Name of Teacher	**PROF (DR) VINAY KUMAR SINGH**
Mob. Number	**9807110100**
E-mail	**vinay.zool@ddugu.ac.in**
Designation	**Professor**
University Name	**Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur**
Stream	**BIO-GROUP**
Faculty	**SCIENCE**
Department/ Subject	**ZOOLOGY**
Course	304- Applied Zoology
Course Duration	Semester (CBCS)
Sub Topic	**Beekeeping in India**
Content	Introduction, Natural Beekeeping, Honeybee Species in India, Social Organization, Honey, Composition & properties, Colony Reproduction: Swarming and Supersedure, Obtaining equipment and bees, Acquiring beehives, Bee Enemies.
Search KeyWords	Apiculture, Beekeeing, Apis Species, Hives

Learning Outcomes

Understanding about the beekeeping in India.
Information of various types of bees their role in pollination and natural diversity.
Identify the different Bees in India.
Suggest various methods for the Beekeeping.

Fig shows bees inside the hives

Introduction:

Honey bees are highly organized social insects reported from all over the world. Although they are active throughout the year but in extreme winter they do little work and do not

rear the brood. They exhibit polymorphism and good division of labour. Beekeeping is an art and a mesmerizing science. In India beekeeping is mostly practised as a full-time occupation and an engrossing hobby to produce handsome income and table honey. Honeybees are special gift to mankind because beekeeping can be done for both their pollination services and their cherished products such as honey, beeswax, propolis, bee venom, etc. These products have their widespread use in different small and large scale industries in India. The only bitter part of beekeeping is the bee sting. Honeybees sting to defend their colony, but this bitterness squeezed from a single colony of rock bee per year. Because of their pollinating activities, honey-bees are the most economically important insect on earth, and certainly the most studied. Honey production is essentially a side issue. The hony-bee's role- and thus the beekeeper's role- in this becomes more important and valuable by the day as our farming and other practices dramatically eradicate the habitats of other types of bees and pollinating insects. Some insects can exists only by eating the pollen of certain plants.

Natural Beekeeping

There is a current movement that eschews chemicals in the beekeeping and believes that health issues in bees can most effectively be addressed by reversing trends that disrespect the needs of the bees themselves. Crop spraying unnatural conditions in which bees are moved thousands of miles to pollinate commercial crops. Frequent opening of the hive for inspection, artificial insemination of queens, routine medication and sugar water feeding are all thought to contribute to a general weakening of the constitution of the honey bee.

Honeybee Species in India

Rock Bee *(Apis dorsata)*

They are huge and ferocious bees that construct a single comb in the open usually about 3-4 feet tall. They can be seen all over the subcontinent mainly in the forests and also in concrete jungles. In hilly regions they construct their nest up to an altitude of 2700 m. Rock bees habitually shift their places. Nearly 50–80 kg of honey can be squeezed from a single colony of rock bee per year. The giant honeybees of Nepal and the Himalayas have recently been reclassified as belonging to another species of *Apis*, as *A. dorsata laboriosa*. *Apis dorsata binghami* is another subspecies of *dorsata* distributed in restricted areas of the northeast, namely, in Khasi Hills, Sikkim and Meghalaya. Mostly these bees construct their combs at a height of more than 20 ft from the ground, but in some cases, we can also see the colonies hanging from branches just

above 2 ft from the ground. Colonies of *A. dorsata* may occur singly or in groups. The lower part of the comb is the energetic area in which the foraging and scout bees will take off and land. There is general concern that the total number of *A. dorsata* nests all over Asia is declining, partly due to shrinking forest areas, the use of toxic pesticides in foraging farm lands and bee hunting.

