WOLLO UNIVERSITY, COLLEGE OF AGRICULTURE, DEPARTMENT OF ANIMAL SCIENCE

LECTURE NOTE ON APICULTURE AND HONEYBEE DISEASE

PREPARED BY TEWODROS ALEMU (MSc, Assistant Professor)

Dessie, Ethiopia

Chapter 1. TYPES OF BEEKEEPING

There are three types of beekeeping as described below.

1.1. Traditional Beekeeping

Traditional beekeeping is the oldest and richest practice, which has been carried out by people for thousands of years. The farmers in order to produce their bee baskets they use cheap local materials like clay, straw, bamboo, false banana leaves, and bark of trees, logs and animal dung. Like in other branches of agriculture, they do not need to invest and they use very few tools, mostly knife. Almost all methods are based on the concept of minimal management. They fix up the beehives and hung them on certain trees. For harvesting they have to climb up the trees to reach the baskets, which were placed in the upper branches, then use a flaming torch to clear the baskets and allow the honey to be collected. During harvesting, the colony will often be destroyed or at least damaged because the honeycomb together with the brood and the pollen is cut out with a knife. It includes forest and backyard beekeeping. Forest beekeeping is the intermediate stage between honey hunting and back yard beekeeping in its developmental stages.

Fixed-comb hives are no more than man-made cavities. These can be hollowed-out logs, bark cylinders, clay pots, wooden boxes, baskets of straw, bamboo, mud-plastered wicker containers, or discarded metal cans or drums. In some areas, cavities for bees are carved in the mud walls of houses or in nearby earthen embankments. The bees attach the combs directly to the upper surfaces of the hive and usually to the sides. The bees naturally leave the bee space between the combs as they construct them. Combs can be removed from such hives only by cutting them out, and it is not practical to replace them. Thus, beekeeping is impossible with fixed-comb hives. These hives allow only for bee-killing (honey hunting) or bee-hiving (housing bees in traditional hives).

Advantages of fixed-comb hives:

√ Materials for their construction are usually readily available and they are cheap

√ Beeswax production is relatively high. (There is a ready local market for beeswax).

√ They are traditional, and methods are established for working with them.

Disadvantages of fixed-comb hives:

√ It is impossible to remove combs and replace them, thus examination of the colony condition and hive manipulations are impossible.

√ Swarming is often common because of limited space.

√ Brood is often lost in harvesting honey.

√ Honey production is hindered.

√ Honey quality is usually low because it comes from old comb or is mixed with pollen, brood, or ash.

1.2. Transitional (Intermediate) Beekeeping

It offers a cheap system for bee killers and bee hivers who use fixed-comb hives to make the transition to beekeeping. They provide a relatively simple beekeeping system that is more within the economic and technical reach of most small-scale projects, while still allowing the user to employ the most current beekeeping knowledge. Most intermediate systems sacrifice some honey production for wax production, but wax too is a valuable product.

The use of an intermediate technology system in a beekeeping development program is not incompatible with "high-tech" beekeeping. Both have their place. It is the job of the program planner to determine the nature of the bee-human relationship and the cultural and economic realities of the area. From this the planner can suggest the type of equipment to use in the program. In some areas, the use of both types may be justified. The beekeepers themselves should make the final decision.

Transitional hive/Top-bar hive/ movable comb hive can be Kenyan type or Tanzanian type.
Materials used for construction of top-bar hives can be: 1. Timber 2. Mud block 3. From locally available materials (Shembeko, bamboo, eucalyptus sticks (cheraro).

Kenyan top bar hive is a popular type of intermediate technology hive. It was developed in Kenya in the 1970s and has been extensively used in beekeeping development projects. This is a practical hive to use in small-scale beekeeping projects. When compared to other intermediate technology hives, this hive offers a relatively large number of management options. Its simple design also allows for the use of a wide range of materials: each top bar hive accommodates 27-

30 top bars where bees attach their combs. For African races of the western hive bee, the width should be 32 mm; for European races, it should be 35 mm. It is important that the width of the top bar hive be correct so that the bees will construct only one comb per bar. The sides of the hive should be inclined at an angle of 120 degrees to the bottom. This minimizes the combs being stuck to the sides as it follows the similar form in which bees naturally construct their comb.

