MAAREC
Mid-Atlantic Apicultural Research & Extension Consortium

Delaware, Maryland, New Jersey, Pennsylvania, West Virginia and the USDA cooperating

MAAREC Publication 1.4
March 2004

BASIC BEE BIOLOGY FOR BEEKEEPERS

Although humans have had a long association with honey bees, *Apis mellifera*, we have not domesticated the honey bee. A beekeeping "key" is skillful application of knowledge of bee/colony biology. In a phrase — **Beekeeping is Applied Bee Biology.**

Our greatest bee culture success has been with the temperate region European races of honey bee - specifically German, Italian, Caucasian and Carniolan honey bees. Transport of European bees to the Americas, Australia and New Zealand has resulted in highly successful beekeeping in those areas. Some bee races of the Mediterranean and Middle East are less productive but are managed in their native lands by beekeepers with great skill. The bee races below the Sahara Desert of Africa are even more difficult to manage (by European beekeeping standards) and less profitable. Introductions of European *Apis mellifera* to South Africa and Asia (where there are other species of honey bees) have not been successful. Introduction of the major African bee race *scutellata* to South America resulted in the Africanized or "killer" bee, a serious management liability.

Bee Culture is Both an Art and a Science. Better beekeepers understand the natural features of honey bees. Understanding bee/colony biology is the essence of the science of beekeeping; the art of beekeeping is a skillful and timely application of that knowledge.

Some of the major biological features that beekeepers need to understand are: basic bee nest ecology, the bee caste system, bee anatomy, the development of bee brood, worker bee sequence of duties, caste brood rearing/adult population seasonality, communication as a "key" to maintaining the social cohesion of the colony, queen and colony reproduction/replacement, and how to read/understand bee behavior/biology.

The Bee Nest

Apis mellifera is a cavity nester. Understanding the basic nest ecology has led to an effective and efficient, man-made hive – the Langstroth hive. The natural or feral nest (and beekeeper hive) has these five features:

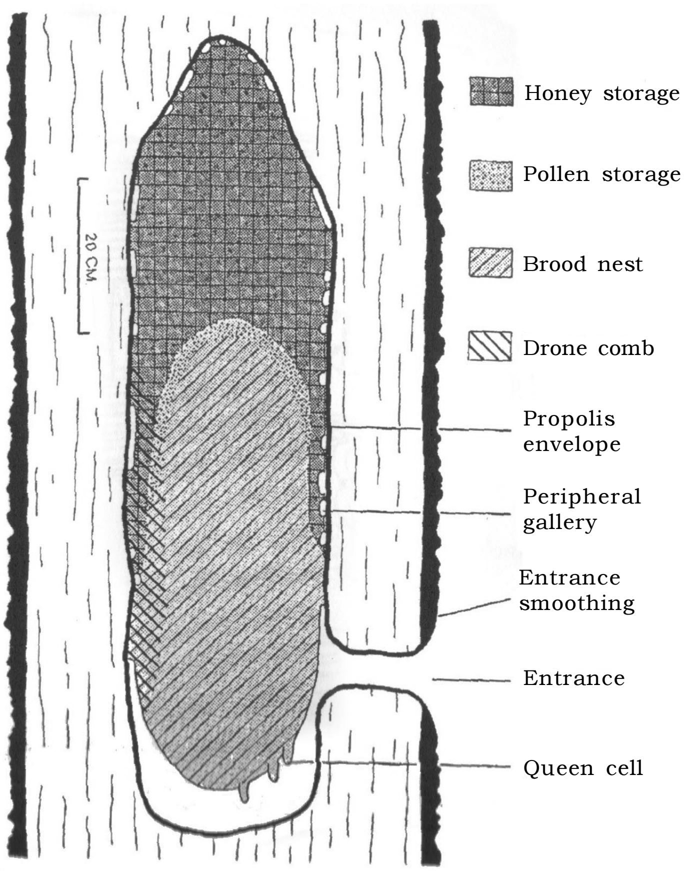
- Sheltered, darkened enclosure
- Small, defensible entrance
- Size of adequate volume
- Hexagonal beeswax cells molded into parallel comb separated by bee space
- Separation of brood (a central sphere) and food (to the top and sides).

A tree cavity is a common nest site in the temperate area. Maple, oak and ash trees are commonly available but bees will select virtually any tree if a suitable cavity is present. Knotholes are the most common types of opening but cracks or other openings can also be used. Bees prefer openings high in a tree, but will nest wherever the cavity is available. Most tree nests are in live trees; the cavities are the result of fungal action on the inner wood.

Since beeswax comb is fragile, shelter is important for successful winter survival of a bee colony. Occasionally a bee colony will build in an exposed location but such colonies seldom survive the winter in temperate climates. Tropical bees survive with such nests more frequently. A darkened enclosure is needed for efficient wax secretion — worker wax glands secrete more wax and bees build more comb in darker sites compared to bees exposed to light.