Little Bee (*Apis florea*)

Apis florea or dwarf honeybee is also a wild honeybee spp., but these bees are small and less ferocious when compared to the rock bees. These bees build single vertical combs. They also construct palm-sized combs in the bushes, hedges, buildings, caves, empty cases, etc. The major difference between the rock bee and little bee comb is that the little bees construct combs encircling the twigs while the rock bees construct the comb on the undersurface of the branch. The honey produced by these bees is dramatically less when compared to the rock bee as these bees produce only about half a kilo of honey per year per hive. However, in the Kutch area of Gujarat, large quantities of honey from *A. florea* are harvested. As these bees also have a habit of shifting their colonies frequently, they are also non-rearable, but attempts in India have brought partial success. These bees are found only in plains and not in hills. Compared to other honeybees, these bees are attractively coloured with red to brown colouration having white bands. They are excellent pollinators, which give them an important ecological role in the places they inhabit. *Apis florea* is also identified for their hissing sounds when they see a predator. This hissing sound is audible to human ear.

Indian Bee (*Apis cerana*)

Indian honeybee or Eastern honeybee is a well-known bee species in India. Prior to the introduction of Italian bee, this was the only rearable *Apis* bee spp. in India. These are comparatively non-aggressive and rarely shift locations. These bees construct multiple parallel combs in dark places such as clay pots, logs, wall, tree openings, etc. and produce 7–9 kg of honey per colony per year. They are classified *Apis cerana* into subspecies based on the living habitats and genetic diversity; of these *Apis cerana indica* and *Apis cerana cerana* occur in India. In India, the subspecies *Apis cerana indica* is recognized into two morphotypes like “hills bee” (black coloured) and plains bee (yellow coloured). Presently beekeeping with Indian bees is mostly done in south India and particularly in Kanyakumari district of Tamil Nadu, with more than 50,000 beekeepers involved. Since these bees have built their colonies in dark cavities, it

enables man to keep them in specially constructed movable frame hives. The combs of *A. cerana* colony are built parallel to each other and at uniform distance known as the "bee space", which is respected between them. Compared to rock bees and Italian bees, these are small in size but bigger than the dwarf bees. Brood comb consists of cells of two sizes: smaller for the worker brood and larger for the drone brood. The queen cells are built on the lower edge of the comb. Like other bee species, these bees also store honey in the upper part of their hive. Because of this behaviour, the bee boxes are designed in such a way that the super chamber or the honey chamber is in the upper part of the hive where these bees store honey which helps in easy honey extraction.

European Bee/Italian Bee (*Apis mellifera ligustica*)

Italian bee (*Apis mellifera ligustica*) is one of the sub species of *A. mellifera* and is not native to India and was introduced from Europe during the second half of 20th century. The introduction was primarily because the native Indian bee colonies were vanishing because of the Thai sacbrood virus. Presently they are well established in India and mostly present in northern India because of the rich flora such as mustard, safflower, sun flower, etc. As rice is the major crop in south India, these bees don't get enough amount of food they need. In south India, beekeeping with Italian bees is hardly practised; for commercial beekeeping, these Italian bees have to be migrated by floral mapping. They are also similar in habits to Indian bees, which build parallel combs in dark places and store honey at the upper portion of their colony They are bigger than all other honeybees except *Apis dorsata*. They produce 25–40 kg of honey per colony per year. Probably these bees are the one of the most studied animals. The introduction of *A. mellifera* to India created problems such as the interspecies transmission of bee pests and diseases. But the introduction of these bees to India can be recorded as success story because it created employment for many people in India with profitable income and also by the pollination service these bees done to Indian flora.

Stingless Bee

Stingless or dammar bees are of smallest size compared to other honey-yielding bees (less than 5 mm). They belong to the family Apidae and subfamily Meliponinae. It consists of two genera *Melipona* and *Trigona*. Meliponinae includes eight genera, having 15 subgenera and more than 500 species. These bees are widely known as dammar bees in India (dammar is a resin from among dipterocarp trees) with additional local names commonly applied, e.g. "putka" in Sikkim

and Nepal “ngap siwor”, “ngap hamang” and “ngap khyndew” in Khasi language; and “cherutheneecha” and “arakki” in Kerala. As the name implies, these bees can’t sting as their stingers are highly reduced, but they try to defend their colony from intruders using their mandibles. The stingless bees are important pollinators of various food crops and can be domesticated. But the honey yield per hive per year is very low approximately 100 g. As in other regions where stingless bees occur, colonies can be kept in tree logs, wooden boxes and clay pots for harvesting small quantities of highly prized medicinal honey, wax and propolis, used for its household and curative properties. The materials used for nest building are mainly pure wax or cerumen, a mixture of wax and propolis, resins, plant fibres and clay.

