Beekeeping Basics

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Part 5:
Honey Bee Communication

Communication is important for a social species like the honey bees. And these creatures have developed some very sophisticated forms of communication that are also elegant in their simplicity. We have already briefly discussed a few the numerous **pheromones** that bees use to communicate. These pheromones are chemical signals that convey specific messages. They may be broadcast into the air as odors, or they may be passed between individuals through food-sharing or the touch of an antenna. Some of these chemical messages also serve as **biological feedback mechanisms** that help to initiate, inhibit or regulate complex behaviors in individual bees or in the colony as a whole.

Alarm pheromone is released when a bee feels threatened. One of its main chemical components, *isopentyl acetate*, give this pheromone the familiar and distinct smell of bananas. Beekeepers routinely use smoke to temporarily cover up this odor, and keep more bees from recognizing that others have become upset or alarmed. Detecting this pheromone quickly alerts other bees that danger has been reported, and can quickly make an entire colony highly defensive. This is especially true of the Africanized honey bees, which respond to perceived threats very quickly, and in greater numbers than the more docile European honey bees we prefer to keep. Bees release alarm pheromone when they bite or sting an intruder, effectively tagging the unwelcome stranger as trouble. This helps other hive members recognize and fend off a foreign bee that may be hoping to rob a hive of its honey.

You may notice **guard bees** standing at the entrance of a hive, looking outward, who appear to be touching incoming bees with their antennae. Their job is to ensure that these bees trying to enter the hive belong there – that they smell like this queen bee, and not like the queen from another hive. If a strange bee is persistent, they will be physically repelled by the guards. More bees, alerted by alarm pheromone, will join the altercation if necessary. The intruder may even be killed if she doesn't take the hint that she is unwelcome. Scouts from strong colonies will sometimes seek out weak colonies, with poorly defended entrances, and return with a large number of her nest mates to steal all the honey from the weak hive. Beekeepers call this robbing behavior, and it is most often observed in the summer, when there are few flowers in bloom. The guard bees must not allow a robber bee to enter unchallenged and then return home to report that their hive is poorly guarded.

Honey bee **queen pheromone** is referred to by many names and it is very important to the stability of the colony. It may be called **queen substance** or **queen scent** or sometimes called **QMP** for "queen mandibular pheromone" – although not all her pheromones are produced in the mandibular glands. This pheromone is actually a complex mixture of numerous compounds, and the precise ratio of each is slightly different in each queen bee. This substance gives each queen a unique identifying scent, which she imparts to every member of her colony.

Each queen has a **retinue**, also called the queen's **court**. This is a group of young bees that surround her whenever she pauses in her egg laying. They feed her royal jelly and can be seen licking her abdomen and tapping her body with their antennae. They are attracted to her by the strong pheromones she produces, and they pick up these same chemical compounds from the surface of her body, and from her mouth as she is being fed. The social honey bees share food with each other constantly within the hive, a behavior known as **trophallaxis**. This activity helps to pass nutritious food, and also important information. The queen's retinue takes up the pheromones, and in turn passes them on to other colony members. These bees will pass them on further and further with each interaction with other bees. In this way, the queen's pheromones are distributed throughout the hive on a continuous basis. And through this process, every bee in the hive remains aware that the queen is present and in good health.

