SECTION 2 – THE BEE COLONY

The colony

Honey bees are social insects and live in a colony consisting of one queen, a few hundred males (drones) and, in a strong, healthy colony, up to 80,000 workers.

Honeycomb

The honey bee has evolved one of the cleverest systems of nest-building of all insects. Worker bees have four pairs of wax glands located on the underside of their abdomens. Drones and queens do not have these glands.

The building of the comb begins from an irregular pattern of wax spots that the bees make on the surface above them. In the wild this can be the roof of a cave or the inside of a hollow tree. In a hive, it will be along the top side of one of the frames. One of the spots is then built on and grows. It grows as a pattern. Bees working out from the centre stop when they encounter another bee working on a cell. The pattern is hexagonal (six-sided).

The hexagons are very strong. When the comb is finished, about 50 g (2 oz) of beeswax will hold 2 kg (4½ lb) of honey.

The combs are developed vertically downwards and parallel to one another. The hexagonal cells are not horizontal but slope slightly downwards from the outside to the inside. When the queen lays her egg in the cell it does not roll out. The honeycomb consists of two sets of cells 'back-to-back'. For even greater strength, the walls of the one set of cells cross the mid-point of the other cells. Scientists have recently found that the hexagonal-shaped cells are the strongest possible shape that could be used.

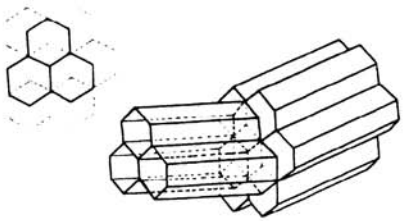


FIG. 9. Comb cells on one side of the central wall have their centres where three cell walls from the other side of the central divide meet. This helps to give the comb strength.

FIG. 10. Comb that has become established on a top bar from a hive with sloping sides.

They give maximum storage space and use the least amount of wax.

Drone cells are slightly larger than worker cells. Queen cells are totally different and are always built downwards.

FIG. 11. Worker, queen, drone.

Anatomy of a honey bee

Bees have an external skeleton (exoskeleton) consisting of layers of cuticle which provides a hard protective casing over the body. It is waterproof and much of it is covered with hairs to provide insulation and further protection. Some hairs are important in the gathering of pollen and for certain sense organs.

Like any insect the body is divided into three parts – head, thorax and abdomen.

The thorax has four segments of which three are recognized as true thoracic segments and each of these supports a pair of legs; two segments each carry a pair of wings. The two wings on the same side of the bee's body are joined to each other by a row of hooks on the front edge of the rear wing which engage in the rear edge of the front wing.

The queen

There is one bee bigger than all the rest, she is the queen and it is her task to lay eggs. She has a sting which is used only against males and rival queens. About five days after emerging from her cell, the queen takes a series of flights during which she mates with a number of males. The males' sperm is stored and the queen never mates again. A further five days after these flights, she starts to lay. She can live for several years and lays up to 2,000 eggs per day. Older queens do not have the egg-laying capacity of younger

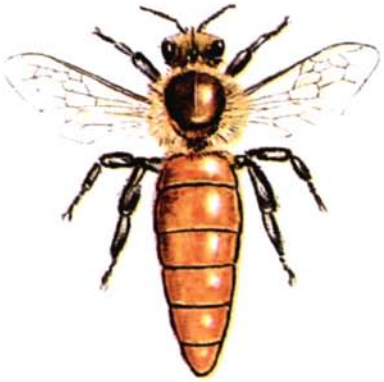


FIG. 12. Queen.

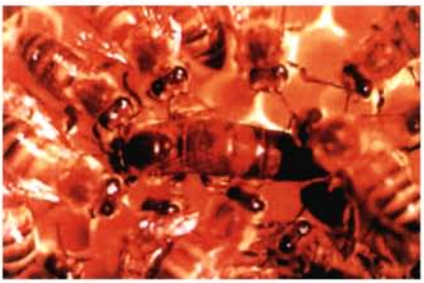


FIG. 13. The queen is surrounded by her attendant workers. She is an egg laying machine laying one egg per cell.

queens, which are therefore preferred by beekeepers. She does not feed herself and is fed by the workers.

Several of the queen's glands produce complex chemicals, or pheromones. These chemicals are distributed throughout the nest and serve to control the other individuals and harmonize the behaviour of the colony.