Social Organization

The Queen

Queen bee is the mother of all other bees in the colony. It can be identified with its long abdomen and short wings. The duty of the queen is to lay eggs. The queen maintains the colony by its pheromones. Her productivity depends on the amount of food the workers bring in and the amount of brood space in the colony. She can lay more than 1500 eggs a day. If it is a honey flow season and if there are enough cells available, she will lay up to 2500 a day. Queen emerges from queen cell which is situated at the bottom portion of the comb and looks like a small cup, and in India it is famously known as cow’s teat because of its structural resemblance. After emergence the newly emerged queen destroys the remaining queen cells in the colony and fights any other queens she finds. The virgin queen will typically stay in the colony for a few days in order to feed and gain strength and allow her reproductive organs to mature a little further. After 6–8 days, the queen will leave the colony for her nuptial flight, which occurs 30 m above the ground where she mates with many strong drones who can fly with the queen as she flies better than drones. Postmating, the queen returns to the hive to lay the eggs. Average life span of queen is about 5 years, but the egg laying capacity will be only up to 2 years.

Queen

The difference between a worker bee and a queen is due solely to the quality and quantity of the food fed to the larvae. The queen larvae receive a much larger percentage of royal jelly over a longer period than do worker larvae. Royal jelly contains a much higher proportion of worker mandibular gland secretions, and the difference is very marked. Royal jelly has up to 10 times more pantothenic acid and 18 times more biopterin than food fed to worker larvae, but quantity is also important, and queen larvae must consume far more food than workers. For the first two or three days of larval development, the respiratory and growth rates of queens and workers are similar. The queen rates accelerate, however, during the last few days so, although the development of workers and queens is based on nutrition.

The Worker

There are thousands of workers in a colony, and they perform all the duties in the colony including foraging, defending, brood rearing and cleaning activities. They are smaller than the queen and drones. There are about 8000–25,000 workers in *A. florae* colony, 40,000–50,000 workers in *A. mellifera* colony, 20,000–40,000 workers in *A. cerana* and 50,000–80,000 in *A. dorsata* colony. For defending the colonies, worker bees possess sting which is a modified ovipositor, and venom is pumped out at the time of stinging. Workers may lay eggs, under certain conditions, which develop into drones since workers never mate and they have no sperm to fertilize their eggs.

However, in a normal queen right colony, worker regulation occurs and workers consume eggs produced by other workers. In *A. cerana*, unlike *A. mellifera*, there can be a relatively large number of egg laying workers. Workers at their young stages perform indoor duties, and they will get license to go out for foraging only when they are old enough (normally after 21 days).

The Drone

Drones can be easily identified by their dark colour and eyes touching at the top of their head. Their only function is to fertilize the queen and enjoy the food inside the hive. They do not sting as they lack stingers. Drones are “haploid”, and they only possess one-half of the pairs of genes found in the “diploid” workers and queen. In a colony there are about hundreds of drones, drone cells differ from worker cells with enlarged cappings, and in India commercial beekeepers decap these drone cells as drones consume the stored honey. They have excellent navigation abilities when compared to the other two castes because they have around 75–80 % more facets in their compound eyes than the workers or queen.

Structure of a bee colony

A domesticated bee colony is normally housed in a rectangular hive body, within which eight to ten parallel house the vertical plates of honeycomb which contains the eggs, larvae, pupae and food for the colony. The two outside combs at each side of the hive tend to be exclusively used for long term storage of honey and pollen.

Within the central brood nest, a single frame of comb will typically have a central disc of eggs. Larvae and sealed brood cells which may extent almost to the edges of the frame. Immediately above the brood patch or arch of pollen filled cells extends from side to side and above that again a broader arch of honey-filled cells extends to the frame tops. The pollen is protein-rich food for developing larvae, while honey is also food but largely energy-rich rather than protein-rich. The nurse bees which care for the developing brood secrete a special food

called "Rayal Jelly" after feeding themselves on honey and pollen. The amount of Rayal Jelly which is fed to a larva determines whether it will develop into a queen.