If the queen is removed from a colony, or she suddenly dies (perhaps due to beekeeper clumsiness), then the level of queen pheromone in the colony will begin to drop off immediately because there is no other source to produce it. Within a matter of hours, the worker bees will recognize this decrease, which causes a physiological change in them. They quickly become motivated to rear new queens – called **emergency queens**. They will select a number of young larvae that have only been fed on royal jelly – no bee bread. They will begin provisioning these cells with extra royal jelly, and extend the cells outward from the surface of the comb and down, turning them into recognizable queen cells. If the bees don't quickly respond to their queenless situation, all the brood in the hive will become too old to successfully rear a new queen. The colony then becomes **hopelessly queenless**. The colony will continue to function normally for a while, but a generation of workers will begin to develop in an environment that has never been exposed to a queen pheromones. Another function of the queen's pheromones is to inhibit the development of a worker bee's ovaries. Without this inhibition, a number of workers will begin to lay eggs. Because worker bees cannot mate, they can lay only unfertilized eggs, which always develop into drones – the male bees. Within a few weeks, the foraging workers will be dying off from old age as the hive begins to fill up with more and more drones – the offspring of the laying workers. And because drones don't forage, all surplus food is consumed without being replenished, and the colony population begins to collapse. This final production of numerous drones could be seen as the colony's last desperate tactic to continue their family genetic line by hopefully having one or more of these drones mate with another colony's queen. The most obvious symptom of laying workers is the presence of multiple eggs in a single cell. A newly mated queen is inexperienced in egg-laying, and may also place more than one egg in a cell, but she will quickly learn proper technique. So if a beekeeper observes multiple eggs, the problem may disappear in a week or so and then they will begin seeing plenty of capped worker brood. But if the brood all develops into drones, the colony is probably queenless.

Once a colony becomes queenless, and laying workers develop, it can be difficult to re-queen. The laying workers sometimes will not accept a new queen that is introduced because she smells foreign. If a beekeeper suspect a hive is queenless, because there is no evidence of egg laying or young brood, a frame of eggs and young brood can be introduced from another hive. If the colony has no queen, the workers should respond by starting to raise one or more from the available brood. If they do in fact have a queen, they will simply rear the brood as their own workers. A hopelessly queenless hive probably has a small or dwindling population of bees. It can be combined with a stronger, queenright hive. The workers in the queenright hive will protect their queen, and may kill the laying workers, which they may perceive as a threat to their own queen's sovereignty.

A sufficient level of queen pheromone also lowers the likelihood of swarming. When a queen is given royal jelly by her workers, she actually receives some of her own pheromones, fed back to her in the diet. If the level of pheromones she receives falls below a certain threshold, she will initiate swarming behavior by placing eggs into queen cups, which will be reared as new queens by the workers. A young, healthy, vigorous well-mated queen tends to produce the most queen pheromones. The workers continually evaluate their queen by the level of pheromones she produces. As she ages, or perhaps if she is injured, she will tend to produce less and less pheromone, until she finally is superseded and replaced by a daughter queen. A poorly performing queen in a small colony may produce sufficient pheromones for each bee to receive enough. But in the spring, as a colony's population grows exponentially, each bee begins to receive a smaller share of the pheromones being spread throughout the colony, and back to the queen herself. The result of each bee receiving a progressively smaller share of queen pheromones may trigger swarming. A young queen, however, who produces more pheromones, can sustain a larger population before the swarming instinct takes over.

Each bee larva produces its own **brood pheromone** odor, which will change gradually as the larva develops. This scent attracts nurse bees to the cell, and indicates to them what kind of food they need, and how much to provide, depending on the age of the larva and whether it is to become a drone, a worker or a new queen. Brood pheromones also prompt the nurse bees to cap a larva's cell prior to pupation. The same useful pheromone, however, can elicit a response in the honey bees' number one enemy: the parasite **varroa mite**, which can only reproduce on live honey bee brood. While blind, this mite has a well-developed sense of smell. It can determine the age of a honey bee by her odor, and clings to younger nurse bees, who care for and tend to the oldest larvae. This ensures that the varroa mites remain in close proximity to the oldest brood, about to pupate. When a mite detects the pheromone from a larval cell that indicates it should be capped, she will hide in the cell and wait for workers to cap the cell over. Then the mite is free to reproduce in relative safety, without being disturbed. The mites is also able to distinguish worker brood from drone brood, and seem to prefer drone cells if they can find them, because they can reproduce more successfully on drones which remain in the capped phase about 3 days longer than workers. These are tiny mites, but very crafty, and can be devastating to a honey bee colony.

Honey bees have a special gland near the end of their abdomen, called a **Nasanov gland**, which releases a very useful substance called **Nasanov pheromone**. We often see bees standing at the entrance of a hive, assuming a posture with their heads down, facing the hive, and their abdomens extended into the air. They flex the last segment of their abdomen, revealing a light colored band near the tip. Their feet are all on the ground, but they will also be vigorously fanning their wings, creating an air current that carries this Nasanov scent away from them. The main function of this signal is to attract other bees.

