I M. Sc, Zoology – II Semester

Subject: APICULTURE

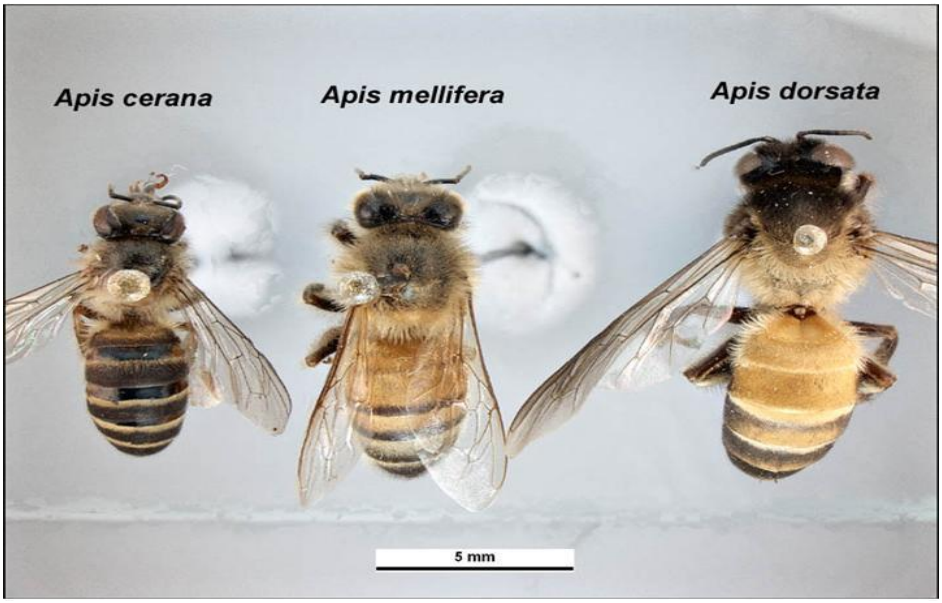
Sub. Code: 18KP2ZELZ2

(Unit I & II)

Unit I

APICULTURE

Apiculture or bee-keeping is the technique of rearing honey bees for honey and wax from their comb or beehives. Selection of sites for quality honey and protection of bees and combs from pests and diseases are part of apiculture.



Bees are economically important social insects. They not only provide us with honey and wax, they are also responsible for pollination of flowers of the majority of damaged bee larvae, pollen grains, etc. of commercially important plants. The common Indian honey bees are Apis (Megapis) dorsal, A. (Microapis) florea and A. indica.

HISTORY OF BEEKEEPING

- Primitive man used to rob bee colonies found in the cavities of hollow trees or on rocks and in traditional mud houses and this is still being followed by some tribes.
- There was no development in beekeeping until 16th century.
- Proper beekeeping started only when man started giving protection to colonies found in the nature.
- Idea to keep bees in log hives has been reported to come from the fallen trees which were nested by the cavity nesting bees.
- Development of modern bee keeping has its origin between 1500 and 1851 when many attempts were made to domesticate bees in different types of hives but were not successful because bees attached their combs together as well as to the walls of hive and combs required had to be cut for honey.
- The discovery of the principle of bee space in 1851 by L. L. Langstroth in USA resulted in first truly movable frame hive. This bee space was 9.5 mm for Apis mellifera.
- This discovery was followed by subsequent innovations like comb foundation mill, honey extractor, smoker, etc., which helped in the development of modern bee keeping we see today.

HISTORY AND DEVELOPMENT OF APICULTURE IN INDIA

Apiculture (from Latin apis, a bee) or bee-keeping is the practice of scientific maintenance of honeybee colonies, commonly in hives, by humans and collection of bee products and marketing them professionally.

Till now more than 20,000 species of wild bees have been described by taxonomists. Many of these species are solitary (e.g., mason bees), and many others rear their young in burrows and small colonies, (e.g., bumble bees).

Apiculture is concerned with the practical management of the social species of honey bees, which live in large colonies of up to 100,000 individuals.

In Indian subcontinent uses of bees and honey are common from the pre-historic ages. In our country, Veda, Ramayana, Koran has mentioned different uses of honey. Former Kings and Sultans used the symbol of bee as a mark of glory.

Some of the earliest evidence of gathering honey from wild colonies is from rock paintings, dating to around 13,000 BC from different countries. Since early days honeybees are not cultured for honey, instead honey is collected from wild natural hives.

It is recorded that in 1882, artificial culture of honeybees were introduced in undivided Bengal following European methodologies. In 1883-84 the process was initiated in Punjab. In 1894, India Government first circulates details of information regarding the bee culture as promotional measure. Bee-keepers Association was established in 1907 in Punjab with its Head Office at Simla.

In 1939, All India Bee-keeping Association was established and very soon it spread its branches to most of the states and districts of India. Now it merges with ICAR (Indian Council of Agricultural Research) and has expanded its activities. In 1945, Central Bee-keeping Research Station was established. It expands its research centres to Coimbatore (Tamil Nadu), Ruptala (Andhra Pradesh), Sundar Nagar (Himachal Pradesh), etc.

In 1953 Khadi and Village Industries Commission and in 1956 Bee-keeping Directorate were established by the Central Government. In 1962 Central Bee Research Training Institute was developed. After that its branches were established in Kodaikanal, Mahabaleswar, Kangra, Kashmir and other places.

In 1980 ICAR, DST, INSA, Khadi and Village development Directorate jointly organised International Conference on Apiculture in Tropical Climate for discussion on the development on the apiculture around the world.

Beekeeping in India

- In India first attempt to keep bees in movable frame hives was made in 1882 in Bengal and then in 1883-84 in Punjab.
- In south India, Rev. Newton during 1911-1917 trained several beekeepers and devised a hive for indigenous bee Apis cerana based on principle of bee space (which was named after his name as "Newton hive").
- Beekeeping was also started in the Travancore state (now Cochin) in 1917 and in Mysore in 1925.
- In Himachal Pradesh modern beekeeping with indigenous honey bee A. cerana started in 1934 at Kullu and in 1936 at Kangra.
- The exotic bee A. mellifera was successfully introduced for the first time in India in 1962at Nagrota Bagwan (then in Punjab state and now in Himachal Pradesh), because this bee has potentials to produce more honey.
- At present both the hive bee species are being used in modern bee keeping and lot of honey is also being collected from the wild bees viz. A. dorsata and A. florea.
- India is producing approximately 70000 metric tons of honey annually from all the four species of honey bees.