Apart from the honey stored within the central brood frames, the bees store surplus honey in comb above the brood nest. In modern hives the beekeeper places separate boxes called 'Supers', above the brood box, in which a series of shallower combs is provided for storage of honey. This enables the beekeeper to remove some of the supers in the late summer, and to extract the surplus honey harvest without damaging the colony of bees and its brood nest below. If all the honey is stolen including the amount of honey needed to survive winter, the beekeeper must replace this store by feeding the bee's sugar or corn syrup in autumn.

Honey

All beekeepers start beekeeping by wanting to produce honey, and this is probably the best way to begin. If given a shelter to live in, a colony of bees will produce honey without a beekeeper's intervention but, if you want them to produce it in abundance and in a manner that makes it easy to extract, then you need to learn more about beekeeping. But, in the meantime, what is this sweet substance and where does it come from?

Composition

Being a natural product, honey varies in composition enormously but, essentially, it is a fluid, viscous or crystallized substance, produced by bees from the nectar of blossoms that bees collect, transform or combine with substances of their own, which they then store and leave to mature. Its main components are water and sucrose. Sucrose is composed of glucose and fructose, and it is the glucose-to-fructose ratio that determines some of honey's most noticeable physical characteristics, such as how long it will take to crystallize, for example. Water is always present in honey, and the amount is critical to the beekeeper when processing or storing extracted honey.

A more detailed definition of the composition of honey would be as follows:

Honey is composed mainly of sugars and water.

The average honey is 79.6% sugar and 17.2% water. The main sugars are fructose (38.2%) and glucose (31.3%). Other sugars include maltose (7.3%) and sucrose (1.3%). Honey also contains acids (.57%), protein (.26%), a small amount of minerals (.17%) and a number of other minor components, including pigments, flavour and aroma substances, sugar alcohols, colloids and vitamins. This group of materials constitutes about 2.2% of the total composition.

Properties

Honey has many determinative properties but, for the average beekeeper who wants to sell honey, the important ones are as follows.

Hard or soft (liquid honey)

Most honeys eventually crystallize, but the rate of crystallization depends on the ratio of glucose to fructose in the honey, and that depends mainly on the floral source. Some honey, such as that from oilseed rape (canola), often crystallizes on the comb while still in the hive, making it very difficult for the bees to use as stores and difficult for the beekeeper to extract using standard equipment. To the beekeeper, honey viscosity is very important, especially during extraction and packing, and larger companies will heat their honey so that it flows through their equipment more readily and can be packed in jars or drums easily. Some honeys may be thixotropic, which means they become jelly-like if left undisturbed.

Taste

The taste of honey varies enormously. Try some clover honey and then some manuka honey and you will find a huge difference. Manuka isn't highly regarded for taste and used to be thrown away or fed back to the bees.

Colour

Colour shouldn't be an issue really but, in fact, in some countries such as the USA and Germany, for example, it is very much a determinant of price. The Americans prefer their honey 'water white', and dark honeys are referred to as 'bakers' honey' and command a lower price. In Germany, dark honey is preferred, and pale or white honeys are lower in price. I once produced some honeydew from the cork-oak forest aphids of southern Spain. It was a dense black and had a remarkably strong taste.

Antibacterial quality

Honey's 'hyper-osmotic' nature (due to the high concentration of solids and low moisture content) prevents the growth of bacteria and yeasts as this draws water out of the organisms, killing them by desiccation. It literally sucks them dry. Honey also has a high acidity, which plays an important role in the system that prevents bacterial growth. The pH of honeys may vary from approximately 3.2 to 4.5 (average pH = 3.9), making it inhospitable for attack by most, but not all, bacteria. Honey also has its own antibacterial substance in its make-up. Bees add an enzyme called glucose oxidase to honey, and this enzyme reacts with glucose to produce

hydrogen peroxide and gluconic acid, both of which have an antibacterial effect. This system is most active in dilute honey and probably helps preserve honey diluted for brood food use. Like most products of the hive, honey is essentially a by-product of the all-important pollination process. The value of honey in the economy of the major honey-producing nations is far less than the value of pollination, but there is a huge global trade in honey and many beekeepers can make a very decent living by producing good honey either in bulk or packaged for sale.