Honey bees search for suitable cavities for their nest. Usually the searching is done by scout bees from a swarm. The European bees seldom move very far from the original homesite. From numerous studies their nest selection criteria involve:

- Volume – bees prefer 40 liters (range 20 to 100 liters). Tropical bees prefer smaller cavities and will nest in the open more readily.
- Height from ground – bees seem to prefer higher sites than those at ground level or close to the ground. Usually 3 meters (9 feet) is ideal.
- Exposure – sites in the open exposed to wind or full sun are less preferred.
- Entrance size & position – bees definitely prefer smaller entrance holes, openings at the bottom of the cavity and southward facing exposures.
- Cavity quality – bees prefer dry, unoccupied sites. They are attracted to smell of previous bee occupancy.



When scout bees search for a new homesite, they enter potential cavities and walk inside to measure dimensions. Because most cavities are in trees, the usual cavity is a tall cylinder. Once a homesite is selected, the swarm moves in. They may use **propolis** to smooth the entrance and inner wall areas of their nest and may reduce the size of the entry area with propolis. Some bee races such as Caucasians use extensive amounts of propolis, almost sealing the entrance area. Most nests have a single entrance.

Worker bees manufacture the only necessary nest material – **beeswax**. The beeswax is molded into parallel beeswax sheets termed combs. Most of the comb consists of worker cells. The cells are six-sided (hexagonal) and have a three-part bottom pyramid shape. Cells are horizontal facing both directions from a central midrib that provides important comb strength. The cells slope slightly upward and are planed to minimum thickness with a rim of extra wax at the top of the cell walls for ease in walking.

The hexagonal cells are of two sizes — worker cells are used to rear worker bees and for storage of honey and pollen. They average about five cells per linear inch. Bees also construct some drone cells in their comb. Drone cells average about four per linear inch; they are larger than worker cells but are still six-sided and otherwise similar to worker cells. Drone cells are used to raise drones and can be used for honey storage. When in a feral nest, bees build mostly worker cells and only about 15% drone-size cells.

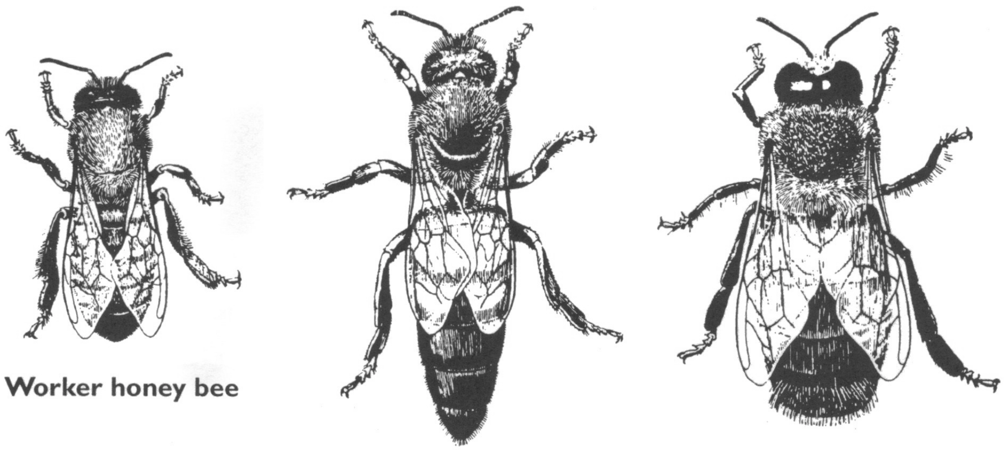
In the natural nest, bees build several parallel combs at one time. As the colony expands, additional combs are added. When building their comb, bees adhere to a basic principle in spacing; they leave approximately 1 cm or 3/8 of an inch (the height of a bee) between combs. We call this space "**bee space**." The comb is suspended from the top of the nesting cavity. Spaces less than 3/8" are filled with propolis. If the space is larger than 3/8", the bees will attempt to fill the space with comb.

In the sheltered, darkened cavity, the bees separate the area where they store their food and the area where they rear their brood (brood = egg, larval and pupal stages of bees). The brood is reared in the lower portion of the beeswax comb in a compact, spherical-shaped section because of the temperature requirements of the growing larvae. (Immature larvae need a temperature of 90-95° F or 32-36°C for optimal development.) Honey (stored as food) is above and to the sides of this central brood-rearing area.

Pollen, needed to feed the larvae, is stored in empty cells in the brood area and immediately to the outside of the active brood-rearing area. This central sphere of brood expands or contracts depending on the time of the season.