ORIGIN, SYSTEMATIC AND DISTRIBUTION OF HONEY BEE

A **honey bee** is a social flying insect within the genus ***Apis*** of the bee clade, all native to Eurasia but spread to four other continents by human beings. They are known for their construction of perennial colonial nests from wax, the large size of their colonies, and surplus production and storage of honey, distinguishing their hives as a prized foraging target of many animals, including honey badgers, bears and human hunter-gatherers.

Only eight surviving species of honey bee are recognized, with a total of 43 subspecies, though historically 7 to 11 species are recognized. Honey bees represent only a small fraction of the roughly 20,000 known species of bees.

The best known honey bee is the western honey bee (*Apis mellifera*), which has been domesticated for honey production and crop pollination; the only other domesticated bee is the eastern honey bee (*Apis cerana*), which occurs in South Asia.

Some other types of related bees produce and store honey, and have been kept by humans for that purpose, including the stingless bees, but only members of the genus *Apis* are true honey bees. Modern humans also value the wax for use in making candles, soap, lip balms, and other products.

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Hymenoptera
Family:	Apidae
Clade:	Corbiculata
Tribe:	Apini Latreille, 1802
Genus:	*Apis* Linnaeus, 1758

Honey bees appear to have their center of origin in South and Southeast Asia (including the Philippines), as all the extant species except *Apis mellifera* are native to that region. Notably, living representatives of the earliest lineages to diverge (*Apis florea* and *Apis andreniformis*) have their center of origin there.

The first *Apis* bees appear in the fossil record at the Eocene-Oligocene boundary (34 mya), in European deposits. The origin of these prehistoric honey bees does not

necessarily indicate Europe as the place of origin of the genus, only that the bees were present in Europe by that time. Few fossil deposits are known from South Asia, the suspected region of honey bee origin, and fewer still have been thoroughly studied.

No *Apis* species existed in the New World during human times before the introduction of *A. mellifera* by Europeans. Only one fossil species is documented from the New World, *Apis nearctica*, known from a single 14 million-year-old specimen from Nevada.

The close relatives of modern honey bees – e.g., bumblebees and stingless bees – are also social to some degree, and social behavior seems a plesiomorphic trait that predates the origin of the genus.

Among the extant members of *Apis*, the more basal species make single, exposed combs, while the more recently evolved species nest in cavities and have multiple combs, which has greatly facilitated their domestication.

Species

While about 20,000 species of bees exist, only eight species of honey bee are recognized, with a total of 43 subspecies, although historically seven to 11 species are recognized:

- ***Apis andreniformis* (the black dwarf honey bee);**
- ***Apis cerana* (the eastern honey bee);**
- ***Apis dorsata* (the giant honey bee);**
- ***Apis florea* (the red dwarf honey bee);**
- ***Apis koschevnikovi* (Koschevnikov's honey bee);**
- ***Apis laboriosa* (the Himalayan giant honey bee);**
- ***Apis mellifera* (the western honey bee); and**
- ***Apis nigrocincta* (the Philippine honey bee).**

Honey bees are the only extant members of the tribe Apini. Today's honey bees constitute three clades: *Micrapis* (the dwarf honey bees), *Megapis* (the giant honey bee), and *Apis* (the western honey bee and its close relatives).

Most species have historically been cultured or at least exploited for honey and beeswax by humans indigenous to their native ranges. Only two species have been truly domesticated: *Apis mellifera* and *Apis cerana*. *A. mellifera* has been cultivated at least since the time of the building of the Egyptian pyramids, and only that species has been moved extensively beyond its native range.

DIFFERENT SPECIES OF HONEY BEES

There are five well known species of honey bees in the world:

1. **The rock bee, *Apis dorsata* (Apidae).**
2. **The Indian hive bee, *Apis cerana indica* (Apidae).**
3. **The little bee, *Apis florea* (Apidae).**
4. **The European or Italian bee, *Apis mellifera* (Apidae).**
5. **Dammer bee or stingless bee, *Melipona irridipennis* (Meliporidae).**

Rock bee *(Apis dorsata)*

- They are giant bees found all over India in sub-mountainous regions up to an altitude of 2700 m.
- They construct single comb in open about 6 feet long and 3 feet deep .
- They shift the place of the colony often.
- Rock bees are ferocious and difficult to rear.
- They produce about 36 Kg honey per comb per year.
- These bees are the largest among the bees described.

Little bee (*Apis florea*)

- They build single vertical combs.
- They also construct comb in open of the size of palm in branches of bushes, hedges, buildings, caves, empty cases etc.
- They produce about half a kilo of honey per year per hive.
- They are not rearable as they frequently change their place.
- The size of the bees is smallest among four *Apis* species described and smaller than Indian bee.
- They distribute only in plains and not in hills above 450 MSL.

Apis florea

Indian hive bee / Asian bee (*Apis cerana indica*)

- They are the domesticated species, which construct multiple parallel combs with an average honey yield of 6-8 kg per colony per year.
- These bees are larger than *Apis florae* but smaller than *Apis mellifera*.
- They are more prone to swarming and absconding. They are native of India/Asia.

Apis cerana indica

European bee / Italian bee (*Apis mellifera*)

- They are also similar in habits to Indian bees, which build parallel combs.
- They are bigger than all other honeybees except *Apis dorsata*.
- The average production per colony is 25-40 kg.
- They have been imported from European countries (Italy).
- They are less prone to swarming and absconding.

Apis mellifera

Dammer Bee

- Besides true honey bees, two species of stingless or dammer bees, viz. *Melipona* and *Trigona* occur in our country in abundance.
- These bees are much smaller than the true honey bees and build irregular combs of wax and resinous substances in crevices and hollow tree trunks.
- The stingless bees have the importance in the pollination of various food crops.
- They bite their enemies or intruders. It can be domesticated.
- But the honey yield per hive per year is only 100 gms.