Honeydew

Honeydew is a sugar-rich sticky substance, secreted by aphids and some scale insects as they feed on plant sap. Because the sap has little protein, the aphids need to take in large quantities of this high-pressure liquid and, when their mouth-part penetrates the phloem, the sugary liquid is forced out of the gut's terminal opening at the back end. Bees and ants feed on this liquid, which drips off the aphids onto the leaves and bark of the tree. Honeydew is therefore still a plant-derived substance but it also has the addition of insect enzymes as well as bee enzymes and generally has a broader spectrum of sugars. Honeydew is usually very dark in colour, often due to the sooty mould that can form on it.

Colony Reproduction: Swarming and Supersedure

All colonies are totally dependent on their queen, who is the only egg-layer. However, even the best queen live only one or two years. All the time that the queen is fertile and laying eggs, she produces a variety of pheromones which control the behavior of the bees in the hive; these are commonly called 'queen substances'.

A queen cell hanging from the bottom of a frame (note the 'sculpture' of the cell)

A virgin queen emerges

If left alone, after around 16 days, from one or more of these cells a virgin queen will emerge that will take over the colony, the old queen having departed with the swarm. This new virgin queen will go to the other queen cells, if allowed to by the workers, and will sting through the cell to kill off her potential rivals. The virgin, however, is now in a precarious position. She has to leave the hive and fly off to a drone congregation area to mate with many drones and then return to the hive. This is a very dangerous period of her life. She could become lost, be eaten, hit bad weather or be sprayed with pesticide. The worker bees may have protected one or more of the remaining queen cells just in case she doesn't return and they need another virgin, and they may have prevented the first virgin queen from harming it. If she mates successfully and returns to the colony without mishap, however, she will be allowed to kill off any rivals, whether they have emerged or not, or the bees themselves may tear down any remaining queen cells.

Swarming: The process of leaving off the colony by the queen termed as swarming. It happens towards the end of spring or early summer but the real cause of warming is still not well known. When a plenty of food is available and hive is overcrowded by the bees, the queen leaves the hive on a fine fore-noon with some old drones and workers and establishes a new colony at some other places. Now in the old hive a worker is given Royal Jelly and is converted into a new queen of the colony. This new impress of the colony never tolerates her successor as a natural law in the hive so she orders to kill the other sisters, if any, in the hive.

Supersedure: When the egg laying capacity of the old queen is lost or is suddenly dies, a new young and vigorous queen takes the position of the old queen and is called as supersedure.

Absconding: The migration of the complete colony from one place to another takes place due to some unfavourable condition of life, such as destruction of the comb by termites or wax-moth and scarcity of nector producing flowers around the hive. This phenomenon is quite different from that of swarming.

Marriage flight or Nuptial: The first swarm is led by the old queen but the second swarm is led by the 7 days old virgin queen which is followed by the drones and is called marriage flight. One of the drones starts copulating with the queen in the sky and fertilizes the queen and dies during the course of copulation. The queen receives spermatophores and stores in the spermatheca. Along with the queen, dried drone falls on the ground and the queen reaches the hive.

Obtaining equipment and bees

Now that you know why you should keep bees and what beekeeping can do for you, it's time to move on to learning about how you can enter this fascinating and potentially lucrative sphere of activity. Getting started in beekeeping is not difficult and, to start off, you will need the following items: beehive(s), beekeeping tools, beehive sites and, finally, somewhere to keep all your equipment.