The drones

These are male and are bigger than the workers but not as big as the queen. They have large eyes that cover practically all of the head. The end of the abdomen is rounded but there is no sting. At any one

FIG. 14. Drone.

time there may be between 200 and 300 drones in a colony. Their only job is to mate with a queen. Mating takes place in the air away from the colony. Mature males gather in certain areas where they wait for a virgin queen to fly by. When resources are limited and times are hard for the colony, the drones are thrown out of the nest and die as they cannot look after themselves.

The workers

There can be as many as 80,000 workers in the colony. They are all female but do not lay eggs. They do a number of different jobs including: cleaning the hive, feeding the larvae and the queen, building the honeycomb, defending the hive, collecting pollen and nectar.

FIG. 15. The honey bee worker.

Workers have special glands and organs to help them do these various tasks. Glands on the front of the head produce brood food and royal jelly. Wax glands under the abdomen produce the material for the comb. Odour glands on the upper part of the abdomen produce a scent to communicate with other bees when, for example, the colony is disturbed.

At the tip of the abdomen there are glands associated with producing venom for the sting which the bee uses to defend the colony. In the head is a long tongue used for gathering nectar.

A part of the intestine is enlarged to form the honey sac or honey stomach where nectar and water are carried.

On the back (hind) legs are pollen baskets. Pollen is combed from the body and pressed into pellets and carried in these baskets back to the hive. Propolis (see page 17) is carried in the same way.

How a worker grows

Each honey bee in the course of its life passes through four stages:

egg – larva – pupa – adult

The workers develop in the near horizontal cells that form the comb from fertilized eggs that have been laid in response to the queen's reaction to worker-size cells.

In the egg, the embryo develops by absorbing the rich source of protein that is the yolk. The larva hatches from the egg after three days and feeds on the provisions put into the cell by the nurse bees. Feeding continues for about five days. Thus, after a total of about eight days' development the cell is sealed.

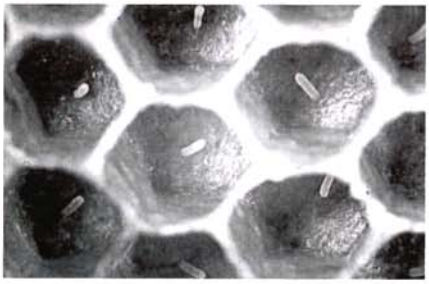


FIG. 16. One egg laid in each cell. The cells slope towards the centre so that the eggs do not fall out.

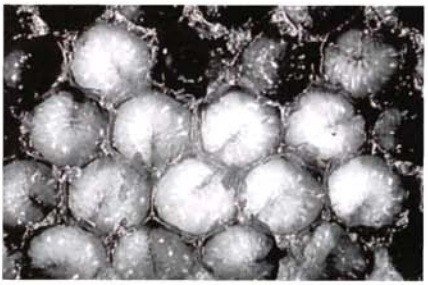


FIG. 17. Brood, otherwise known as larvae, developing.

The worker brood occupies most of the brood nest in the central, most protected and thermally regulated part of the cluster of bees — that is, where the temperature is best controlled.

The newly formed adult worker nibbles away the cap of the cell and emerges as a rather soft greyish bee. From egg to emergence takes between 18 and 20 days.

How a queen bee grows

Queens, like workers, develop from fertilized eggs. They become queens as a result of a different diet secreted and placed in the cells by nurse bees.

The queen cell is very different from other cells. It hangs vertically and may be built between the combs thereby interfering with the bee space. The exterior is mottled in colour with a tapered shape.

There are two types of queen cell. One is made by enlarging a worker cell and allowing the worker larva to migrate into the enlarged portion where it will be specially fed to become a queen. This is an emergency queen cell, built when a colony becomes queenless. The other type of queen cell is built as part of the normal reproductive process. Again vertical and often at the bottom of the comb.

The larva hatches after three days. It is fed on royal jelly for approximately five days when the cell is capped. The queen emerges about 15 days after the egg was laid.

How a drone grows

Drones develop from unfertilized eggs laid by the queen in drone cells which, although still almost horizontal, are slightly bigger than the cells of worker brood. The queen controls whether an egg is fertilized or not as she lays it.