Dammer Bee (Stingless Bee Keeping)

Characteristics of well known species of honey bees:

	Apis dorsata	***Apis florea***	***Apis cerana***	***Apis mellifera***
Nesting	Open nesting. Builds single large comb (ca $1m^2$) attached to branches of trees or rocks etc.	Open nesting. Buildssingle small comb (ca size of palm of hand) fixed to branches ofbushes.	Cavity nesting. Buildsmany parallel combs in cavities of tree trunks, hollows of rocks, poles and other covered places	Cavity nesting and similar in habits to *Apis cerana* and builds parallel combs.
Distribution in India	Found in plains as well as hills up to 1600 metres above sea level. Highly migratory.	Found in plains up to 300 metres above sea level. Highly migratory.	Found throughout India having 3 subspecies	Exotic bee to India. Introduced successfully in 1962. It has Many subspecies (more than 23)throughout world
Size	Biggest honey bee (16-18mm)	Smallest*Apis* bee (9-10mm)	Medium size (14-15mm)	Medium size (14-16mm)
Swarming/ Absconding	Strong tendency	Strong tendency	Strong tendency	Strong tendency only in African sub species
Temperament	Furious	Mild	Furious	Gentle except African sub species
Average honey yield Per colony/year	40 kg (wild bees; cannot be domesticated)	500 g (wild bees; cannot be domesticated)	5 kg (Hive bees; can be domesticated)	15 kg Hive bees; can be domesticated)

LIFE CYCLE OF THE HONEY BEE

The lifecycle of a honey bee consists of three main stages:

The larval, pupal, and adult stages. Within a normal hive situation, a single queen bee lays fertilized and unfertilized eggs.

Fertilized eggs can hatch worker and queen bees, unfertilized eggs hatch drone bees.

Eggs hatch after about 3 days, but development rates and processes vary among bees within the hive, as well as between species in the genus *Apis.*

Honey bee Colony life

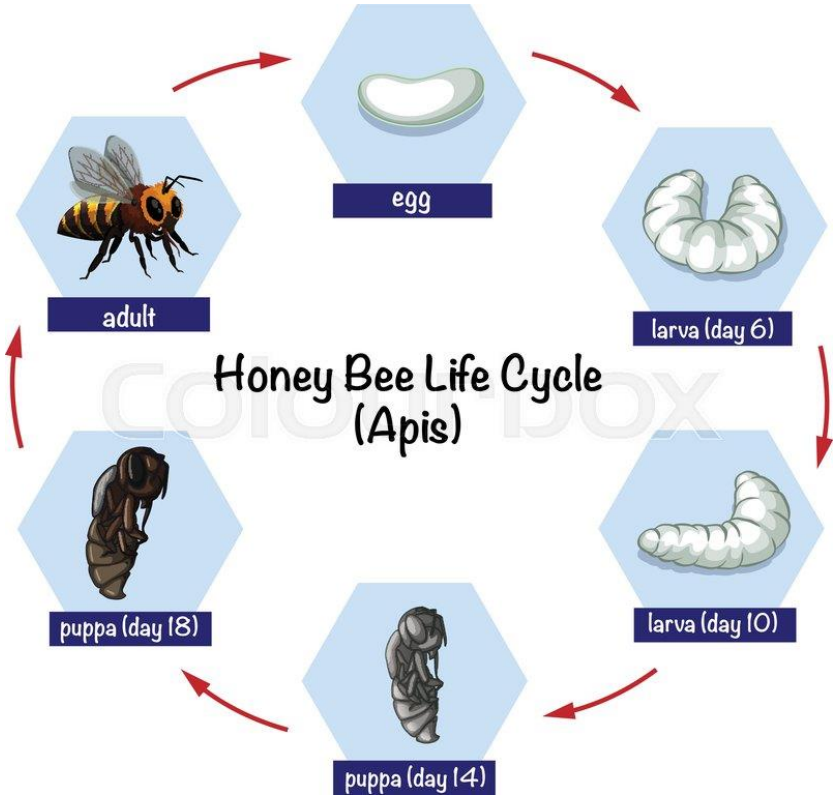
The life of a honey bee colony is perennial. The three types of honey bees in a hive are: queens (egg-producers), workers (non-reproducing females), and drones (males whose main duty is to find and mate with a queen).

Unlike the worker bees the drones do not sting. Honey bee larvae hatch from eggs in three to four days.

They are then fed by worker bees and develop through several stages in the cells. Cells are capped by worker bees when the larva pupates.

Queens and drones are larger than workers, so require larger cells to develop. A colony may typically consist of tens of thousands of individuals.

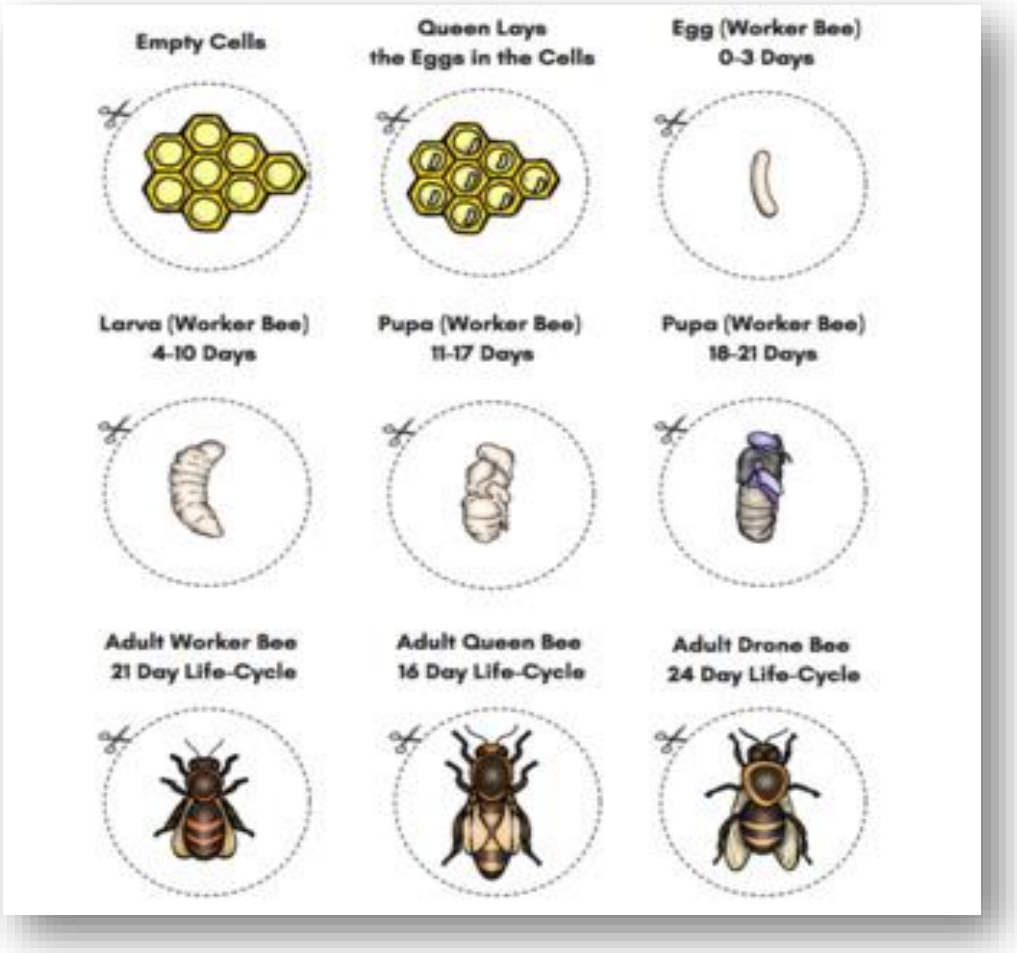
While some colonies live in hives provided by humans, so-called "wild" colonies (although all honey bees remain wild, even when cultivated and managed by humans) typically prefer a nest site that is clean, dry, protected from the weather, about 20 liters in volume with a 4- to 6-cm^2 entrance about 3m above the ground, and preferably facing south or south-east (in the Northern Hemisphere) or north or north-east (in the Southern Hemisphere).



