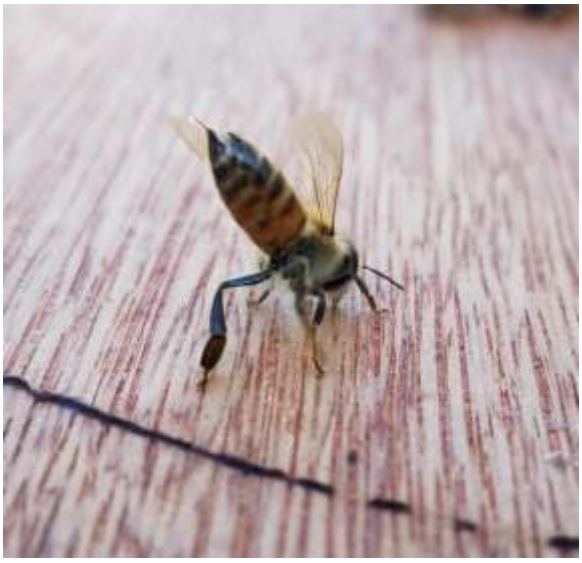
"Smell is a potent wizard that transports you across thousands of miles and all the years you have lived. The odors of fruits waft me to my southern home, to my childhood frolics in the peach orchard. Other odors, instantaneous and fleeting, cause my heart to dilate joyously or contract with remembered grief. Even as I think of smells, my nose is full of scents that start awake sweet memories of summers gone and ripening fields far away."
— Hellen Keller

The notion that smells convey information is not any great secret. When my toddler grandson smells rancid, it is his way of asking for a diaper change. During my years as a student at Jack and Jill Preschool in High Point, fire drills were initiated by the cook coming into each classroom and saying, "I smell smoke!" And does anything express, "Life is good!" better than the smell of bacon in the morning? Yet sophisticated humans typically don't appreciate olfactory signals as an important communication medium and even mask them with perfumes, deodorants, exhaust fans and regular bathing.

Ask any school-age kid how honey bees communicate and they'll enthusiastically say, "by dancing!" The Bee Dance is fascinating, but it represents a small, single-purpose function, not really warranting the attention that it receives. An important element of the Bee Dance is smell, but that is seldom mentioned.[1] Perhaps because humans have largely abandoned olfactory communication (our noses aren't very good at it anyway, compared to other creatures), pheromonal communication in the honey bee world seems to be poorly understood by average beekeepers. But consider: how does one simultaneously send a message to a population with tens of thousands of members? How does one communicate in the pitch blackness of a hive? How does one communicate with teammates who



This bee is communicating loudly and clearly to her hive mates. The message is, "Alarm! Alarm! Come quick and bring your stinger!" Study her posture: her end is elevated with the tip pointed forward, exposing the sting sheath and releasing alarm pheromone.
Photo: Jessica Helgen, UMN Bee Squad

(apparently) only have rudimentary hearing? The answer to these questions of "how does one…" is, "Very well indeed, if one is a honey bee!" Chemical transference, airborne and by touch, is the solution. About fifty pheromonal substances have been identified in the honey bee hive and no doubt there are more to be discovered.

The importance of smell to a honey bee cannot be emphasized enough. It is innate within their very being. Fruit flies have 62 genes for odor reception, mosquitoes have 79 while honey bees have 150. (Conversely, fruit flies have 68 genes for taste compared to 76 for mosquitoes and only 10 for honey bees. Our bees are good at distinguishing "sweet" from "not sweet" but lack much further taste discrimination.)

Structures on the antennae called plate organs act as bees' noses. Queens, who live a pretty simple life, have 3,000 plate organs on each antenna. Workers earn their living by deciphering pheromonal signals within the hive

[1] The dancer's body warms up considerably during her frenetic dancing, causing the odor of the pollen grains captured in her hair to aerosolize. The dance motion communicates what direction and distance to go; the odors communicate what to seek when the foraging bee gets there.

as well as sniffing out food to ensure everyone's survival, so it is no surprise that they have twice that many (6,000 per antenna). But a drone's entire existence is solely devoted to discovering a fast-flying virgin queen. Drones have 30,000 plate organs on each antenna to allow them to detect her unique smell. (See "Drones Don't Get No Respect" for more on their underappreciated story.)

What are pheromones?

Simply put, pheromones are chemicals a body produces that are used to illicit a response from another member of the same species. We are likely more familiar with hormones, which are chemicals a body produces to illicit an internal response (a classic example is adrenaline, which, when humans are threatened, is released to prepare us for "fight or flight"). Other chemicals of a similar type are called allomones: they spark a reaction in a species other than our own. An example is a skunk's spray: its purpose is to strongly suggest that non-skunks mind their own business.

There are two types of pheromones: 1) releasers, which trigger an immediate response (think of adrenaline), and 2) primers, which initiate a long-term response (think of testosterone and estrogen, which cause specific differentiation in the growth of cells). Furthermore, there are two types of pheromonal responses: 1) stimulatory (causes something to happen) and 2) inhibitory (prevents something from happening). These concepts are all extremely important for understanding how our bees communicate, a vital skill when we insert ourselves into their world.

Pheromones have many different sources and many different roles. Not only do queens, workers, drones and brood all have a mix of distinct pheromones, even wax comb emits a pheromone-like chemical signal that influences behavior. Remarkably, while queens and workers share most of the same glands, the substances produced are different between the two. An abbreviated summary of some of the more interesting pheromones follows.