When we open or disturb a hive, we may shake out a lot of young bees which may become disoriented, such as nurse bee who have not yet been outside the hive much, if at all. When they detect this pheromone they can instinctively follow the plume of odor back to its source, where the scent is strongest: at the entrance to their hive. The same pheromone is used to keep a bee swarm together as they exit their hive and settle nearby. It also keeps the swarm cohesive while it is in this resting state. And once a new home has been selected, a small number of scout bees can successfully lead a swarm of many thousands on a long flight by emitting this potent signal. Individual foragers may also give off this scent when collecting water or food, which helps other bees more easily locate a source that may not have a characteristic scent.

The smell of Nasanov pheromone is very similar to that of **lemongrass oil**. A small amount of this essential oil can be used to make a swarm trap or bait hive more noticeable or attractive to a new swarm of bees. Beekeepers can also purchase commercially produced swarm lures that contain a blend of lemongrass oil and other synthetic compounds that mimic the Nasanov scent.

Honey bees also communicate using what has been described as a **dance language**. While elegant in its simplicity, the dance language of the honey bee is able to convey amazingly precise information from an individual to other members of the colony. The dance actually encodes a miniature reenactment of a bee's foraging flight outside the hive. Foragers can use their dance steps to symbolically relate the relative direction, distance and quality of a recently discovered source of food. They do this by repeatedly moving in a figure-8 pattern across the vertical surface of the honey comb. As a bee moves through the middle of this figure-8 dance step, she vigorously shakes her abdomen and audibly vibrates her wings, in what is termed the **waggle run** of the dance. She will then turn to one side, circle around, and make another waggle run, then turn in the opposite direction, and repeat the circuit. The duration of this waggle run – the number of times her abdomen shakes – is directly proportional to the distance she has flown to reach her destination. In addition, the precise angle the bee faces during her waggle run, relative to the top of the honey comb, indicates the direction from the hive to the food source, relative to the position of the sun in the sky at the moment.

For example, if a bee is dancing at an angle of 30 degrees to the right of the vertical, she is directing her nest-mates to exit the hive, face the direction of the sun, then turn 30 degrees to the right, and fly in a straight line. Each second of vibration during the waggle run of her dance indicates approximately 1000 yards of flight. Incredibly, when other bees observe this dance, they are able to decode the information and follow these instructions very precisely to the destination indicated. Bees that have found a particularly attractive source of food – such as a large patch of flowers with a high sugar content in the nectar – will repeat their dance enthusiastically, hoping to catch the attention of many other bees, and recruit them to visit the this valuable resource. Bees will dance less vigorously for less desirable food sources, which may not recruit as many new foragers. In this way a colony is able to fan out across thousands of acres to search for food, and then concentrate their efforts on specific locations that offer the greatest reward at that particular time. Floral resources are often very ephemeral, with a succession of different plant species continuously blooming for only a short period each year. And so the bees must constantly locate newly blooming flowers and take advantage of their resources before a competing colony discovers them first. These plants get the benefit of the bees' pollination services, and the visiting bees are rewarded with nectar. Thus the plants that are most successful at attracting bees will be most likely to produce seeds, ensuring more pollinator-friendly flowers next season, while plants that are less able to attract pollinators will produce fewer seeds. In this way, bees and flowering plants have developed a strong cooperative and mutually beneficial relationship over their long ecological history.

Honey bees also use the same type of dance language when a swarm of bees is searching for a new nest site. Once a swarm exits their original hive, they will settle nearby and cluster together in a group to protect their queen and conserve their energy. A relatively small number of scout bees will explore in all directions for a suitable cavity, such as a hollow tree. These bees investigate any openings they encounter, and will survey and evaluate a cavity they discover. When they return to the swarm, they will perform their ritualized dance steps on the surface of the clustered swarm – right on their sisters' heads and backs. In the same way they recruit foragers to visit food sources, these dancing scouts recruit other bees to visit a potential new home site and return. If a site is deemed to be a highly desirable nesting spot, the scouts and new recruits dance vigorously to enlist others to investigate and further recommend it. Suitable but less attractive sites will result in less enthusiastic dancing. Perhaps they are saying, "This might be acceptable, but we can probably do better."