Nest Occupants

When one looks into a bee nest, three different and distinct adult bees and three immature stages can be seen. The three adult stages present in a bee colony are the queen, the worker and the drone. Queen and workers are females, the two members of the caste system characteristic of eusocial insects. They have different tasks - termed division of labor. The male bee adult is called a drone.



Worker honey bee

Queen honey bee

Drone honey bee

(USDA)

The **queen** is a fully-developed female whose two functions are to lay eggs and to produce chemicals that help maintain colony cohesion and regulate colony reproduction. The queen is very specialized for these duties and cannot survive alone or perform the usual basic necessities such as feed herself, groom her own body hairs or leave the hive to excrete waste. A colony has a single queen, although for short periods there may be a mother-daughter queen situation in a colony or multiple, newly emerged (virgin) queens present. Queens usually live two or more years.

The male bee or **drone** is bigger than the queen and roughly barrel-shaped. He has very large eyes that meet at the top of the head. The drone is a haploid adult, developing from an unfertilized egg (termed parthenogenesis or haplodiploidy) a situation often found in the insect order Hymenoptera. Drones mate with virgin queens. They do not lay eggs, do not work or otherwise assist in hive activities. Drones gather on comb just outside the brood area and are not very active inside the hive. They move about only for 2-4 hours in the afternoon when they leave the hive to mate. Few drones actually mate and those that are successful die in the process. A drone usually lives about one month.

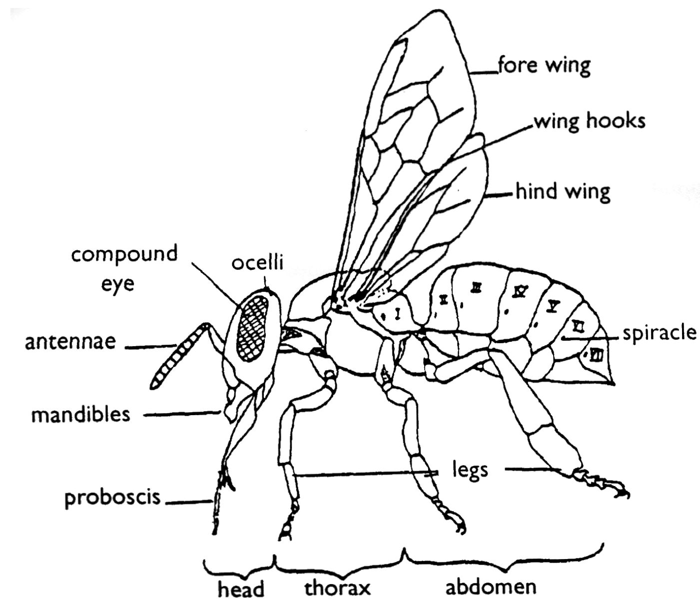
The vast majority of the adult population in the bee hive are **workers.** Like the queen, they are females but they lack full development of their reproductive organs. Worker bees differ in several anatomical aspects from queens including smaller size, possession of pollen baskets on hind legs, wax glands on the abdomen and mandibular glands that are unable to produce the queen pheromones.

Adult Bee Anatomy

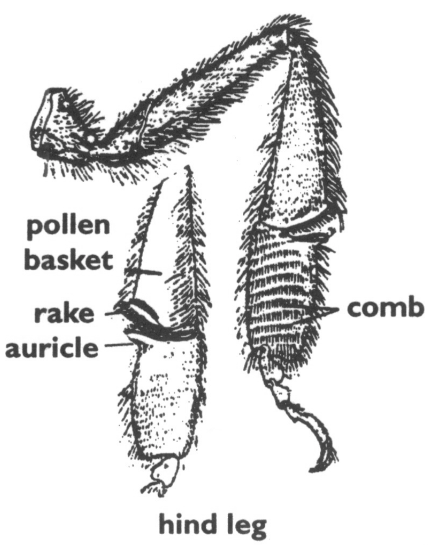
Understanding worker bee anatomy can help beekeepers understand bee biology. They are well equipped for life as social animals and to be successful in the environment.

Bees are well covered by branched (plumose) body hairs. They also have thousands of unbranched hairs covering their body which are for sensory purposes. The hairs extend from the body **exoskeleton** that gives shape and form to a bee. There are no internal bones - bees like all insects have an external skeleton rather than an internal one. The exoskeleton helps protect the delicate internal structures, conserves internal body fluids so the body does not desiccate, and also serves as a protective barrier to the entry of pathogens.

Bees are typical insects in that they have three body regions -- **head, thorax** and **abdomen**. A pair of antennae extend forward from the head - in bees they have a unique shape with an elbow-like angle so terminal segments bend at a right angle. The head also has conspicuous compound eyes which have a fair degree of visual ability including the detection of colors, movement and distance.