Advantages of moveable-comb hives:

- √The combs are removable and can be replaced without destroying them. Thus, beekeeping is possible. Swarming can be controlled, and colonies can be easily increased with simple queen-rearing methods.
- √ They are easier to construct because they have fewer areas where critical dimensions are important.
- √ They can be easily made of materials, which are readily available to the small farmer. Thus, they are more economical than Langstroth- type hives.
- √ They offer a cheap and intermediate alternative to beekeeping for bee-killers and bee-hivers that are using fixed-comb hives.
- √ They do not require foundation to guide the construction of comb within the frame to achieve their optimum returns.
- √ Beeswax production is relatively high.
- √ Honey can be harvested from new comb. Thus higher quality honey can be produced.
- √ The top bars can be constructed so that they meet, leaving no openings along the top of the hive. This makes it easier to work with more defensive strains of bees.

Disadvantages of moveable-comb hives:

- √ The combs are attached only to the top bars; thus, it is difficult to move the colonies without breaking the combs. Also, care must be used when removing combs and inspecting them.
- √ Since the combs are attached to the top part of the hive, the colony can only expand in a horizontal plane, This somewhat limits the expansion of the brood nest, as the natural tendency of bees is to increase the brood nest in an upward direction (vertically).

1.3. Improved (modern) Beekeeping

It is a method of beekeeping in which moveable frame hives are used. The rapid development of modern beekeeping is attributed to four very important discoveries:

a. The discovery of moveable frame hive in 1806.

b. The application of bee space by Langstroth in 1851 and the subsequent development of modern moveable frame hive.

The bee space is the crawl space needed by a bee to pass easily between two structures (7.5 mm for the western hive bee, less for the eastern hive bee). If the space between any two surfaces in the hive is too small for a bee to pass through easily, the bees will seal it with propolis. If the space is larger than a bee needs to pass through easily, the bees will construct comb in the area. When the space between two surfaces in the hive is the right size, the bees will leave it free as a crawl space. If the bee space is considered and respected in the construction of a hive, a hive that allows for easy comb removal and replacement will result.

Lorenzo Langstroth was the first person to make use of the bee space in hive construction. He constructed the first modern hive in 1851, using moveable frames to contain the comb within the hive. The modern frame hive currently used for “high-tech” beekeeping is still sometimes referred to as the Langstroth hive.

c. The discovery of equipments such as casting mould, queen excluder and finally honey extractors.

The moveable-frame system (improved) beekeeping system is the ultimate in beekeeping development. Nevertheless, such a system will remain economically out of reach of many people who might like to improve their methods of honey or wax production. Until they accrue the necessary capital and expertise to engage in beekeeping with moveable-frame equipment, an intermediate technology system can serve their needs.

This system uses moveable frames in several boxes. This system allows for easy manipulation of combs. Both frames (containing combs) and boxes can be easily interchanged for management. Frames containing honey are removed from the hive, the cappings of the cells cut off with a heated knife, and extractor. The empty combs are then returned to the colony for the bees to refill.

Honey production is maximized at the expense of wax production with moveable-frame hives. Bees need to produce about eight kilograms of honey to produce one kilogram of wax. Because the empty combs are returned for refilling, honey production is enhanced.

Comb foundation, or sheets of beeswax embossed with the dimensions of worker cells are used in the frames. The main function of this is to produce strong comb centered in the frame. Comb foundation also reduces the amount of wax that the bees have to produce, which also increases honey production. Since the combs are attached to the frame on four sides, and the frame usually contains several strands of thin wire to reinforce the comb, hives can be easily moved with little chance of breakage. Therefore, migratory beekeeping can be carried out with moveable-frame hives.

In migratory beekeeping, colonies are moved to take advantage of the variations in nectar flow between regions. This effectively increases the period of honey flow for the beekeeper. A moveable-frame beekeeping system also gives beekeepers the option to produce pollen, royal jelly, or queens in large numbers. The lack of understanding of how to construct and use the inputs is the factor that prevents the economic use of a "high-tech" beekeeping system in most small-scale development situations. The principles of hive management are the same for high-tech beekeeping as for intermediate technology beekeeping. High-tech beekeeping provides for more ease in manipulations and gives more options to the beekeeper. It also calls for a greater investment.

High-tech beekeeping will give greater return for the investment in most beekeeping situations. However, the options of a high-tech system must be fully used to realize such a return. The combination of lack of capital for investment and lack of understanding of timing, organization, and bee biology often makes the success of high-tech beekeeping difficult for small farmers.

Advantages of moveable-frame hives:

√ Combs can be easily removed, inspected, and interchanged since they are built in frames.

√ Combs containing honey can be removed, the honey centrifuged from the combs, and the empty combs returned to the colony. This enhances honey production, as the bees do not have to construct new comb.