Again after three days, the egg hatches. The larva is then fed for approximately seven days and so receives much more brood food than the larvae of worker bees. The cell is

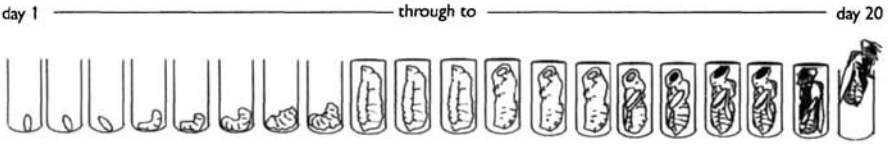


FIG. 18. Developmental growth of the worker honey bee – day by day.

FIG. 19. A ripe or capped queen cell.

sealed and the cap is domed to make enough room for the larger drones. The drones emerge after 25 days. Most drones are produced during the reproductive (swarming) phase of the colony's cycle.

By the time the bee emerges from the cell, the adult body form is defined and fixed. However, full development of the glandular and reproductive systems takes place afterwards.

A short but busy life

Bees live for about six weeks and then die from overwork. In this short time, they perform many different tasks within the hive at different ages: cleaner, nurse, stores' manager, builder, guard and food gatherer. Most worker activities within the nest are social but what each bee does depends on the development of its various glandular systems. This is linked to age and to the needs of the colony.

During the first days of life it is essential that the worker bee feeds in order to develop her different glands to their full potential. When the worker bee emerges from her cell in the comb, she finds a cell full of pollen and eats well. She can then start her working life as a cleaner. The honeycomb cells are cleaned so that they can be reused by the egg-laying queen or for food storage. The worker bee does this job for about four days, gaining strength all the time.

From day five to about day nine in her life she has the job of nurse. Glands in her head secrete food which becomes part of the royal jelly that nurtures larvae, some of which may be destined to be queens. She also makes a mixture of honey and pollen – bee bread – and feeds it to the older larvae.

By about the ninth day, the glands on the bee's head have become inactive. However, the glands on her abdomen now start to produce wax. Therefore, from the 10th to

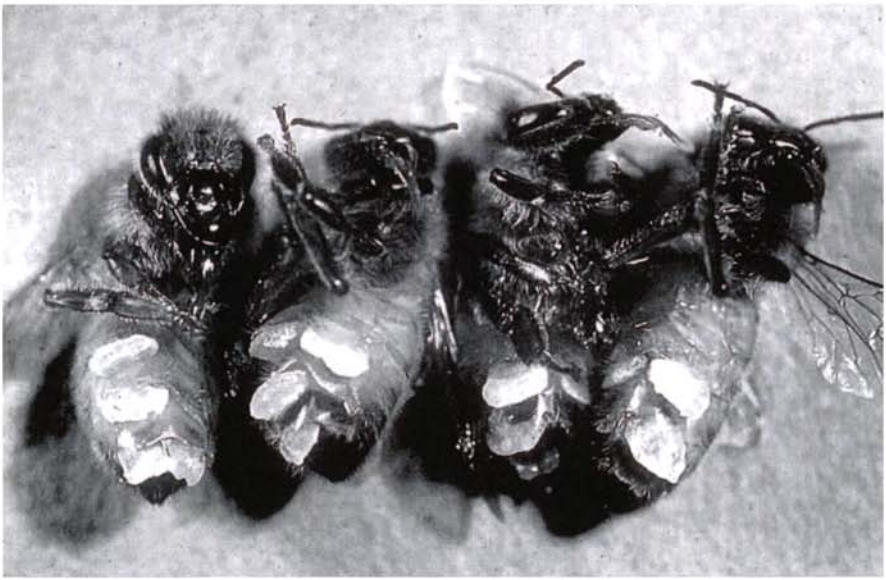


FIG. 20. Wax glands producing wax scales.

FIG. 21. Pollen collected in the pollen baskets of foragers.

the 16th day she is busy using wax to build comb.

When the wax glands cease to secrete, the worker becomes a stores' manager. The 17th to 19th days are spent taking pollen and nectar from bees returning to the hive and carefully packing it as a food store in the comb. During this period she also helps to ventilate the hive by flapping her wings. This allows the air to circulate, it also strengthens the muscles that work the wings in preparation for the first flights from the hive.