You can watch a honey bee swarm and often observe bees dancing in different orientations. These bees are advertising the merits of potential new homes at different locations, and in different directions. After a short while each individual scout stops her dancing. A nesting location will only be advertised by those bees she has recruited, who have also been there and back, and also agree it could be a good new home. Locations suggested by the most enthusiastic dancers will recruit the most scouts, and thus remain a part of the discussion longest. Remarkably, over time, a majority of these scout bees are able to reach a quorum consensus, and the swarm will prepare to move off to their new home. The swarm will begin to dissolve into a large cloud of flying bees. This event appears quite chaotic, but is actually highly organized – again by pheromone communication. Incredibly, the small minority of scout bees who have already been to the newly chosen site, will be able lead the rest of the swarm – usually many thousands of bees – swiftly and directly to their new home, which could be over a mile away.

These amazing insects are only about ¾" long, but they may fly up to 3 miles or more away from their hive to seek food and other resources. If we do that math (remember: πr^2) we can see that as the distance from the hive increases, the colony's foraging territory grows exponentially. A 1-mile radius around the hive represents over 3 square miles or over 2,000 acres of territory. A 2-mile radius gives the bees more than 12.5 square miles or more than 8,000 acres, and a 3-mile range from the hive gives bees a foraging area around their hive of more than 28 square miles, or over 18,000 acres.

While honey bees can easily cover this range, they are also highly efficient in their activities. They typically stay within a mile or so of home as long as they can find all the food they need, but will fly farther if necessary. Also, the bees will concentrate their efforts on the food sources with the highest nutritional value, or highest sugar content in the nectar, for the effort they must expend. They might fly right over lower quality forage to reach higher quality forage farther away. Bee colonies will also actively seek out multiple plant species for pollen collection, to balance out protein and amino acid deficiencies in individual pollen sources. And when numerous bee colonies are concentrated in an area, increased competition makes them more likely to visit flowers they might consider less desirable.

Because a honey bee colony has such a huge potential foraging range, there is practically no certified organic honey produced in the United States. It is nearly impossible to locate an apiary in the middle of 18,000 acres of land that can be confirmed as having no history of synthetic fertilizers or pesticides of any kind. Placing the term "organic" on any food label is actually restricted by law, and allowed only when produced according to strict standards. Therefore, true organic honey sold in the U.S. probably comes from other countries, in areas with little or no large scale agriculture. As an alternative to the USDA certified organic label, other organizations, such as **Certified Naturally Grown**, have developed similar standards. While they acknowledge that honey bees forage on their own, away from the hive, they can certify that a beekeeper follows natural and organic practices of colony management, and that the honey is produced as naturally as possible.

The honey bee is a truly amazing creature. And working together, a colony of bees can accomplish truly remarkable things. Although a single bee is small, her impact on the ecology of terrestrial ecosystems is immense. Because of their tireless pollination services they have been deemed the most important creatures on earth. Keeping honey bees is a tradition that has been handed down from ancestors for countless generations. It is a craft; a mixture of both art and science. Much of the science of beekeeping can be taught in the classroom or found in books and instructional videos, but much of the art of handling and working with live honey bees can only be learned by experience. Whether you decide to pursue beekeeping as a full time career, a side business, or just a hobby, you are in for an extraordinary treat. Make no mistake that beekeeping also involves work. Don't expect a colony to survive long if you are not willing to provide any effort or care. But for most, beekeeping is a labor of love, just like gardening. It's certainly easier to buy produce than to grow it yourself, but you know can get such better results if you put in some effort. It's the same with honey. It's easier to buy it at the supermarket, but once you have tasted it fresh and warm from your own bee hives, you'll never be satisfied with anything else.

In our next lesson we'll learn how to get started in beekeeping, and discuss several practical methods for setting up your first bee hives.