√ As only honeycombs are removed and extracted, honey quality is high.

√ The combs are securely attached to the frame. Less care is needed when removing and inspecting combs, and the colonies can be moved with little comb breakage. This permits migratory beekeeping or the moving of colonies to take advantage of nectar flows in different areas.

√ Space in the hive can be increased in a vertical plane by adding supers. This enhances the natural tendency of the bees to expand the nest in an upward direction.

√ They can be easily used to produce pollen of for the mass rearing of queens.

Disadvantages of movable-frame hives:

√ They require relatively good quality wood and expertise in carpentry to build; thus, they are expensive.

√ For their optimum return, they require comb foundation and a honey extractor. These are expensive, and are often difficult to obtain.

√ For their optimum return they require much expertise in beekeeping

√ There are numerous bee spaces between the top bars of the frames. This makes it difficult to control highly defensive strains of bees

√ Sizes and Dimensions of hive boxes and Frames

Chapter 2. BIOLOGY OF THE HONEYBEES

2.1. Honeybee species and races

Race (sub-species): it indicates a group under the same species with some common distinct features. There are a few characters, which can be used to distinguish among races:

a. Size:- By measuring certain individual parts of the body (width of thorax and abdominal segments, length of tongue, legs and wings), smaller differences in size can be objectively determined. There is extremely a 1.7 mm difference between the tongues of the two extremes in races.

c. Hair coverage:- some races have wide, dense; others have only narrow and dispersed bands.

d. Veins of wings:- in taxonomy of honeybees veins (blood vessels) of the wings play a big role.

Species of bees

There are many different species of bees. Most bees are solitary, but some are social. The social bees live together in colonies with a division of labor among individuals. The habit of visiting flowers makes all bees important as pollinating agents. All bees gather nectar and pollen from flowers, but only a few of the social bees store the nectar as honey. Of the bees that store honey, there are even fewer species that store it in sufficient quantity to make the effort of harvesting the honey worthwhile.

a. Stingless bees: In tropical regions, some species of sting less bees-notably Trigona and Melipona are robbed of their honey. All of these bees build their nests inside cavities. Even though these bees do not sting, they defend their colony by biting the intruder. Some secrete irritating substances along with the bites. Since sting less bees use a different type of nest structure for honey storage and brood, improved methods for keeping these bees are limited in their effectiveness for increasing production. This, coupled with low yields, makes the keeping of these bees economically feasible only for home honey consumption.

b. Apis/true honeybee: bees of the genus Apis (the true honeybees) are the major producers of honey and other hive products. There are four species in the bee genus Apis. Three of them are native to Asia and one which is native to the Euro-African region. All of these are similar in appearance, though there are size and color differences. All build vertical combs that are two cells thick.

The giant or rock honeybee (Apis dorsata) and the little honeybee (A. florea) are found in Asia. Both of these bees build a single-comb, exposed nest. Nests are often seen hanging from branches of trees, roofs, or ceilings. Brood and honey stores are in the same comb; the brood in the lower section and the honey in the upper section.

Two other species of Apis (mellifera and cerana) normally build multi-comb nests in enclosed cavities. These bees can be kept in hives, and methods have been devised to allow for a more rational utilization of their potential. It is with these species that a potential for beekeeping exists. The western hive bee (Apis mellifera) is native to western Asia, Europe and Africa. Apis mellifera has been introduced into most of the world for use in beekeeping. There is tremendous variation in this bee across its range, and at least twenty different sub-species or “races” are recognized.

European races of honeybees have been introduced into most parts of the world. This bee has been studied intensely from both biological and beekeeping viewpoint. Under good conditions, desirable races build large colonies and produce large surpluses of honey. Yields of 100 kg/year are possible under optimum conditions. The western honeybee offers a great potential for beekeeping development. In Addition to high honey yields, its ability to survive under a wide range of conditions and its availability due to past introductions are characteristics, which have made this bee popular for beekeeping. On the other hand, the African honeybee is often more amenable to low management beekeeping than the European bee. Small-scale farmers who want to start beekeeping have a cheap source of bees in the wild colonies of the African bee.

Honeybee races of Ethiopian (*A. mellifera* races): Being part of Africa, Ethiopian honeybee races are very similar to that of African races. According to recent study done on morph clusters of geographical races of Ethiopian honeybees by Amssalu B. e.tal. (2002), the following 5 honeybee races have been reported to exist in the country. These are:

1. *A.m. monticola* - found to exist in the northern high mountainous part of the country
2. *A. m. bandansii* - found in central highlands of the country
3. *A. m. scutelltata* - occupy the wet tropical forest lands
4. *A. m. jemenitica* - exist in the eastern regions of Ethiopia

5. *A.m. woyi-Gambella* - found in the extreme western and southern semi-aired to sub moist low lands

A.m. woyi-Gambella is found only in Ethiopia.