There are always workers to attend to the queen. As she gets on with the business of laying eggs there are workers to feed her and groom her. While touching her, these workers pick up her 'messages' through chemicals called pheromones. They then pass the message on to other bees as they make contact crawling round inside the hive. In this way, the queen can control a colony of 30, 50 or even 80 thousand bees.

Before taking flight in search of nectar and pollen, there is another job to perform – that of sentry. Around the entrance to every hive there are guard bees whose duty it is to keep out wasps, moths and other intruders. At times of food shortage they will kill off the drones (male bees) by preventing them from returning to the hive.

The rest of the worker bee's life is spent seeking food. This main work of the bee is known as foraging, that is to go out and collect nectar and pollen.

Nectar is the sweet liquid plants produce to attract insects for pollinating. The bees suck up the nectar from the flowers and store it in their honey sacs and carry it back to the hive. There they regurgitate it and pass it to another bee. During these processes, enzymes are added to the nectar which start to change it into honey. The honey is stored in the honeycomb.

Pollen is the fine dusty material that collects on bees as they collect nectar. They carefully comb their bodies and collect the pollen in special pollen baskets on their back legs. It is taken back to the hive where it is pressed into the comb by hive bees using their heads like hammers. Pollen is always stored near the larvae so that it is readily available and most of it will be used to feed the young.

Bees collect other materials on their foraging trips. Like all living creatures, they need water to satisfy their own thirst but also to control the atmosphere within the hive. During very hot periods, bees will carry water back to the hive where it can evaporate and so help control the temperature.

Bees also produce propolis (this is not a food but a building material). It is a sort of bee glue and is used to seal cracks in the hive, to strengthen the comb and to mummify any intruder such as a beetle or even a mouse which has been killed and is too large to move. Propolis is plant resins collected from the buds of various plants, some trees, sometimes mixed with beeswax. The bees carry it in their pollen baskets. It is very sticky and so the workers need the help of other bees to remove it when they return to the hive.

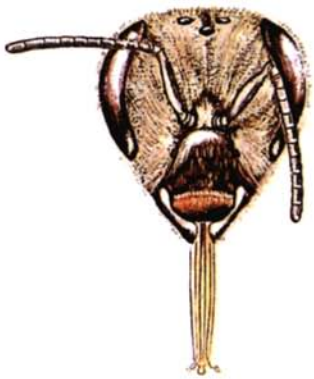


FIG. 22. Bee senses: head of worker.

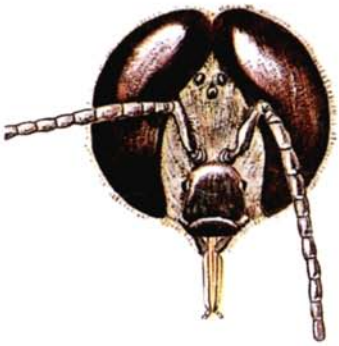


FIG. 23. Head of drone.

Bee senses

In comparison with other insects, the bee has an unusually large brain in relation to the size of its body.

Bees have two large compound eyes and three simple eyes. The compound eye is made up of very many tiny lenses. These eyes may not see things clearly but are sensitive to small movements. They also recognize colour but not the same colours that are seen by the human eye. Bees do not see red but can see ultraviolet which is not visible to humans. Ocelli or simple eyes on top of the head react only to light intensity.

The antennae provide sensory information on movement, taste and humidity. They also respond to smells and the presence of carbon dioxide.

Bees also react to sounds which they perceive as vibrations felt by the antennae and the legs. The hairs on the bee's body are sensitive to touch.

Communication and control of the colony

Living in a large group or community, bees need to communicate with one another. They do this in a number of ways, not all of which are understood by science. They may communicate by making various noises perhaps by drumming of feet or flapping of wings. They may also communicate by touch and food exchange.

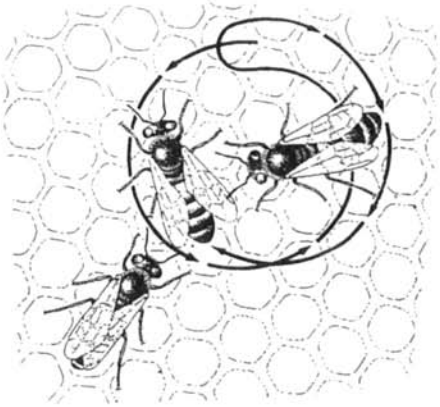


FIG. 24. The round dance tells other bees the nectar is not far away (less than 100 metres).

