a drone cell is quite domed and often is





(l) Figure 7. Capped brood. The capped worker cells share space in the brood nest with stored bee bread (yellow material in the open cells). (r) Figure 8. Uncapped (lower left) and capped honey (upper right). Notice that the cappings on the honey cells differ in appearance from those on the brood cells in Figure 7. *Photographs by Mike Bentley*.

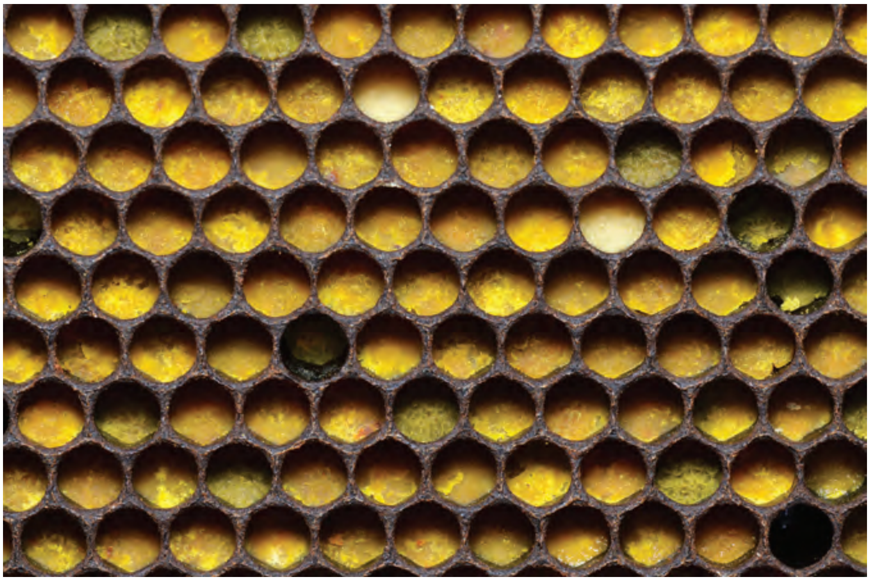


Figure 9. Bee bread stored in worker sized cells. ***Photograph by Mike Bentley*.**

described as bullet-shaped. This is in contrast to a capped worker cell that is slightly domed, if domed at all.

Typically speaking, worker bees do not use drone cells for the storage of nectar, honey, or bee bread. Rather, drone cells are used principally for the rearing of drones. The foundation that most beekeepers use is sized exclusively for worker bees and contains no drone size cell bases. Therefore, all drone cells result from workers' intentional manipulation of the comb in an effort to produce at least some drone cells in the nest. Incidentally, worker bees build a considerably higher percentage of drone cells when allowed to produce comb naturally.

Queen honey bees develop in cells that are oriented vertically, with the immature queen developing head down. The typical wax comb contains numerous **queen cups** whose openings face down. Queen cups (Figure 5) are quite common and their presence in a colony usually is not cause for alarm, though many beginner beekeepers become concerned when they see queen cups. A queen bee will lay an egg in the cup, at which time the cell ceases to be called a queen cup and, instead, becomes a **queen cell** (Figure 6). Wax is added to the new queen cell. A **mature** or **ripe queen cell** is the capped stage of queen cell development. Mature queen cells have almost the size, shape and texture of a peanut hull.

Often, worker bees need to produce a queen in an emergency situation, for example, when the old queen dies suddenly or otherwise must be replaced by the workers. In this case, the worker bees will choose among the available female larvae, usually destined to become a worker, and begin redesigning the worker cell into that of a queen cell. When this happens, workers widen the cell, pull it out from the face of the comb, and then turn it downward. These queen cells often are smaller than queen cells that first started as queen cups, being always destined to be used in queen production.

All three bee types develop as pupae in capped cells collectively called **capped brood cells** or **capped brood** (Figure 7) for short. The capping of a capped brood cell is made of wax but has a somewhat different consistency/construction from that of the pure wax used to cap ripe nectar.

The wax combs also serve as a storage place for nectar, honey, and bee bread. **Nectar** (Figure 8), sometimes called **uncapped honey** or **unripe honey**, is the sugar water that bees collect from flowers, store in the combs, and ripen into honey. Nectar from different floral sources is different in color, composition, and flavor. This is where the varietal honeys originate. All plant species that produce nectar yield species-specific nectar, thus resulting in the wide array of available honey.

Nectar must be processed somewhat before it is usable by the bees as honey. The worker bees collecting and handling the nectar initiate enzymatic digestion of the components of nectar. Furthermore, the moisture content of nectar is much too high for it to be stored and used as honey, which usually is between 15.5-18.5% water. Different cohorts of worker bees spend considerable time evaporating the moisture from the nectar in an attempt to dehydrate it to moisture levels normally found in honey. **Honey** is not really a food for bees as much as it is a fuel for bees. Honey is the honey bee's carbohydrate source. Bees work all year to store honey so that it is available for them during the fall and winter months, when nectar-bearing plants are scarce or absent. The collection of nectar and processing of it into honey is one of the most fundamental tasks and desires of a honey bee colony. Correspondingly, bees construct lots of comb for the purpose of processing and storing honey.