Development

- Development from egg to emerging bee varies among queens, workers, and drones. Queens emerge from their cells in 15–16 days, workers in 21 days, and drones in 24 days.
- Only one queen is usually present in a hive. New virgin queens develop in enlarged cells through differential feeding of royal jelly by workers.
- When the existing queen ages or dies or the colony becomes very large, a new queen is raised by the worker bees.
- When the hive is too large, the old queen will take half the colony with her in a swarm. This occurs a few days prior to the new queen emerging.
- If several queens emerge they will begin piping (a high buzzing noise) signaling their location for the other virgin queens to come fight.
- Once one has eliminated the others, she will go around the hive chewing the sides of any other queen cells and stinging and killing the pupae.

- The queen takes one or several nuptial flights to mate with drones from other colonies, which die after mating.
- After mating the queen begins laying eggs.



- A fertile queen is able to lay fertilized or unfertilized eggs. Each unfertilized egg contains a unique combination of 50% of the queen's genes and develops into a (haploid) drone.
- The fertilized eggs develop into either (diploid) workers or virgin queens (if fed exclusively royal jelly).
- Every honey bee (*Apis mellifera*) in a hive exists to perform specific duties determined by their gender and age.

- Like every member of its colony, the nurse honey bee plays a vital role in the survival of its hive. Nurse bees are charged with the care and feeding of the queen and the next generation.
- The average lifespan of a queen is three to four years; drones usually die upon mating or are expelled from the hive before the winter; and workers may live for a few weeks in the summer and several months in areas with an extended winter.

Worker Bees

Worker bees are female bees that hatch from a fertilized egg. After hatching, the bees spend an average of six days in the larval stage. During the first few days larvae are mass-fed a compound known as “worker jelly” or “brood food”- a mixture of fluids produced by the hypopharyngeal food glands and the mandibular glands of adult worker bees. Larvae are fed between 150-800 times per day for up to three days before the diet is changed to a less rich content and less frequent feeding schedule.

During the larval stage fat bodies are built up that are able to store lipids, glycogen, amino acids, and mitochondria bodies for later use in the pupal stage. After eight or nine days, the brood cells are capped and the larvae molt. They begin to spin a cocoon with silk produced from thoracic salivary glands, this marks the beginning the pupal stage.

The pupal stage is when most parts of the adult bee form; the wings, legs, abdomen, internal organs, and muscles. Pupae draw upon the stores of the fat bodies built up during the larval stage during this period of growth. Stored lipids, amino acids, and glycogen fuel the continued growth of the developing pupa.

After about 20 to 21 days, the pupa chews through the brood cell cap and emerges as a *teneral* or *callow* bee. These newly hatched bees do not leave the cell for three to four hours, as they have a soft skin, or cuticle, that takes time to harden.

Once emerging from the brood cell, bees must feed within a few hours. Without the bacteria and proteins that ingesting pollen brings, the development process and

lifespan of the bee can be threatened. Young bees spend the first one to three weeks of their lives carrying out functions within the hive.

These tasks include feeding and cleaning larvae, cleaning the hive cells, building comb, guarding, patrolling, accepting pollen from foragers, storing, curing, and packing pollen, and more. After about three weeks the glands that produce larval food and wax begin to degenerate. The bee moves from the brood nest and begins integration into the life of a forager.

Worker bees typically live 15-38 summer days. In the winter, changes in the bees anatomy- specifically well-developed hypopharyngeal glands and an increased supply of fat bodies, enable worker bees to live 140-320 days.

Queen Bees

Queen bees and worker bees both hatch from unfertilized eggs. The only difference between these two bees is their diet. Special cells, known as “queen cups”, can be constructed by worker bees in which an existing queen will lay eggs into.

Larvae in these queen cells are mass-fed with a royal diet for the entirety of their larval development. The royal diet contains three different stages. In the first stage, a white fluid produced by the mandibular gland is fed to larvae for three days.

The next dietary stage involves a half-and-half mixture of secretions from the mandibular and hypopharyngeal glands. In the final two days of larval life, honey is added to the queen larvae diet. The addition of honey provides a increased sugar content as well as high levels of a hormone known as *juvenile hormone.* High levels of this hormone alter the development of the body by inducing the production of hormones and proteins specific to producing the anatomy of a queen bee.

When a queen bee first hatches, she is known as a virgin queen. One of her first priorities upon emerging is to eliminate the presence of other queens. This process usually involves the killing of an existing queen and/or additional queen larvae.

Six days after emerging, the virgin queen will leave the hive on a mating flight on which she will mate with up to 20 drones. When the queen's sperm sac, or spermatheca, is full she returns to the colony. Once having mated, the queen will never leave the colony again, unless in the case of swarming.

Three days after mating, the queen will begin to lay up to 1000 eggs a day for the rest of her life. Queen bees, on average, have a lifespan of two to five years and can lay around 200,000 eggs a year.

Queen rearing is a process brought about by the worker bees to produce a new queen. When a hive is preparing to swarm, has a queen performing at a substandard level, or when a queen is lost or dies, the worker bees will begin construction of new queen cells to host a queen, or will adjust the diet of a worker larva to produce a new queen.