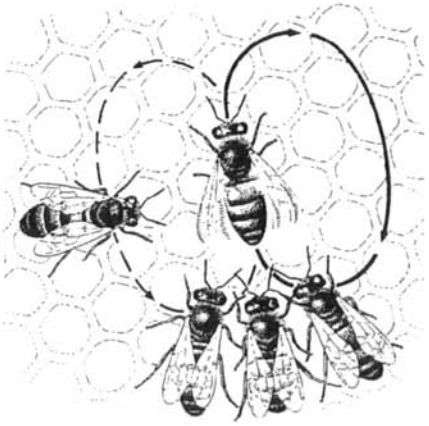


FIG. 25. The waggle dance tells other bees the nectar is further away. The bee moves around the figure-of-eight and waggles its body as it moves along the middle.

Although the life of the colony centres on the queen, she does not rule it. Colony 'decisions' are taken by the collective behaviour of the bees, and many factors are involved. Pheromones play an important part in control of the colony. These are chemical substances produced by bees to convey precise messages to other bees. Honey bees have a number of pheromone systems controlling their behaviour, but the methods by which these chemicals exert control are extremely complex.

Queens, drones and worker bees, including brood, all produce pheromones. Queen pheromones attract workers to her, stimulate foraging, brood-rearing and comb-building, and inhibit queen-rearing. The presence of the queen has a profound effect upon the workers. If the queen is removed from a hive then a change in behaviour of the colony can be detected very quickly. This communication is brought about by important behaviour – food-sharing. When two bees meet in the colony they are likely to exchange food: one offering nectar, the other drinking it. Thus, every bee in the colony is constantly giving and receiving food and all bees within the colony share the same odour. This is very important in aiding guard bees to detect intruder bees from other colonies. Minute traces of pheromones are mixed in with the food, and the absence of the queen and her pheromones will quickly be realized by every bee. This explains why a colony swarms when its population becomes very large: workers are no longer in close enough contact with the queen and begin to rear replacements.

The waggle dance

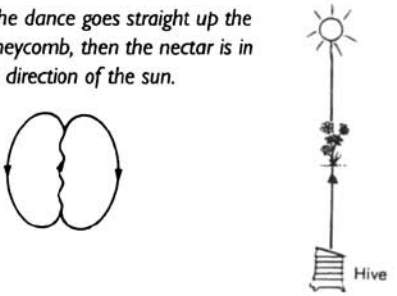
The most studied form of communication is the waggle dance. This is generally believed to be the way in which bees tell one another of the location of food, although odour is also important.

The returning bee will give the other bees a taste of the nectar she has collected. It is almost as if she is saying: 'This is good, watch me and I will show you where to get more'.

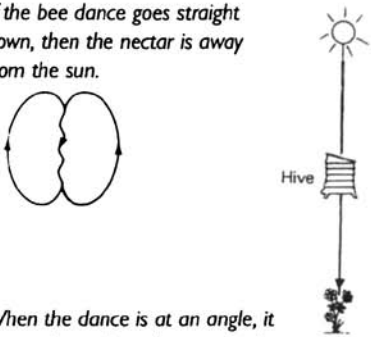
There is a round dance which tells the other bees that there is nectar not far away – probably within 100 m (100 yards) of the hive. The bees fly off and look around the hive.

The waggle dance tells the other bees the nectar is further away. The bee moves in a figure-of-eight and waggles her abdomen when she moves up the central line.

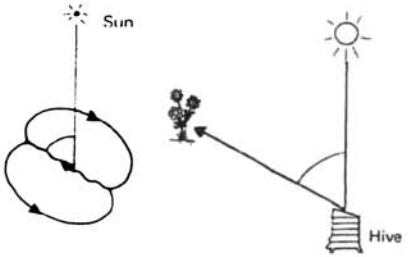
If the dance goes straight up the honeycomb, then the nectar is in the direction of the sun.



If the bee dance goes straight down, then the nectar is away from the sun.



When the dance is at an angle, it shows the angle to the sun the bees must fly to find the nectar.



The waggle dance also tells other bees how far away the nectar is. The longer she waggles while dancing, the farther away the nectar, while the faster it waggles the nearer the nectar.

FIG. 26. Explanation of the waggle dance.