The lower portion of the honey bee head has several structures that combine to make up the **mouthparts.** Bees have spatula-shaped mandibles to manipulate beeswax and a proboscis, of several parts folded together, to form a straw-like tube to suck up liquids. Tiny antenna-like palpi are loaded with sensory hairs to enable bees to detect numerous sugars, salt, sour and bitter foods.



The middle body portion, the thorax, is made up of three box-like segments with a pair of **legs** extending from the lower portion of each segment and a pair of **wings** from the top corner of the second and third segments. Both are features unique to insects. The first pair of legs have antennal cleaning hairs, and the third pair have stiff hairs arranged in rows on the inner portion to comb pollen from body hairs and a special arrangement of long, curved hairs to form a **pollen basket** on the outer surface. Wings are unequal with larger front wings coupling to smaller hind wings via tiny hooks to give bees exceptional flying ability and agility.

The abdomen appears as a series of similar rings or segments from the outside. Each segment has a pair of openings, spiracles, which are openings into the internal respiratory system. The segments of the abdomen taper to the back where a sting is concealed until used for defense.

Internally the head includes a several part brain and muscles to move mouthpart segments and the antennae. The thorax includes a tube-like esophagus to take food from (and back to) mouthparts, honey stomach and the powerful flight muscles. Most of the digestive tract and the rest of the internal organs are located in the abdomen.

Honey bees have reversible movement of foods from mouthparts to a **honey stomach**. The honey stomach is a crop or storage area to hold freshly collected nectar (or water) for transport and then deposit inside the nest following regurgitation. Digestion of foods occurs in a mid-gut or ventriculus. The hind-gut reclaims water and vital minerals and salts before excretion of only small amounts of undigestible wastes through the anus.

Insects lack arteries and veins and their liquid plasm and blood cells circulate openly within the body cavity (**open circulatory system**). A tube with muscles (heart) in the abdomen extends forward to the head as the only circulatory structure in an insect. Blood carries food, hormones and cells to fight diseases but does not contain red blood cells holding oxygen. A separate transport system, the **tracheal system**, carries oxygen-rich air from the exterior to the body cells and gaseous carbon dioxide waste back outside. **Spiracles** are the openings on the exoskeleton. The body cavity tubes (the **trachea**) branch repeatedly to smaller tubes (**tracheoles**) throughout the interior.

Insects also lack kidneys and a liver; thin filamentous projects from the junction of mid and hind gut, termed **malpighian tubules,** cleanse the blood of nitrogenous cell wastes and deposit them as non-toxic uric acid crystals into the undigestible food wastes for elimination from the anus. There is no liquid waste in bees as their small body size makes water conservation a necessity.

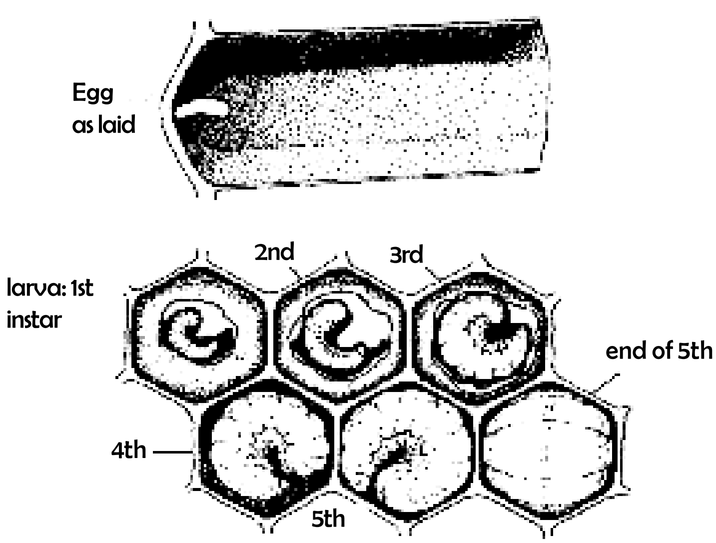
Also, internally a series of nerve cells extend from the brain to concentrations of nerve tissue in each body segment (**ganglia**) constituting a central nervous system. Bee nerve tissue is not protected within a spinal column -- they are in the group of animals termed invertebrate which lack a backbone (vertebrae). Nerves extend from brain and ganglia to send signals to body parts and structures to coordinate behaviors.

Finally, among the muscles and connective tissue inside the body are numerous internal glands. Some deliver their chemicals via the blood inside the body (**hormones**), other glands produce chemical **pheromones** and have exterior openings or open into the digestive tract tube. Pheromones and hormones are critical communication chemicals that insure normal body functioning and coordinate individual and social behaviors.

