

The Social Organization of Honey Bees¹

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Insects exhibit several levels of social organization. Many species live in groups for some portion of their lives, but not all of these groups are truly social. For instance, **chimney bees**, *Anthophora abrupta*, do live in groups for periods of time, but they are nevertheless solitary bees. Female chimney bees build nests in large aggregations, giving the impression that they are social, but in fact each female builds and provisions her own nest. In contrast, some insects, **ants**, for instance, live in complex societies called colonies and depend on continual social interactions to survive. Members of these social species cannot survive as individuals; they must live as a part of a colony.

Three characteristics define the levels of sociality observed in insects. These characteristics are: 1) **reproductive division of labor**: most individuals are non-reproductive and specialize in colony growth, maintenance, and defense while only a few reproduce; 2) **cooperative brood care**: individuals within the colony care for offspring that are not their own; and 3) **overlapping generations**: offspring contribute to colony labor while their parent(s) (at least their mothers) are still alive and inside the colony. Species that express all three of the above characteristic are highly social or *eusocial*. The most common eusocial insects are bees, wasps, ants, and termites (Table 1).

Honey bees (Hymenoptera: Apidae: *Apis*) meet all three of the criteria described above and are therefore eusocial:

- **Reproductive division of labor**—Each honey bee colony consists of a queen (reproductive female), workers

(non-reproductive females), and drones (males). Each caste has a clearly defined role that is not performed by any other caste.

- **Cooperative brood care**—Workers care for the queen's offspring. In most cases the queen's offspring are sisters to the workers who are rearing them.
- **Overlapping generations**—Honey bee queens can live several years and coexist in the colony with their offspring (workers and drones).

Social Structure: Honey Bee Castes

There are three castes of honey bees: drones, queens, and workers (Figure 1).

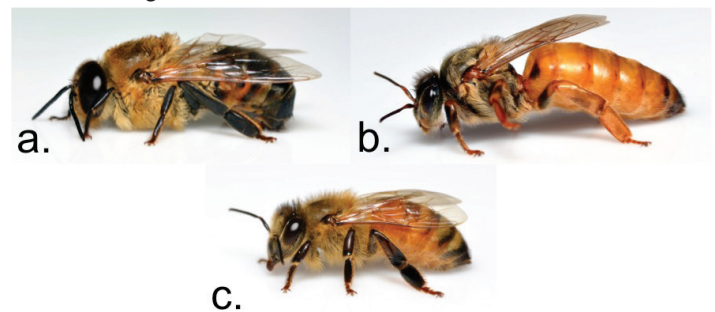


Figure 1. Honey bee castes: a) drone (male), b) queen (reproductive female), and c) worker (non-reproductive female).

Credits: Mike Bentley, UF/IFAS

Drones—Drones are male honey bees. The drone's head and thorax are larger than those of the females. Drones' large eyes touch on the top center of their head, which makes them appear more "fly-like." Their abdomens are thick and blunt at the end rather than pointy like the

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abdomens of the females. Drones are responsible for passing the colony's genes on to the next generation by mating with queens from other colonies.

Queens—Honey bee queens are the reproductive females of the species. The queen's head and thorax are similar in size to those of the worker. However, the queen has a longer and plumper abdomen than does the worker. Throughout most of the colony life cycle, the queen is the only reproductive female in the colony and is responsible for producing all of the offspring within the colony.

Workers—Worker honey bees usually are non-reproductive females. They are the smallest in physical size of the three castes, and their bodies are specialized for pollen and nectar collection. Workers perform all brood care, hive maintenance, and hive defense tasks in their colony. Rather than specializing in one job only, each worker progresses through colony tasks in predictable order based on age. This progression is called temporal (or age) polyethism.

Temporal Polyethism

Temporal polyethism is the age-related division of labor that occurs within honey bee colonies. At different ages, worker bees are better suited to perform different tasks. Each worker performs colony tasks in a somewhat predictable progression throughout her lifetime rather than specializing in a single task.

In general, young workers perform jobs in the central area of the hive where the brood (immature honey bees) is. Young workers' jobs include cleaning brood cells, feeding and tending the brood, and tending to the queen. As they age, the workers take on duties in the outer regions of the hive. These jobs include building comb, receiving nectar and pollen, storing nectar and pollen, processing honey and ventilating the hive. The oldest bees perform tasks outside of the hive, such as guarding the hive, removing dead bees from the hive, and foraging.