Drone Bees

Drone bees make up about 15% of the colony population. Being large in size, they are distinguishable from the queen by the tapered shape of their abdomen. Drones are the only males in the hive, hatching from unfertilized eggs laid in larger cells by the mated queen. Drone larvae are fed a modified version of the worker bees diet that includes increased quantities of pollen and honey. After four to five days of feeding, drone cells are capped- their appearance distinguishable from other capped cells by their increased size and dome-tipped shape.

Newly emerged drone bees are fed a combination of pollen, honey, and brood food from nurse bees until they are mature enough to feed themselves from the hive honey stores. Adult drones never collect food, secretes wax, or feed the young. They lack a stinger as well as a long tongue suited for nectar collection.

Drones are often referred to as "flying penises" as their sole purpose is to mate with virgin or newly mated queens. They first leave the hive about six days after emerging, flying to areas known as drone-congregating areas, or DCAs, only returning to

the hive after a failed mating outing. The few drones that do succeed in mating with a queen die shortly after.

Drones typically have a lifespan of eight weeks, although it is relative to when he succeeds in mating with a queen. Not being essential an essential factor in the function of the colony, pressured situations, such as a nectar shortage or the onset of fall, may lead worker bees to cannibalize or clean out drone broods and/or expel drones from the colony.

Unfertilized eggs can be laid by mated queens, unmated queens, failing queens, or by laying workers. In all situations, male drones capable of mating will hatch. In the case of laying worker bees, this usually will come about as a result of the colony being unable to rear a new queen.

Unit II

HONEY BEE COLONY

Honey bees are social insects, which mean that they live together in large, well-organized family groups. Social insects are highly evolved insects that engage in a variety of complex tasks not practiced by the multitude of solitary insects. Communication, complex nest construction, environmental control, defense, and division of the labor are just some of the behaviors that honey bees have developed to exist successfully in social colonies. These fascinating behaviors make social insects in general, and honey bees in particular, among the most fascinating creatures on earth.

A honey bee colony typically consists of three kinds of adult bees: workers, drones, and a queen. Several thousand worker bees cooperate in nest building, food collection, and brood rearing. Each member has a definite task to perform, related to its adult age. But surviving and reproducing take the combined efforts of the entire colony. Individual bees (workers, drones, and queens) cannot survive without the support of the colony.

In addition to thousands of worker adults, a colony normally has a single queen and several hundred drones during late spring and summer (Figure 1). The social structure of the colony is maintained by the presence of the queen and workers and depends on an effective system of communication. The distribution of chemical pheromones among members and communicative “dances” are responsible for controlling the activities necessary for colony survival. Labor activities among worker bees depend primarily on

the age of the bee but vary with the needs of the colony. Reproduction and colony strength depend on the queen, the quantity of food stores, and the size of the worker force. As the size of the colony increases up to a maximum of about 60,000 workers, so does the efficiency of the colony.

Queen

Each colony has only one queen, except during and a varying period following swarming preparations or supersedure. Because she is the only sexually developed female, her primary function is reproduction. She produces both fertilized and unfertilized eggs. Queens lay the greatest number of eggs in the spring and early summer. During peak production, queens may lay up to 1,500 eggs per day. They gradually cease laying eggs in early October and produce few or no eggs until early next spring (January). One queen may produce up to 250,000 eggs per year and possibly more than a million in her lifetime.

A queen is easily distinguished from other members of the colony. Her body is normally much longer than either the drone's or worker's, especially during the egg-laying period when her abdomen is greatly elongated. Her wings cover only about two-thirds of the abdomen, whereas the wings of both workers and drones nearly reach the tip of the abdomen when folded. A queen's thorax is slightly larger than that of a worker, and she has neither pollen baskets nor functional wax glands. Her stinger is curved and longer than that of the worker, but it has fewer and shorter barbs. The queen can live for several years—sometimes for as long as 5, but average productive life span is 2 to 3 years.

The second major function of a queen is producing pheromones that serve as a social "glue" unifying and helping to give individual identity to a bee colony. One major pheromone—termed queen substance—is produced by her mandibular glands, but others are also important. The qualities of the colony depend largely on the egg-laying and chemical production capabilities of the queen. Her genetic makeup—along with that of the

drones she has mated with—contributes significantly to the quality, size, and temperament of the colony.

About one week after emerging from a queen cell, the queen leaves the hive to mate with several drones in flight. Because she must fly some distance from her colony to mate (nature's way of avoiding inbreeding), she first circles the hive to orient herself to its location. She leaves the hive by herself and is gone approximately 13 minutes. The queen mates, usually in the afternoon, with seven to fifteen drones at an altitude above 20 feet. Drones are able to find and recognize the queen by her chemical odor (pheromone). If bad weather delays the queen's mating flight for more than 20 days, she loses the ability to mate and will only be able to lay unfertilized eggs, which result in drones.

After mating the queen returns to the hive and begins laying eggs in about 48 hours. She releases several sperm from the spermatheca each time she lays an egg destined to become either a worker or queen. If her egg is laid in a larger drone-sized cell, she does not release sperm. The queen is constantly attended and fed royal jelly by the colony's worker bees. The number of eggs the queen lays depends on the amount of food she receives and the size of the worker force capable of preparing beeswax cells for her eggs and caring for the larva that will hatch from the eggs in 3 days. When the queen substance secreted by the queen is no longer adequate, the workers prepare to replace (supersede) her. The old queen and her new daughter may both be present in the hive for some time following supersedure.

New (virgin) queens develop from fertilized eggs or from young worker larvae not more than 3 days old. New queens are raised under three different circumstances: emergency, supersedure, or swarming. When an old queen is accidentally killed, lost, or removed, the bees select younger worker larvae to produce emergency queens. These queens are raised in worker cells modified to hang vertically on the comb surface (Figure 2). When an older queen begins to fail (decreased production of queen substance), the

colony prepares to raise a new queen. Queens produced as a result of supersedure are usually better than emergency queens since they receive larger quantities of food (royal jelly) during development. Like emergency queen cells, supersedure queen cells typically are raised on the comb surface. In comparison, queen cells produced in preparation for swarming are found along the bottom margins of the frames or in gaps in the beeswax combs within the brood area.

Drones

Drones (male bees) are the largest bees in the colony. They are generally present only during late spring and summer. The drone's head is much larger than that of either the queen or worker, and its compound eyes meet at the top of its head. Drones have no stinger, pollen baskets, or wax glands. Their main function is to fertilize the virgin queen during her mating flight. Drones become sexually mature about a week after emerging and die instantly upon mating. Although drones perform no useful work for the hive, their presence is believed to be important for normal colony functioning.While drones normally rely on workers for food, they can feed themselves within the hive after they are 4 days old. Since drones eat three times as much food as workers, an excessive number of drones may place an added stress on the colony's food supply. Drones stay in the hive until they are about 8 days old, after which they begin to take orientation flights. Flight from the hive normally occurs between noon and 4:00 p.m. Drones have never been observed taking food from flowers.