Bee Brood

There are three development stages in bees which collectively are known as **brood**. Bees begin their life in the tiny white **egg stage**. A queen will deposit one egg in each worker or drone cell. The eggs are about the diameter of a pin and stand on end in their cells. They are very difficult to see. The eggs that will develop into workers are fertilized, while the eggs that will yield drones are not. We cannot tell the difference between fertilized and unfertilized eggs but the bees can. If the queen makes a mistake, the egg is removed and destroyed by worker bees. The egg stage lasts three days.

When an egg hatches it becomes a **larva**. The bee larva (plural: larvae) is a legless and featureless white grub. It is specialized to eat and never leaves the individual wax cell. Larvae grow at a rapid rate in a five-step development called metamorphosis, increasing 1500 times the original size. The larvae are visited 10,000 or so times during their development by adult nurse bees for inspection, feeding and eventually capping of the cells. Worker bees bring food place it in the cell. They do not directly feed the larva.



The last stage, sometimes termed the prepupa, engorges on extra food before the cell is sealed with a wax capping. The pupal development stage for drones is 6.5 days, workers 6 days, and queens 5.5 days. If brood nest temperature drops, development takes longer. When fully grown and filling the cell the larva changes to a **pupa** (plural: pupae). The pupal stage, frequently termed **capped stage**, is one of change – the grub-like larva rapidly takes on the features of the adult. It does so still in the same cell that has now been capped with wax by the workers. In addition to containment in a capped cell, the last larval stage also spins a thin silk cocoon within each cell to enclose the pupa. The pupa does not eat or move.

All bee larvae (female and male) receive royal jelly after the egg hatches. **Royal jelly** is a protein-rich food made in the glands of worker bees and placed in cells just before the egg hatches. Initially the cell with a young larva is **mass provisioned**. A pool of royal jelly is kept replenished in the bottom of the cell and the C-shaped larvae simply lie in a pool of its food. After 2.5 to 3 days, however, the diet of the worker and drone larva changes to a mixture of pollen and nectar and food is not so generously supplied. This is called **progressive-provisioning**. The queen larva remains on a diet of royal jelly, continued in generous supply, her entire larval life.

Worker-Queen Differentiation

An important difference leading to worker-queen differentiation for the bees is the size and orientation of the cell of developing larva (see figure to left from Sammataro and Avitabile). Worker bees develop horizontally in hexagonal cells of approximately 0.2 inch (5 mm) diameter (5 cells/inch). The queen measures the cell opening with her front legs as she inspects each cell prior to laying her egg. Drones develop in slightly larger horizontal cells.

The female queen however develops in a vertically-oriented cell (appropriately called a **queen cell**). The existing queen herself lays fertilized eggs in special cup-like structures, called **queen cups**, oriented vertically on the face of the horizontal worker and drone comb or, more usually, at the bottom margin of the comb. Upon hatching, the queen larva is vertically positioned. Surface tension and a narrowing of the developing queen cell help it stay in place and keep it from falling out.

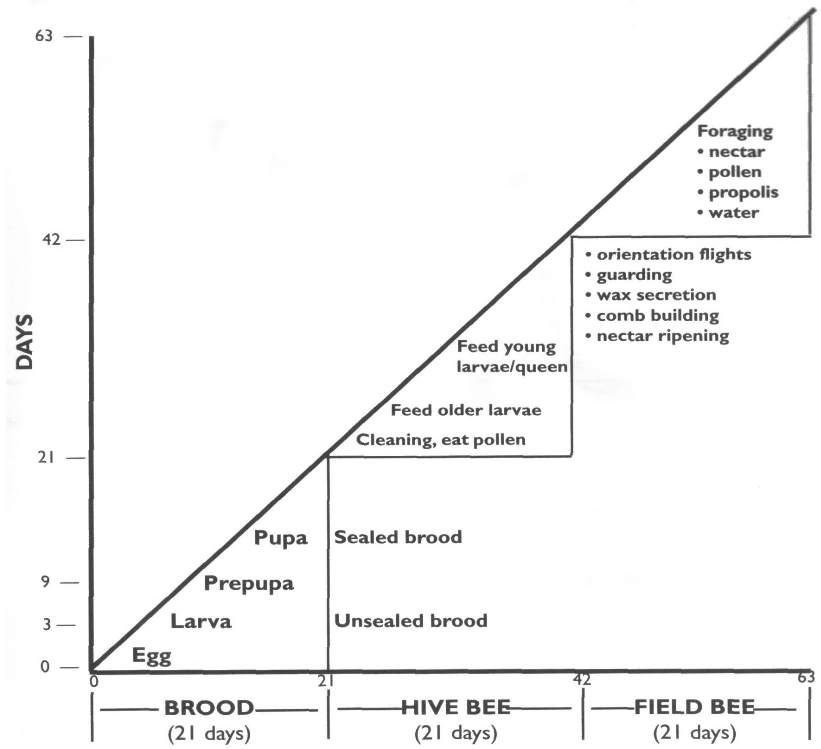
The developing queen cell is enlarged vertically as the larva grows and it eventually becomes peanut-shaped as a capped cell with the pupa inside. As in worker and drone brood, the developing pupa does not eat although abundant food is left within the queen cell (it might assist in keeping the cell interior humid). The queen has to chew her way out of the capped cell (as do worker and drone adults) after the shortest pupal stage (seven days) of the three adult hive members.