Once the bees dry the nectar to an acceptable moisture content, a cohort of worker bees will cap the cell with pure, white beeswax. At this point, the processed nectar becomes known as **capped honey** (Figure 8). This is the stage of nectar processing that the beekeeper most wants to see achieved by his or her bees. We usually tell beekeepers to harvest honey only after it has been capped by the bees. Only then is it considered **ripe honey**, or honey that bees consider matured appropriately. Wax comb containing honey is called **honey comb**. Honey usually is stored in the upper corners of brood cells and in all combs located above the brood nest.

Bee bread (Figure 9) is another component of the honey bee nest. Bees collect pollen from flowers, mix in some nectar,

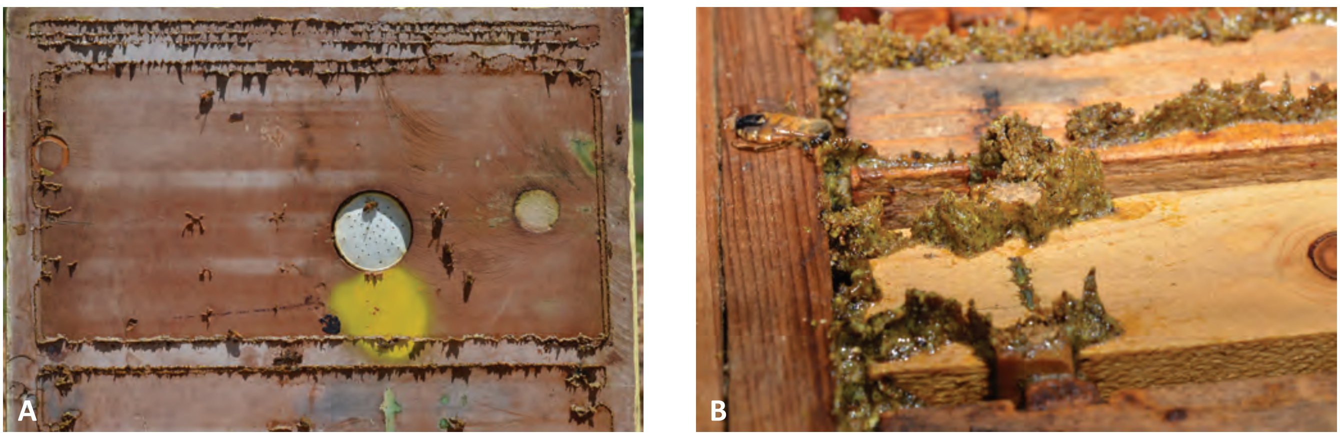


Figure 10. Propolis on the underside of a migratory lid (A) and the top of a frame (B). The propolis outline seen in A is indicative of where the boxes and lid were joined together by the bees using propolis. The propolis in B is toward the upper end of the top bar of a frame. ***Photographs by Mike Bentley*.**

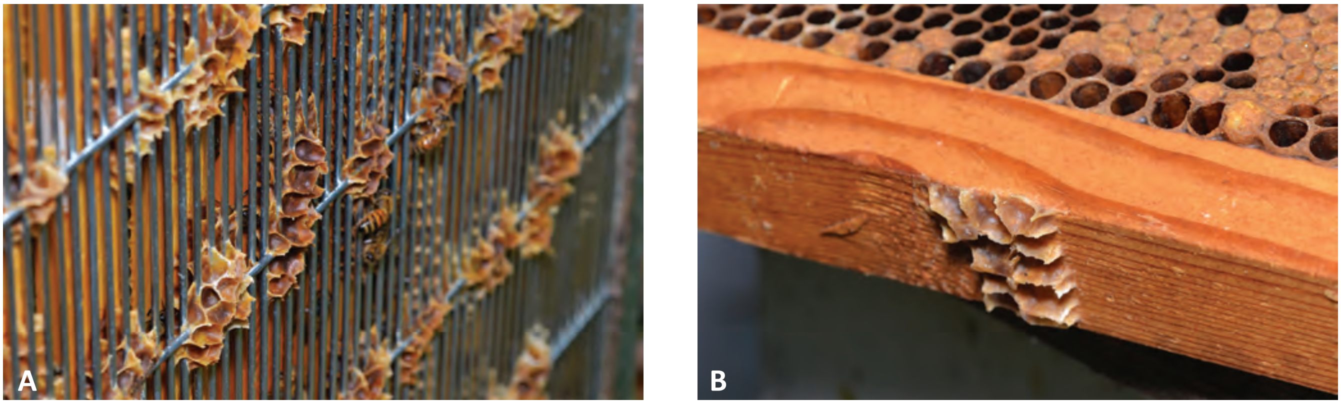


Figure 11. Burr comb on the underside of a queen excluder (A) and top of a frame (B). ***Photographs by Mike Bentley*.**