2.2. Anatomy of Honeybees

The term Anatomy is defined as a science, which deals with the form and structure of living organisms. The exoskeleton of honeybee consists of layers of cuticle, which provides a hard protective casing that encloses the body (the outer cuticle is water proof). Much of it is covered with hairs, which are protective and thermal insulation. Some are important in gathering of pollen and in certain sense organs. Like all insects, the honeybee has three main parts: head, thorax and abdomen.

A. Head: The head is triangular in shape. It consists of the mouthparts, eyes and antennae. The structure of the head differs among the members of the colony, worker and queens have triangular head but drone has a slightly circular head due to the enlarged compound eyes.

1. The mouthparts

Proboscis: It is used for drawing up liquid foods such as nectar, water and honey.

Mandibles: These are pairs of jaws suspended from the head and of the bees mouth. The insect uses them to chew wood when redesigning the hive entrance, to chew pollen and to work wax for comb building. They also permit any activity requiring a pair of grasping instruments.

2. Antennae

These are a pair of sensitive receptors whose base is situated in the small socket like membranous areas of the head wall. They move freely in every direction. The functions are to feel or touch and to smell, and thus to guide the bee outside and inside the hive, to differentiate floral and pheromone odors, and to locate hive intruders. Terminal segments of worker and drone antennae also react to difference in temperature, humidity and co_2 concentration.

3. Visual organs (eyes)

The visual apparatus of honeybee consists of three simple eyes known as ocelli and two compound eyes with unusual capacities. The compound eyes are composed of many thousands of simple light sensitive cells, called ommatidia, which enable the bee to distinguish light and color and to detect directional information from the suns ultraviolet rays. The ocelli are able to monitor light intensity, period of exposure to light, and color, also regulate the daily start and finish of foraging and, by registering the brightness of the sky, help to maintain the bee in level flight. The eyes of the drone are larger by far than those of the worker or the queen bee, occupying a large proportion of the total volume of the head. The eyes assist the drones to locate the queen for mating purpose.

B. Thorax: This is alarm plated mid section of the insect body and supports two pairs of wings and 3 pairs of legs and carries the locomotors or engine and the muscles that control the movement of the head, the abdomen and the wings.

Legs: honeybees have six legs. Each pair differs in size and shape. The primary function is to serve the bees to walk and run, but it also functions other than this. The foreleg is close behind the head and is used by the bees for cleaning dust, pollen and other contaminant from the head. The middle legs have no special tools have hairs covering the inner side of the base tarsus of the workers are used for cleaning pollen from the thorax and passing to the hind legs. The hind legs of the workers have specialized structures on the tibia and base tarsus known as pollen basket or corbiculae that are used when a forager collects and packs pollen to carry back to the hive. These pollen baskets are concave in shape and surrounded with several long hairs, which bind the contents into an almost solid mass, making pollen movement safer.

Wings: Honeybees contain two pairs of Wings, namely front and hind wings. The front wings are larger than the hind wings because they have veins, which make them strong. The workers wings are used for both flight and for ventilating the hive, while the drones and the queen for flight only. When honeybees regulate the hive temperature, they face inward to the hive entrance whereas when they evaporate the moisture content of honey they face outward from the entrance.

The wing beat of honeybees is 200-300 cycles/second. This is too fast for coordination of the nerve system and difficult to detect with naked eyes unless we use electrical system. Bees can fly at a speed of 18-miles/hour outward flights and 15-miles/hour inward flights because they are loaded with nectar and pollen. Bees can travel up to 7 km distance but need forage for travel, therefore we have to supply them with food and water in their vicinity i.e. 0.5 km radius of their apiary.

C. Abdomen: It contains vital parts of several internal systems such as the heart, honey sac, stomach intestines, reproductive organ, the sting, wax glands and scent or nasanov gland. The structure of the abdomen differs among members of the colony; the abdomen of worker bees is broad anteriorly and tapered towards the posterior, the abdomen of queen is similar to that of workers but relatively larger and looks cylindrical, the abdomen of drones is more rounded posteriorly.

2.3. Physiology of Honeybees

2.3.1. Digestive and excretory system

Food moves from the mouth through the esophagus, and in the worker it then enters the honey sac (crop, honey stomach), and can pass via the Proventriculus to the ventriculus (midgut) where digestion occurs.