Summary of bee development

Brood stage	Queen	Worker	Drone
Egg	3 (fertilized)	3	3 (unfertilized)
Larva	5½ (royal jelly)	6 (rj + nectar/pollen)	6½
Pupa (capped)	7	12	14½
TOTAL	**16**	**21**	**24**

Sequence of Duties of Worker

Workers do the work in the bee society. The figure below summarizes the phases of life of a worker bee. It is possible to identify a "rule of three," such as three brood stages, three days as an egg, 2 X 3 days as larva, 3 X 4 days as pupa, three weeks as hive bees, three weeks as a field bee before death, etc. Workers generally start with hive duties like cleaning, feeding developing larva once hypopharyngeal glands develop, ripening of honey, secreting/molding of wax into combs (once wax glands are functional), followed by guarding and orientation flights. They become field bees after about three weeks and then literally work until their body wears out. Field foragers collect the necessary food (nectar/pollen) plus water to cool the hive and dilute honey and propolis to fight disease pathogens/improve the natural cavity.



(USDA figure)

Seasonality of Brood and Adult Populations

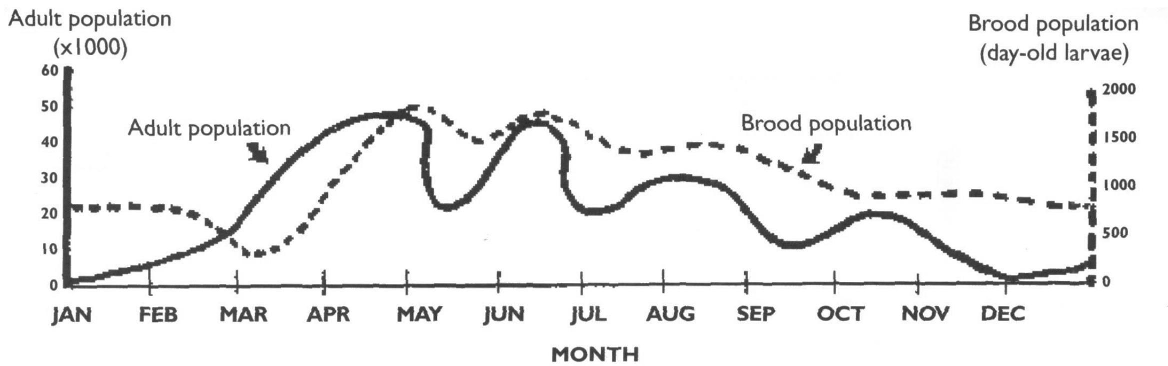
The population of a bee hive fluctuates during the year according to the seasons and food resources. The queen usually lives for a couple of years (in temperate areas at least) and is replaced only during favorable resource [forage] conditions. The numbers of workers fluctuate considerably during the season. Drones are produced when resources improve in the spring and then eliminated in the fall -- a seasonal pattern determined by resource availability.

In January and February, the worker adult population decreases, reaching a seasonal low sometime in February/March when a colony may have less than 20,000 bees. Increasing day length and pollen availability soon insures that birth rate exceeds death rate and the colony population grows rapidly in April, May and June. An average peak population of 60,000 bees is achieved sometime in June. Weaker colonies either have a lower peak population or reach their largest size later in the season.

The adult population remains high but drops during July and August. However, variation exists among bee races; for instance, Italian bee colonies grow slower and stay larger longer into the season than some of the other races. The time of the nectar flow has a great influence on populations during the summer. Some colonies show an increase in adult bees in the early fall before the numbers begin to decline with the fall season. The blooming periods of major nectar and pollen sources greatly influence this cycle.

The brood cycle is also seasonal. In January, many colonies rear little worker brood, and no drones or queens are raised at this time. With increasing day length and especially with the availability of early pollen, the rearing of brood increases rapidly. A queen may produce 1500 eggs daily (nearly her own body weight).

Depending upon the race, brood production continues at a high level during the summer months, although at a rate below spring levels. The number of brood cells in use can peak at 40,000. There may be a second peak in brood rearing in early fall when new pollen sources are available but then rearing of brood falls rapidly with fewer food resources, to reach zero or nearly so by December.