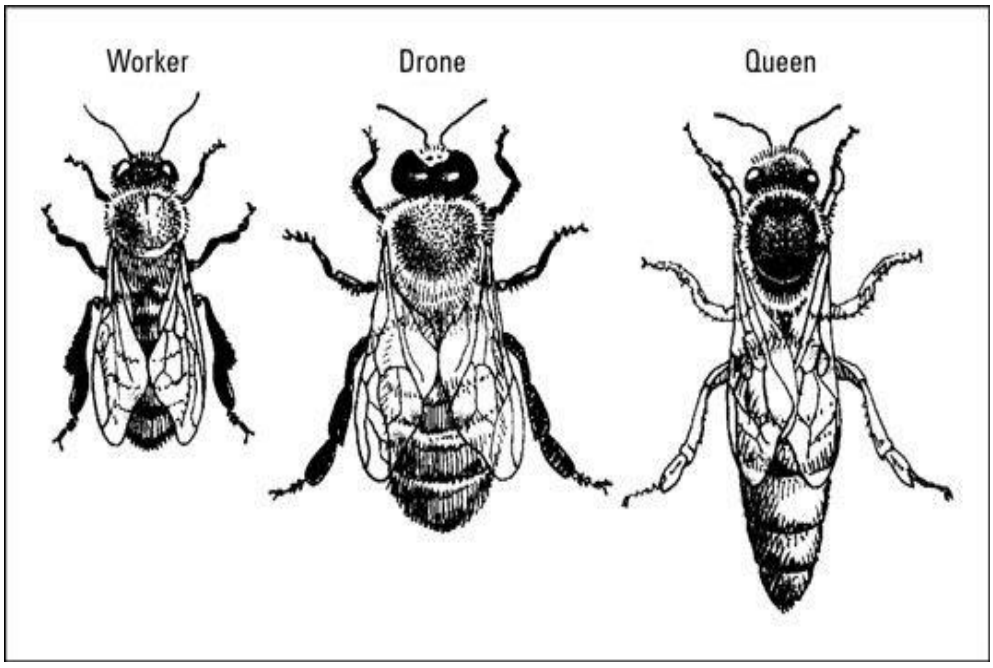
When cold weather begins in the fall and pollen/nectar resources become scarce, drones usually are forced out into the cold and left to starve. Queenless colonies, however, allow them to stay in the hive indefinitely

Workers

Workers are the smallest and constitute the majority of bees occupying the colony. They are sexually undeveloped females and under normal hive conditions do not lay eggs.

Workers have specialized structures, such as brood food glands, scent glands, wax glands, and pollen baskets, which allow them to perform all the labors of the hive. They clean and polish the cells, feed the brood, care for the queen, remove debris, handle incoming nectar, build beeswax combs, guard the entrance, and air-condition and ventilate the hive during their initial few weeks as adults. Later as field bees they forage for nectar, pollen, water, and propolis (plant sap).

The life span of the worker during summer is about 6 weeks. Workers reared in the fall may live as long as 6 months, allowing the colony to survive the winter and assisting in the rearing of new generations in the spring before they die.



Laying Workers

When a colony becomes queenless, the ovaries of several workers develop and workers begin to lay unfertilized eggs. Development of the workers' ovaries is believed to be inhibited by the presence of brood and the queen and her chemicals. The presence of laying workers in a colony usually means the colony has been queenless for one or more weeks. However, laying workers also may be found in normal "queenright" colonies during the swarming season and when the colony is headed by a poor queen. Colonies

with laying workers are recognized easily: there may be anywhere from five to fifteen eggs per cell (Figure 3) and small-bodied drones are reared in worker-sized cells. In addition, laying workers scatter their eggs more randomly over the brood combs, and eggs can be found on the sides of the cell instead of at the base, where they are placed by a queen. Some of these eggs do not hatch, and many of the drone larvae that do hatch do not survive to maturity in the smaller cells.

Bee Development

All three types of adult honey bees pass through three developmental stages before emerging as adults: egg, larva, and pupa. The three stages are collectively labeled brood. While the developmental stages are similar, they do differ in duration (see Table 1). Unfertilized eggs become drones, while fertilized eggs become either workers or queens Nutrition plays an important part in caste development of female bees; larvae destined to become workers receive less royal jelly and more a mixture of honey and pollen compared to the copious amounts of royal jelly that the queen larva receives.

Brood

Eggs

Honey bee eggs are normally laid one per cell by the queen. Each egg is attached to the cell bottom and looks like a tiny grain of rice. When first laid, the egg stands straight up on end (Figure 4). However, during the 3-day development period the egg begins to bend over. On the third day, the egg hatches into a tiny grub and the larval stage begins

Larvae

Healthy larvae are pearly white in color with a glistening appearance. They are curled in a “C” shape on the bottom of the cell (Figure 5). Worker, queen, and drone cells are capped after larvae are approximately 5 ½, 6, and 6 ½ days old, respectively. During the larval stage, they are fed by adult worker (nurse) bees while still inside their beeswax cells. The period just after the cell is capped is called the prepupal stage. During this stage

the larva is still grub-like in appearance but stretches itself out lengthwise in the cell and spins a thin silken cocoon. Larvae remain pearly white, plump, and glistening during the prepupal stage.

Pupae

Within the individual cells capped with a beeswax cover provided by adult worker bees, the prepupae begin to change from their larval form to adult bees (Figure 6). Healthy pupae remain white and glistening during the initial stages of development, even though their bodies begin to take on adult forms. Compound eyes are the first feature begin to take on color; changing from white to brownish-purple. Soon after this, the rest of the body begins to take on the color of an adult bee. New workers, queens, and drones emerge approximately 12, 7 ½, and 14 ½ days, respectively, after their cells are capped.

CASTES OF HONEY BEE

Every honey bee colony comprises of a single queen, a few hundred drones and several thousand worker castes of honey bees. Queen is a fertile, functional female, worker is a sterile female and the drone is a male insect.

Sex differentiation in bees

Queen and worker develop from fertilized egg while drone develops from unfertilized egg. Further differentiation of queen and worker depends on the quality and quantity of food that is fed to the queen or worker larvae.