Acquiring beehives

Initially start with two (or more) beehives. The reason for this is that, during the beekeeping year, much can go wrong with a colony of bees and, as you will learn, if one colony begins to fail due, for example, to a bad queen or if it becomes entirely queenless, you can use bees, larvae and eggs from the second colony to help out. If you have only one colony you will have no immediate source of help and the colony will die out

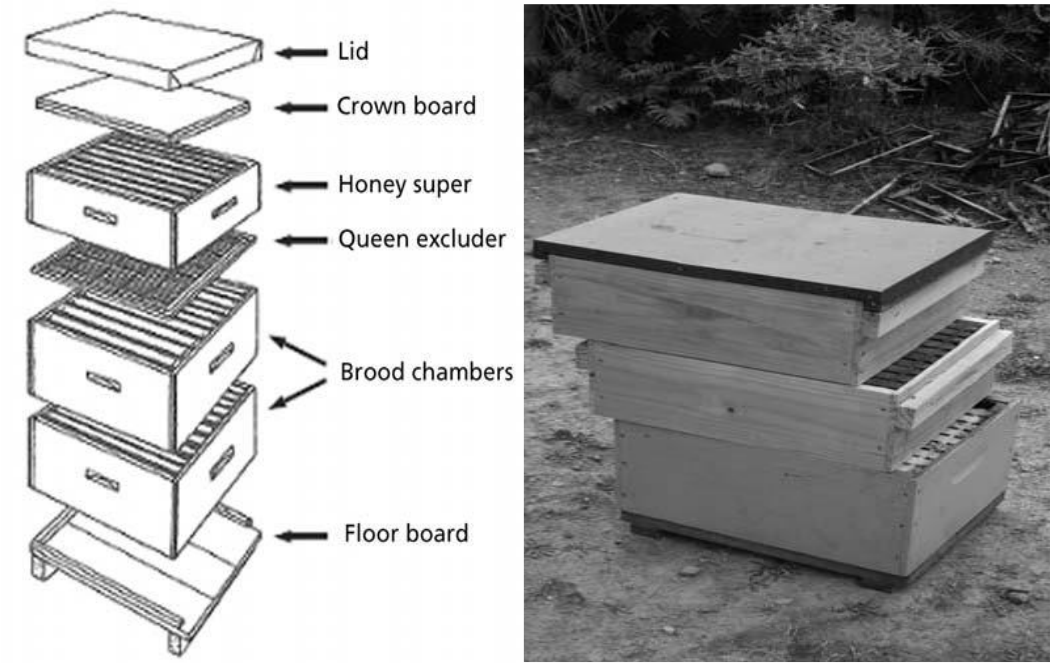


Fig shows different parts of hive

A modern beehive looks complicated to the beginner but is really just a simple series of boxes sitting on top of each other capped by a lid to keep the rain out. Inside the boxes, frames of beeswax hang down from a revetment along the inside edge of the hive. Hives usually have two sizes of box known as 'full' and '.' boxes. These different sizes are in height only and they can be used for different purposes. Many beekeepers use just one size of box; others use the different sizes on one hive.

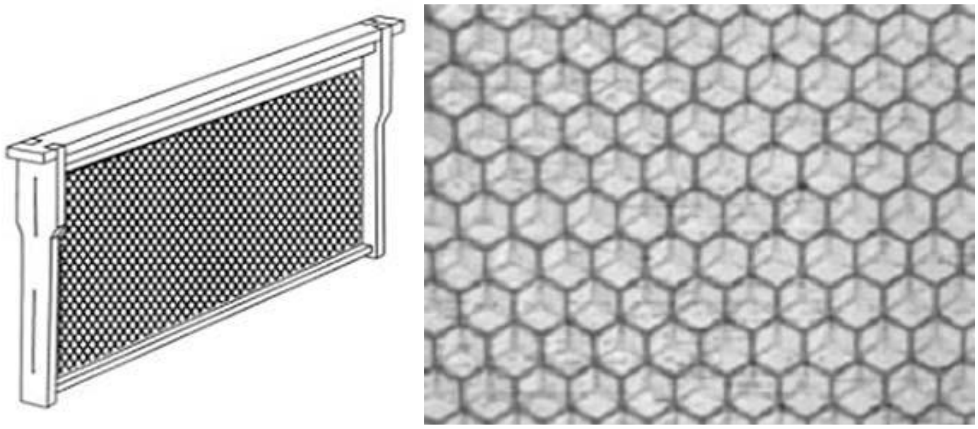
Hive stands

Beehives should not be set directly on the ground. This is especially so if the floor (see below) is open mesh. The main reason is that damp will get into the hive, and this must not be allowed to happen. A hive stand, therefore, is anything that keeps the hive off the ground. Stands can be pallets (four hives to a pallet), concrete blocks, bricks, wooden rails or simple wooden stands that hold one hive. In the main it is far better to improvise than to buy a stand from a beekeeping supply company (it is better in that it is cheaper and just as effective).