This progression of jobs by age is believed to be regulated by juvenile hormone (JH). The levels of JH vary within a worker throughout her life. The changes in JH levels cause glands to activate/deactivate, which in turn changes workers' physiologies to fit their present jobs. For example, young bees tending brood have highly developed hypopharyngeal glands that enable them to produce the larval diet. On the other hand, older bees that are building comb have reduced hypopharyngeal glands, but highly developed wax glands for producing wax.

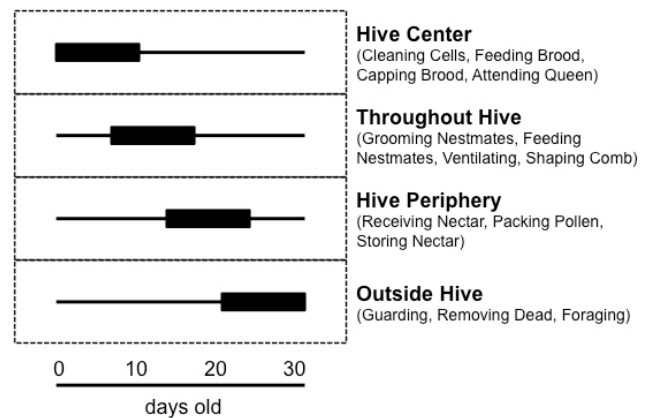


Figure 2. Simplified representation of the order in which honey bee workers perform tasks in a hive. Credits: Ashley Mortensen, University of Florida, data generalized from Seeley (1985)

There is a fair amount of flexibility in the system, and not every bee will progress through the tasks in the most common order. For example, if many foragers are killed by pesticide exposure, younger bees will advance to foraging tasks more quickly than they would ordinarily in order to compensate for the loss. Conversely, if something like a brood disease dramatically reduces the number of young bees emerging, some older bees will revert to the “younger bee tasks” to ensure that all jobs are being completed.

Superorganisms

Eusocial organisms, honey bees included, can be considered *superorganisms* (the colony itself functions like a single organism). When considering a honey bee colony as a superorganism, each bee within the colony can be likened to a cell within an animal. Bees within a colony work together to perform colony level tasks, just as the cells in a human body work together to build and maintain a functional person. A few basic examples of this are thermoregulation (temperature regulation of the hive), respiration (air exchange into and out of the hive), and reproduction (creation of a new honey bee colony).

Thermoregulation—Bees maintain the brood area of the hive at approximately 93°F (34°C). When the ambient temperature rises above 93°F (34°C), worker bees cool the interior of the hive by fanning air over droplets of water. Conversely, when the temperature drops below 93°F (34°C), worker bees cluster around the brood nest and vibrate their wing muscles to generate heat. Individual bees are cold-blooded, but considered as a single organism, they are “warm-blooded.” The colony superorganism behaves like a warm-blooded animal in that it maintains a constant temperature despite fluctuations in the ambient temperature outside the hive.

Respiration—Bees prefer to nest in enclosed cavities (such as those in trees). There is very little passive air exchange in and out of such enclosed cavities. Therefore, workers actively fan air into and out of the colony in distinct inhalations and exhalations through the colony entrance. In fact, the volume of air that a honey bee colony “breathes” in one minute is that same as that of a domestic cat.

Reproduction—Superorganism reproduction is not a single queen laying thousands of eggs. A honey bee *colony* reproduces when it creates a new honey bee colony. This process is called swarming. Swarming is initiated when daughter queens are produced. The resident queen and up to two thirds of the workers leave the hive to find a new nesting cavity. This process produces a daughter colony (the bees that remain at the original nest site) and a parent colony (the bees that left to find a new nest site).

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Table 1. Insect orders that contain eusocial species and the approximate numbers of eusocial species in that order.

Insect Order	Common Name	Number of Eusocial Species
Blattodea	Termites and cockroaches	~2750 species (all termites are eusocial)
Hemiptera	True bugs	~50 eusocial species
Thysanoptera	Thrips	6 known eusocial species
Coleoptera	Beetles	1 eusocial species (ambrosia beetle)
Hymenoptera	Ants	~14000 eusocial species (all ant species are eusocial)
	Wasps	~900 eusocial species
	Bees	300–400 eusocial species (there are ~20,000 species of bees)