The Queen

There is only one queen in a colony. It is considerably larger than the members of

other castes. Her wings are much shorter in proportion to her body. Because of her long tapering abdomen, it appears more wasp-like than other inmates of the colony. The queen is the only individual which lay eggs in a colony and is the mother of all bees. It lays upto *2000* eggs per day in *Apis mellifera.* Five to ten days after emergence, she mates with drones in one or more nuptial flights. When her spermatheca is filled with sperms, she will start laying eggs and will not mate any more. She lives for 3 years.

The secretion from mandibular gland of the queen is called queen's substance. The queen substance if present in sufficient quantity, prevent swarming and absconding of colonies, prevent development of ovary in workers, and maintains colony cohesion. The queen can lay either fertilized or sterile eggs depending on the requirement. The differentiation in worker and queen is due to the quantity and quality of food fed to the larva. The larva which .becomes the queen is fed the *royal jelly,* a secretion from hypopharyngeal glands of the worker bees. The queen is reared in large finger-shaped cells in the lower portion of the combs. Only one queen can remain in a colony, but during unfavourable season two queens are also observed. The old queen is killed as soon as the new queen is fertilized. Generally queens are reared only during swarming season, but if the queen dies accidentally the bees can rear a new queen. The phenomenon of raising queen in off-season is called supersedure. There is a good family planning in the colony. The number of eggs and egg laying depend on the availability of pollen and nectar in nature. If the food is scarce, workers do not permit the queen to lay eggs.The queen is carefully, looked after by young workers, known as-attendants, which feed her and keep her clean and well combed. The queen never leaves the, hive except with a swarm.

TheDrone

The drones are the male bees. They are much larger and stouter than either the queen or the workers although their body is not quite as long as that of the queen. They have no sting; a suitable proboscis for gathering nectar is also absent. They are, therefore,

physically incapable for the ordinary work of the hive. Their only function is to impregnate the young queen a task which they are unable to perform until they are about 10 days of age. They also help in maintenance of hive temperature. They go out of the hive only at the mid-day when the weather is warm. The number of drones in a colony often is very large amounting to hundreds and sometimes to thousands. The drones are reared and tolerated during the breeding season. They are driven out of the hive to die of starvation before the monsoon and the winter. The drones are produced by unfertilized eggs of the queen, or by those workers which take up the reproductive function due to the absence of a queen in a colony. The normal life-span of a drone is 57 days. Mating takes place in the open when the queen is in flight. The drone dies in the act or immediately afterwards. Its abdomen has to burst open to allow the genital organ to function

The Worker

The workers are the smallest inhabitants of the beehive. They form the bulk of the population. The number of workers in a colony varies from 1,500 to 50,000. They are imperfect females incapable of laying eggs. On certain occasions when the colony is in need of a queen, some of the workers start laying eggs from which only drones are produced. These workers, called *laying workers,* are killed as soon as a new queen is introduced or produced in the colony.

The life-span of a worker is about 4 weeks during active season and 8 to 10 weeks during less active season. Their range of flight varies from 1,000 to 1,500 m. The division of work within a colony among the worker bees is based on the age of the individual and on the needs of the colony. Normally, the young bees, immediately after their emergence, do the work of cleaning cells and feeding older larvae. When they are grown and their hypopharyngeal glands have developed, they secrete the royal jelly with which they feed the younger larvae. These bees are called *nurse bees.* For the first 2 to 18 days of their life, the bees perform indoor duty inside the hive, including comb construction when some

young bees start secreting wax. Later on they become foragers, collect water, pollen, nectar and propolis (bee-blue). Pollen is a nitrogenous food and is essential for brood - rearing and young bees. Bees wax, of which the comb is made, is a secretion of the wax glands located in the abdomen of the worker bees. For producing 1 kg of wax the bees consume 10 kg of honey.

Thus the lifespan of workers can be divided into two phases as first three weeks for house hold duty and rest of the life for outdoor duty.

Household duties

- Build comb with wax secretion from wax glands.
- Feed the young larvae with royal jelly secreted from hypopharyngeal gland.
- Feed older larvae with bee-bread, a mixture of pollen and honey
- Feeding and attending queen.
- Feeding drones.
- Cleaning, ventilating and cooling the hive.
- Guarding the hive.
- Evaporating nectar and storing honey

Outdoor duties

- Collecting nectar, pollen, propolis and water.
- Ripening honey in honey stomach.

Seasonal Cycles of Activities in Colonies

A colony of honey bees comprises a cluster of several to 60,000 workers (sexually immature females), a queen (a sexually developed female), and, depending on the colony population and season of year, a few to several hundred drones (sexually developed males). A colony normally has only one queen, whose sole function is egg laying. The bees cluster loosely over several wax combs, the cells of which are used to store honey (carbohydrate food) and pollen (protein food) and to rear young bees to replace old adults.

The activities of a colony vary with the seasons. The period from September to December might be considered the beginning of a new year for a colony of honey bees. The condition of the colony at this time of year greatly affects its prosperity for the next year.

In the fall a reduction in the amounts of nectar and pollen coming into the hive causes reduced brood rearing and diminishing population. Depending on the age and egg-laying condition of the queen, the proportion of old bees in the colony decreases. The young bees survive the winter, while the old ones gradually die. Propolis collected from the buds of trees is used to seal all cracks in the hive and reduce the size of the entrance to keep out cold air.

When nectar in the field becomes scarce, the workers drag the drones out of the hive and do not let them return, causing them to starve to death. Eliminating drones reduces the consumption of winter honey stores. When the temperature drops to 57° F, the bees begin to form a tight cluster. Within this cluster the brood (consisting of eggs, larvae, and pupae) is kept warm-about 93° F – with heat generated by the bees. The egg laying of the queen bee tapers off and may stop completely during October or November, even if pollen is stored in the combs. During cold winters, the colony is put to its severest test of endurance. Under subtropical, tropical, and mild winter conditions, egg laying and brood rearing usually never stop.

As temperatures drop, the bees draw closer together to conserve heat. The outer layer of bees is tightly compressed, insulating the bees within the cluster. As the temperature rises and falls, the cluster expands and contracts. The bees within the cluster have access to the food stores. During warm periods, the cluster shifts its position to cover new areas of comb containing honey. An extremely prolonged cold spell can prohibit cluster movement, and the bees may starve to death only inches away from honey.