Drones and queens are only reared seasonally. Drone production begins in the spring as food resources become reliable and continues through the summer but not into the fall. The size of the drone adult population varies with the amount of drone brood reared. Most colonies eliminate all their drones each fall as food resources dwindle so adult drones may decrease in numbers very rapidly in September/ October. Adults do not reappear until next spring. Colonies that are without a queen tend to retain drones for a longer period in the fall.

Rearing of queens to replace existing queens is also seasonal. During favorable weather, with sufficient food resources available, a colony may attempt to divide the nest population by **swarming** or replace a queen by **supersedure**. Generally, swarming is more common during population build-up in the spring from mid-April to mid-June and occurs more frequently in temperate areas than tropical areas (except in the case of Africanized bees). During the summer, supersedure is more common than swarming. Except under very unusual circumstances, a bee colony does not rear queens during the fall, winter or early spring months.

Communication

The honey bee society cannot function without effective communication. Most honey bee communication occurs by smell and taste. The intricate system of chemical messengers are termed **hormones** and **pheromones**. A pheromone is a chemical secreted outside by an individual that when received by another individual of the same species results in a specific response such as a behavior. A pheromone differs from a hormone in that it passes from one individual to another.

Queen Pheromones

One of the most active and vital chemical communication pheromones in the bee society is the mandibular gland secretion of the queen. The term "**queen substance**," has persisted as the name of this mandibular gland secretion. Chemically it is very diverse with at least 17 major components; 5 of these compounds are: 9-oxo-2- decenoic acid (9ODA) + *cis* & *trans* 9 hydroxydec-2-enoic acid (9HDA) + methyl-p-hydroxybenzoate (HOB) and 4-hydroxy-3-methoxyphenylethanol (HVA). Newly emerged queens have little of the pheromone but by the sixth day the mandibular glands can produce enough chemical to enable the queen to attract drones for mating. Mature queens secrete double the amount and do so daily.

The chemicals are dispersed over the body of the queen as she is groomed by workers. Workers pick up the pheromone by antennal contact with the queen and share it with each other in the behavior of **food transmission**. When the queen is removed from her hive, worker bees become agitated within one hour and begin behaviors of queen replacement within four hours of her absence.

Queen substance is the pheromone responsible for the following behaviors:

- Inhibition in rearing of replacement queens
- Sex attraction
- Swarm stabilization
- Queen retinue behavior
- Stimulation of foraging and brood rearing.

Alarm Communication

Alarm pheromones are widely distributed in social insects. Honey bees have two different alarm pheromones, one from each end of the body. The mandibular glands of workers produce **2-heptanone** and one of the glands of the sting produces **isopentyl acetate**. The **sting pheromone** is better known and is the major alarm chemical.

The chemical released when a bee stings, isopentyl acetate, is absent in newly emerged workers whereas bees 15+ days of age have one to five mg. There are several other components of the gland such as acetates and alcohols and they may work in conjunction with isopentyl acetate. Actual stinging or defensive behavior is correlated with isopentyl acetate. Defensive behaviors range from alerting to flying (buzzing); if disturbance persists stinging is the last response. Bees display a faster reaction time and more concentrated defensiveness upon perception of the alarm pheromone. Generally, bees will respond to alarm pheromone only at or near the colony, not in the field. Smoke in some way masks the pheromone.

The second alarm pheromone, 2-heptanone, is produced in worker mandibular glands. It, like isopentyl acetate, is absent in newly emerged workers but is present by foraging age. Bees respond to 2-heptanone at the nest entrance similarly as they do to isopentyl acetate, but it is not nearly as effective in producing a response, requiring 20 to 70 times as much compound before bees respond. Queen and drones lack 2-heptanone.

Scent or Nasonov Gland

Workers have a **scent (Nasonov) gland** at the tip of the abdomen. The gland emits a mixture of seven terpenoids which serve primarily in orientation. To release the chemical mixture the workers stand high on the hind legs with the abdomen elevated and tilt the last abdominal segment downward while fanning the wings. Bees use the scent to help sisters locate home, food, and water sources. It acts with queen substance in a pheromone concert to keep the bees of the swarm together.

Other Pheromones

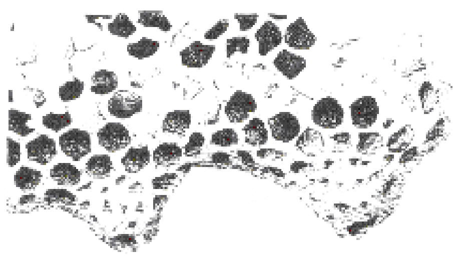
Honey bees have a **trail pheromone** that includes chemicals released from their lowest leg segment, which serve as orientation pheromones. **Brood, drones, and beeswax comb** emit **pheromones** – the former helps to maintain queen dominance as it is responsible for retarding worker reproductive organ development. The mixture of pheromones plus the distinctive queen signature pheromone, mix with food odors to give each bee colony a distinctive **hive odor**. Hive odor is not a specific pheromone but does impart a chemical identity to each social unit.