Queen pheromones

1) Queen Mandibular Pheromone (QMP) is produced by the queen's mandibular glands. It is composed of several chemicals, notably 9-oxo-2-decenoic acid (9-ODA). It is volatile (wafts in the air) and works in combination with other pheromones. Its roles include:
   a) Inhibits construction of queen cells
   b) Inhibits the growth of worker ovaries
   c) Attracts drones to the virgin queen on her mating flight
   d) Stimulates normal foraging behavior
   e) A complex blend of 9-ODA and other chemicals triggers the formation of the queen's retinue
   f) Communicates the presence of the queen in swarms as well as in the hive, declaring that "all is well" within the colony.
2) Tergite gland pheromones (produced by glands on the top side of the abdomen) work with the mandibular gland pheromones for the same purposes. They are spread mostly by touch rather than being volatile, so they work well at very short distances.
3) Tarsal (Arnhart) gland pheromone is deposited by foot pads on the comb surface. It works along with QMP to inhibit queen cell construction. Consider: in a crowded colony, the queen cannot easily reach the edges of comb, and that is where swarm cells are created. The amount secreted decreases with the age of the queen.
4) Rectal pheromone is only produced by young queens less than two weeks old. These queens aren't strongly scented with QMP yet so are subject to inspection and rough treatment by workers. Rectal pheromone, which smells like grapes, repels workers and causes non-aggression.
5) Dufour's gland pheromone is produced in the region of the sting apparatus. Its purpose is unclear, but it is speculated that it marks eggs as being queen-laid rather than worker-laid.

This worker bee is exposing her Nasonov gland (the "smiley face" near the tip of her abdomen) and fanning its pheromone, telling her sisters where home is. Note the critical difference between this posture and the alarm posture on page one. The difference in the position of the tip of the abdomen is subtle but critical. Photo: Wikipedia

Worker pheromones

1) Ethyl oleate is the only primer pheromone in worker bees. It inhibits the behavioral maturation of workers. If a colony already has lots of foragers, the ethyl oleate they produce, spread by touch, slows the younger workers' progression into foragers.
2) Nasonov gland pheromone is an attractant. It is the "come hither" signal. Its purposes include:
    a) Works with QMP to regulate the formation and movement of swarms with respect to orientation to the queen
    b) Marking the entrance to the nest
    c) Marking water and food sources

    Nasonov pheromone, among other things, contains geraniol ("geranium alcohol", which has a sweet rose odor and is used in perfumes), and citral (a key component of lemongrass oil). Production is greatest among foragers. When workers smell Nasonov pheromone, they also begin releasing it.
3) The Koschevnikov gland is within the sting apparatus and produces the well-known alarm pheromone. A key component is iso-pentyl acetate (IPA), which has a banana smell and is found in commercial banana oil and pear oil. Alarm pheromone is released when workers evert their stings, exposing the sting chamber. It is most abundant in guards and foragers. Queens do not produce IPA. (Note that it is a persistent myth that if we eat bananas we will be more likely to be stung. IPA is not the only component of alarm pheromone, and it is the precise mix of chemicals, not just one ingredient, that triggers defensiveness. See "Beekeeping Myths" for more on this fact.)
4) Tarsal gland pheromone is produced on the foot pads and is used for trail marking and entrance marking. It has an additive effect. It can work with Nasonov pheromone, in that workers coming across tarsal gland pheromone begin scenting with Nasonov pheromone. It is as if they come across trail scent and call out, "Hey! I think I'm near home! Is anybody out there?"
5) Mandibular gland pheromone contains 2-hepatanone. Once thought to be an alarm pheromone, in recent years it was found instead to be an anesthetic (stunning substance) that immobilizes bees' foes in combat, as in balling events. It smells like bleu cheese. Produced by guards and foragers, high concentrations act as a bee repellant. It may be used to mark unproductive flowers.

Drone pheromones

1) Drones are simple, focused creatures with only one notable pheromone, produced in their mandibular glands. It attracts other drones in order to form Drone Congregation Areas.

Brood pheromones

1) Brood produces an inhibitory pheromone that suppresses ovarian development in workers. It is spread by contact.
2) Brood recognition pheromone differs for queen, worker and drone larvae and pupae, and varies by age of the brood. This is how nurse bees know what the composition of brood food should be and how Varroa mites know that a larva is almost old enough to be capped within its cell.
3) Foraging-stimulating pheromone stimulates the collection of pollen. It is spread by contact.

Beeswax odors

There are a variety of chemical compounds within beeswax that influence workers' behavior, including those from the mandibular glands of workers. They stimulate foraging and perhaps aggression. Consider: these smells are strongest when the comb is empty, signaling that the bees need to get busy filling and defending them.

Practical implications

If we are to interact productively and effectively with our honey bee colonies, what do these facts about honey bee communication imply? One important consideration is our application of smoke. Its purpose is to mask bees' pheromones, but do we always want to do that? When we install a package, don't we want our bees to signal each other with Nasonov pheromone so that they can find their new home?

When we introduce queens using queen cages, there is the potential for the bees outside the cage to chew off the queen's foot pads. What does that do to her ability to spread tarsal footprint pheromone and prevent the construction of queen cells?

Swarms are coordinated by a combination of pheromonal signals, all working toward the same complex purpose. Photo: the author.

As hives are inspected, workers invariably cast some alarm pheromone. If our hives are placed close together, how alert is the next hive in the row even before we remove its lid? Does this have implications for the order that we inspect our hives, e.g. should we inspect the largest, most volatile colonies first to minimize their pre-agitation?

Should beekeepers strive to reduce the use of stinky perfumes, shampoos, deodorants, etc. to avoid bringing trigger-smells into the bee yard?

These are just a few things to ponder. The bees have much to tell us if we only make the effort to listen, even if we must listen with our noses.

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