The queen stays within the cluster and moves with it as it shifts position. Colonies that are well supplied with honey and pollen in the fall will begin to stimulatively feed the

queen, and she begins egg laying during late December or early January-even in northern areas of the United States. This new brood aids in replacing the bees that have died during the winter. The extent of early brood rearing is determined by pollen stores gathered during the previous fall. In colonies with a lack of pollen, brood rearing is delayed until fresh pollen is collected from spring flowers, and these colonies usually emerge from winter with reduced populations. The colony population during the winter usually decreases because old bees continue to die; however, colonies with plenty of young bees produced during the fall and an ample supply of pollen and honey for winter usually have a strong population in the spring

Spring Activity

During early spring, the lengthening days and new sources of pollen and nectar stimulate brood rearing. The bees also gather water to regulate temperature and to liquefy thick or granulated honey in the preparation of brood food. Drones will be absent or scarce at this time of the year.

Later in the spring, the population of the colony expands rapidly and the proportion of young bees increases. As the population increases, the field-worker force also increases. Field bees may collect nectar and pollen in greater amounts than are needed to maintain brood rearing, and surpluses of honey or pollen may accumulate).

As the days lengthen and the temperature continues to increase, the cluster expands further and drones are produced. With an increase in brood rearing and the accompanymg increase in adult bees, the nest area of the colony becomes crowded. More bees are evident at the entrance of the nest. A telltale sign of overcrowding is to see the bees crawl out and hang in a cluster around the en trance on a warm afternoon.

Combined with crowded conditions, the queen also increases drone egg laying in preparing for the natural division of the colony by swarming. In addition to rearing workers and drones, the bees also prepare to rear a new queen. A few larvae that would

normally develop into worker bees are fed a special gland food called royal jelly, their cells are reconstructed to accommodate the larger queen, and her rate of development is speeded up. The number of queen cells produced varies with races and strains of bees as well as individual colonies.

Regardless of its crowded condition, the colony will try to expand by building new combs if food and room are available. These new combs are generally used for the storage of honey, whereas the older combs are used for pollen storage and brood rearing.

Swarming

When the first virgin queen is almost ready to emerge, and before the main nectar flow, the colony will swarm during the warmer hours of the day. The old queen and about half of the bees will rush en masse out the entrance. After flying around in the air for several minutes, they will cluster on the limb of a tree or similar object. This cluster usually remains for an hour or so, depending on the time taken to find a new home by scouting bees. When a location is found, the cluster breaks up and flies to it. On reaching the new location, combs are quickly constructed, brood rearing starts, and nectar and pollen are gathered. Swarming generally occurs in the Central, Southern, and Western States from March to June, although it can occur at almost any time from April to October.

After the swarm departs, the remaining bees in the parent colony continue their field work of collecting nectar, pollen, propolis, and water. They also care for the eggs, larvae, and food, guard the entrance, and build combs. Emerging drones are nurtured so that there will be a male population for mating the virgin queen. When she emerges from her cell, she eats honey, grooms herself for a short time, and then proceeds to look for rival queens within the colony. Mortal combat eliminates all queens except one. When the survivor is about a week old, she flies out to mate with one or more drones in the air. The drones die after mating, but the mated queen returns to the nest as the new queen mother. Nurse bees

care for her, whereas prior to mating she was ignored. Within 3 or 4 days the mated queen begins egg laying.

During hot summer days, the colony temperature must be held down to about 93° F. The bees do this by gathering water and spreading it on the interior of the nest, thereby causing it to evaporate within the cluster by its exposure to air circulation.

During the early summer, the colony reaches its peak population and concentrates on the collection of nectar and pollen and the storage of honey for the coming winter. After reproduction, all colony activity is geared toward winter survival. Summer is the time for storage of surplus food supplies. The daylight period is then longest, permitting maximum foraging, although rain or drought may reduce flight and the supply of nectar and pollen available in flowers. It is during the summer that stores are accumulated for winter. If enough honey is stored, then the beekeeper can remove a portion and still leave ample for colony survival.

Foraging of Bees

All **bees**, except the queen, depend on flower pollen as a protein source and nectar (a sweet liquid found in flowers) as an energy source. At midlife, it's the worker **bee's** job to fly away from the hive to find flowering plants and return with nectar and pollen to feed her hive mates, including the larvae.

Forager honey bees function not only as gatherers of food for their colonies, but also as sensory units shaped by natural selection to gather information regarding the location and profitability of forage sites. They transmit this information to colony members by means of waggle dances. To investigate the way bees transduce the stimulus of nectar-source profitability into the response of number of waggle runs, Seeley (1994) performed experiments in which bees were stimulated with a sucrose solution feeder of known profitability and their dance responses were video recorded.

The results suggest that several attributes of this transduction process are adaptations to enhance a bee's effectiveness in reporting on a forage site.

1) Bees register the profitability of a nectar source not by sensing the energy gain per foraging trip or the rate of energy gain per trip, but evidently by sensing the energetic efficiency of their foraging. Perhaps this criterion of nectar-source profitability has been favored by natural selection because the foraging gains of honey bees are typically limited by energy expenditures rather than time availability.

2) There is a linear relationship between the stimulus of energetic efficiency of foraging and the response of number of waggle runs per dance. Such a simple stimulus-response function appears adequate because the range of suprathreshold stimuli (max/min ratio of about 10) is far smaller than the range of responses (max/min ratio of about 100). Although all bees show a linear stimulus-response function, there are large differences among individuals in both the response threshold and the slope of the stimulus-response function. This variation gives the colony a broader dynamic range in responding to food sources than if all bees had identical thresholds of dance.

3) There is little or no adaptation in the dance response to a strong stimulus (tonic response). Thus each dancing bee reports on the current level of profitability of her forage site rather than the changes in its profitability. This seems appropriate since presumably it is the current profitability of a forage site, not the change in its profitability, which determines a site's attractiveness to other bees.

4) The level of forage-site quality that is the threshold for dancing is tuned by the bees in relation to forage availability. Bees operate with a lower dance threshold when forage is sparse than when it is abundant. Thus a colony utilizes input about a wide range of forage sites when food is scarce, but filters out input about low-reward sites when food is plentiful.

5) A dancing bee does not present her information in one spot within the hive but instead distributes it over much of the dance floor. Consequently, the dances for different forage sites are mixed together on the dance floor. This helps each bee following the dances to take a random sample of the dance information, which is appropriate for the foraging strategy of a honey bee colony since it is evidently designed to allocate foragers among forage sites in proportion to their profitability.