and store it packed into worker-sized cells. The processed/stored pollen is called bee bread. Bee bread is more than just pollen. It contains nectar, enzymes, and beneficial microflora (yeasts, for example) that help mature the pollen into bee bread. Larval and young adult honey bees consume bee bread. Bee bread provides the protein, vitamins, minerals, and other nutrients that bees need but that honey does not provide. Bee bread typically is stored in cells that occupy a thin, rainbow-shaped region immediately above the brood cells but below the nectar and capped honey. The bee bread is stored close to the developing brood because the larvae consume the bee bread, hence creating the greatest demand for bee bread in the nest.

In addition to providing the infrastructure necessary for brood rearing, and serving as a place of storage for nectar, honey, and bee bread, wax comb also aids in bee communication within the hive, and pathogen, toxin, and general waste management. Concerning the former, an increasing body of data support the idea that bees use wax to facilitate communication between members within the nest. They do this principally through vibrations they send through the comb while dancing and by adding pheromones topically to the wax for slow release into the nest.

Wax combs aid in waste management because many of the environmental toxins to which bees get exposed are lipophilic, meaning that they can absorb into the wax and become inaccessible to bees. Furthermore, wax can become a repository for bee pathogens. This highlights the usefulness of wax moths in the natural cycle of a wild hive. The consumption/devastation of old wax by wax moths ensures that the old combs that contain high levels of environmental toxins and/or pathogens are removed from the hive and made unavailable to the bees.

Propolis (Figure 10) is another component of honey bee nests. It is a very interesting material. A small cohort of worker bees in the nest will forage among plants to collect plant resins or other sticky plant exudates. The worker bees bring the sticky resins to the hive where they place it in cracks and crevices around the nest. Beekeepers call the sticky substances that bees collect propolis. Bees will deposit propolis in many areas inside the nest. In the managed colony, propolis usually is deposited around the end of frame top bars, at joints between the supers, and between the supers and the lids or bottom boards. Propolis use in the nest varies by honey bee subspecies. For example, some African subspecies of honey bees will reduce the size of their nest entrance considerably by blocking much of the entrance with propolis. Some bees build propolis bridges between the bottom of frames and the bottom board of the hive. I have seen bees nesting in cliffs close off the exposed side of the nest by building a wall composed of a single sheet of propolis a foot wide and over 1.5 feet tall.

Many interesting discussions have centered on bee use of propolis. For the longest time, bee scientists said that they believed bees use propolis to seal cracks/crevices in the nest in an effort to waterproof the hive. However, scientists are suggesting increasingly that propolis may function as a natural nest antimicrobial agent. Compelling data exist that suggest propolis use in colonies reduces the amount of pathogens in the honey bee nest. I find this topic fascinating and look forward to the generation of new data on bee use of propolis.

The final nest component I will discuss is **burr comb** (Figure 11). Burr comb, in the simplest sense, is wax that bees deposit in gaps located throughout the nest, but that is not otherwise built on foundation. In reality, burr comb simply refers to any comb that beekeepers do not want in the nest and it may be an artifact of managed beekeeping (i.e. it may not exist in wild colonies). Bees build burr comb when **bee space** is violated. Bee space is the space that bees "prefer" that all internal dimensions of the nest be. The actual gap works out to be about 3/8 of an inch (an inch designated by the **"** symbol). When the gap is larger than 3/8", bees fill the gap with burr comb. When the gap is smaller than 3/8", bees fill the gap with propolis. Notably, bees add neither burr comb nor propolis to gaps that are about 3/8". The entire modern hive is built following the principle of bee space; and this, ultimately, made the movable frame hive possible (see my monthly article in the March 2014 issue of the *American Bee Journal* for more information on bee space).

The actual function of burr comb is not really known, though it often forms a bridge between two items that bees otherwise could not traverse. If the gap where the burr comb is built is wide enough, and enough comb is constructed, bees can store honey and/or rear brood in burr comb. Most beekeepers scrape or remove burr comb from the nest when it is encountered.

The honey bee nest is a fascinating place. It becomes as much a part of the honey bee colony as the bees themselves do. Please consider reading the following two reference sources for more information on ideal nest sites and the components of the nest if anything I have said has peaked your interest on this topic.

1) **Hepburn, H.R., Pirk, C.W.W., Duangphakdee, O. 2014.** *Honeybee Nests: Composition, Structure, Function*. Springer, Heidelberg/New York/Dordrecht/London.

2) **Seeley, T.** *Honey Bee Democracy*. Princeton University Press, Princeton, NJ, USA.