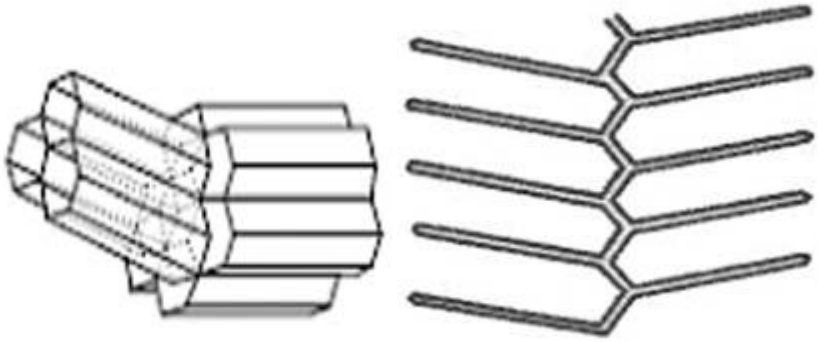
Fig shows a stainless-steel mesh floor

Foundation wax

Unless you are buying a hive already stocked with bees, your frames should have a wax foundation in them. This is a wax sheet that fits inside the frame and that is impregnated with the hexagonal shape of the honeycomb. The bees will use this sheet as the basis for building their honeycomb and will 'pull the wax out' – i.e. they will produce wax and add it to the pattern until a honeycomb is formed.



Foundation wax: (a) in the frame; (b) a sheet of wax



Wax cells: (a) pulled out; (b) sloped upwards to hold honey

Wax sheets can be easily damaged, especially when you want to extract the honey. Wire is usually therefore embedded in the sheet to hold it in the frames and to prevent damage.

A bee breeding system: an example

Bee breeding and improvement are not something that can be undertaken in isolation by small-scale beekeepers. Evaluations of the results require large numbers of trial colonies, but progressive improvements to populations can be achieved on a smaller scale. The following is an example of such an improvement. Closed-population line breeding is employed by breeders all over the world. In this system, instrumental insemination is used to improve the breeding

population progressively and to maintain high brood viability (this minimizes the loss of sex alleles and so minimizes inbreeding depression).

The procedure for closed-population line breeding is as follows:

- ✓ Identify the superior-performing queens in your stock and select 35–50 of these. These are the breeder queens.
- ✓ Produce several virgins from each breeder queen.
- ✓ Mate the virgins with 10 drones selected at random from the population.
- ✓ Place these mated queens in hives and evaluate their performance. The more evaluations, the better.
- ✓ Select superior queens from among these queens and use them as breeder queens.

Researchers have estimated that 35–50 breeder colonies must be selected and maintained in each generation if there is to be a 95% probability of retaining sufficient sex alleles for at least 85% brood viability for 20 generations.

Bee Enemies

Enemies of the bees harm the colony in different ways so they have attracted considerable attention in the different regions of the country. The Wax-moths (*Galleria mellonela* and *Achroea grisella*), Wasp (*Vespa* spp. and *Palarus* spp.), Black ants (*Componotus compressus*) and Kingcrow (*Dicrurus macrocercus*) are common enemies of the honey bee's comb and honey. *Merops aplaster*, commonly known as the bee eater, is a very beautiful bird. In one season a pair of birds can consume up to 30,000 bees.

References:

D Cramp. A practical Manual of Beekeeping. 2008, Spring Hill.

GS Shukla and V.B. Upadhyay. Economic Zoology, Fourth Ed. ISBN-81-7133-434-2, Rastogi Publications, India.

M Kishan Tej, R Aruna, Geetanjali Mishra, and M.R. Srinivasan. Beekeeping in India Chapter-February, 2017 DOI: 10.1007/978-981-10-3304-9_3.

R C Mishra. Honeybees and their management in India, publications and information division Indian council of agricultural research. 1995, Krishi Anusandhan Bhavan, Pusa, New delhi

----#####------