Queen Replacement

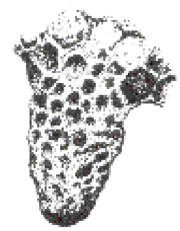
Since there is only a single female reproductive in a bee colony, there is a special procedure to replace her when it becomes necessary to do so. Replacement of a queen by another queen is a process termed **supersedure**. Replacement of the queen and production of another colony is another behavior which is called **swarming**. A third means of replacing a queen, **emergency queen rearing**, is necessary if the queen dies suddenly, is removed by a beekeeper, or is somehow injured or lost from her colony.

Queen failure may lead to reduced egg laying but workers more readily respond to reduced pheromone production. Each worker bee needs to receive a certain level of queen substance daily. This pheromone is distributed through food transmission among workers. If a queen is taken away, the level of this pheromone drops rapidly, though it is persistent. In the case of a failing queen, the queen produces insufficient amounts of queen substance, and therefore is fed back less of the pheromone by the bees of her retinue. This feedback system of queen pheromone distribution is vital for communication.

The first behavior change observable in queen replacement is the laying of a fertilized egg in a queen cup. **Queen cups** are special cup-like precursors of queen cells. They are always present in a bee colony, though their numbers are greatest in the spring months. They are built at the lower margin of beeswax comb (lower margins of frames in a beekeeper's hive) and in spaces where the comb is damaged or left open as a walkway to the opposite side of the comb.



Queen cups at the bottom of the frame. D. Heskes drawing.



Capped queen cell. L. Waters from Demier 1988.

Queen cell emerged. L. Waters from Demier 1988.

The queen herself places the fertilized egg in a queen cup. Worker bees can remove eggs (from queen cups or regular cells) but they are not known to transfer them. The same queen may return to the developing **queen cell**. (Arbitrarily, a cell occupied by an egg or developing queen is called a queen cell — it is a queen cup when empty.) By chewing on the side of the cell, the queen causes the workers to remove and kill the occupant (egg, larva or pupa) inside. It is possible to observe queen rearing repeatedly aborted in a bee colony. The original mated queen (who started the process of queen replacement by laying eggs in queen cups) may be killed before or after emergence of a virgin queen in supersedure or she may depart with a proportion of the adult workers in a swarm before a virgin queen emerges. The workers always begin to rear several new queens rather than a single one.

Emergency queen cells can be distinguished from the queen cells of swarming or supersedure because they originate from a worker cell. The horizontal orientation of the worker cells selected to be converted to queen cells is quickly changed to the vertical by enlarging the base of the cell and drawing the opening outward and downward. This usually means destroying the cell walls and removing the larvae of three to four cells adjacent to the modified cell. Capped emergency cells often seem smaller than capped queen cells started from queen cups.

Hive Management

Basic manipulation of a bee hive conforms to the seasonal cycle of bee biology. Beekeepers disrupt defensive behavior by application of smoke, assist bees in protecting against infection of diseases or predation by small and large predators, provide conditions for normal brood and population expansion and also ensure adequate space for storage of reserves necessary for winter survival. When all goes well, the beekeeper harvests the reserve stores leaving adequate food for daily maintenance and overwinter success.

The "key" to progressive beekeeping and colony management is applying knowledge of colony biology in **manipulation of the bee population**. Behaviors such as defense, reproduction and cohesion are more than just the sum of their parts, for bee colony management skills involve accurate diagnosis of such biologies and sometimes intervention by the beekeeper. Beekeepers seek to defer swarming in favor of supersedure, aid distribution of communication chemicals and reduce defensive behaviors. They provide ample space for storage of food reserves when flowering plants are abundant and they use their bees in pollination of crops.

Beekeeping success is measure in increased product (honey/beeswax) yields and/or production of seeds, and produce resulting from pollination service and/or the enjoyment of stewardship of another organism. Bees are really not too difficult to maintain -- it all starts with an understanding of basic bee/colony biology.

MAAREC, the Mid-Atlantic Apiculture Research and Extension Consortium, is an official activity of five land grant universities and the U.S. Department of Agriculture. The following are operating members:

University of Delaware
Newark, Delaware

University of Maryland
College Park, Maryland

West Virginia University
Morgantown, West Virginia

Rutgers University
New Brunswick, New Jersey

The Pennsylvania State University
University Park, Pennsylvania

USDA/ARS
Bee Research Lab
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Participants in MAAREC also include state beekeeper associations, and State Departments of Agriculture from Delaware, Maryland, New Jersey, Pennsylvania and West Virginia.

MAAREC Publication 4.1

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