The honey stomach: serves as temporary storage of food taken in. The larger the crop size, the better is in food collection. Because, more food from outside can be transported by bees to their nest. It is here where some enzymes mainly inverters and diastase are mixed with liquid food, the nectar. As forager bees reached home, she then regurgitates the liquid food places it inside the comb cell or transfer (pass) it through mouth to mouth with her nest mate.

Proventriculus: very important to retain food in the crop to release it further down of the process. A case study had indicated that Proventriculus mostly retains liquid food in the crop and allow solid food to pass down to the true stomach called ventriculus. Proventriculus acts like a valve located at the posterior part of the crop to effect its function.

2.3.2. Circulatory system

Honeybee blood (heamolymph) transports the dissolved nutrients absorbed from the small intestine of the body, and transports dissolved waste material away from the intestine to malpighian tubules. The blood contains white corpuscles (phagocytes) that ingest and destroy invading bacteria. Insects have no red corpuscles (erythrocytes).

2.3.3. Respiratory system

Respiration in insects involves the intake of oxygen and release of carbon dioxide. Air inters and leaves through ten pairs of holes known as spiracles.

2.3.4. Reproduction system

Queen reproduction: After mating has finished, semen from mated drone is in the queen's oviducts. It soon moved into the spermatheca and store there. During fertilization a few spermatozoa pass out the spermatheca along the spermatheca duct, and into the vagina where one fertilizes the egg.

Drones: During mating the drone everts his copulatory apparatus, injecting the semen into the queen's oviduct and leaving part of the apparatus in the tip of the queens abdomen. This part, which is visible in the queen after mating, is called the mating sign. The drone dies after mating. In all honeybees, the copulatory organs are an internal one, the endocephalus.

2.4. The Honeybee Life Cycle

The development of the honeybee follows a pattern of growth and metamorphosis that is typical of many other insects. The life cycle of the honeybee begins when a queen deposits a single egg near the center of the bottom of a wax cell.

Egg stage: The egg laid by honeybees are small measuring 1.3-1.8mm length and weighing 0.12-0.22mg, pearly white in color and cylindrical and oval in shape. When honeybee first lays an egg, she glues it to the floor of the cell at one end so that it appears to be standing in the bottom of the cell. In approximately three days before hatching the egg gradually sags until it finally rests on cell floor.

The queen honeybee lays two types of eggs: fertilized and unfertilized eggs. Fertilized egg consists of egg cell and sperm cell and develops into female castes i.e. worker and queen. Unfertilized egg consists of only egg cell and develops into male caste (drone) by the process of parthenogenesis. Parthenogenesis is the process or mechanism of reproduction without the intervention of male. Egg stays as egg for three days, then after it develops into larvae.

Larvae stage: The larvae of honeybee is a whitish, worm like grub with no legs, eyes, antennae, wing, sting but it possesses simple mouth which need only lap up the copious quantities of food placed in the larval containing cell. It is also equipped with huge internal digestive system. Bee larvae are essentially feeding machine designed for rapid growth. There are two types of brood food: royal jelly (bee milk) and substituted food. Royal jelly is whitish jelly like substance secreted by nurse bees from their hypo pharyngeal glands. Larvae of all castes used to feed the bee milk for three successive days but the larvae which is going to develop into queen continuously feeds on royal jelly. Substituted food is a mixture of pollen, nectar, honey and water. This type of larval food is fed to larvae, which develops into worker and drone ageing beyond three days old. Developing larvae undergo six moults during which the outer exoskeleton is shed; five of these moulting takes place during the larval stage and the last occurs when the bee emerges as an adult.

All honeybee larvae should have a full-bodied, firm appearance, with distinct segmentation. A healthy bee larva is always pearly white and moist in appearance although it is dry to touch. Good queens lay eggs in concentric bands usually starting from the center of a frame. Very few cells should be left vacant and ideally, all of the larvae in each band should be of similar age. When queen and worker larvae are approximately eight days old and drone larvae ten days old, worker bees seal their cells with wax capping.

Pupae stage: The pupal stage is the last stage (period) before the final stage to adult. It is known as sealed brood stage. All adult bee characteristics are shown. These characteristics are appearance of head, thorax, abdomen wings, legs and other bee organelles. The pupae do not grow or change in shape but internally the muscles and organ system undergo massive changes into their adult form. Only the wings are still small and underdeveloped. As pupae develop the cuticles gradually become darker and these well defined color changes can be used to determine pupal stages. The adult bee gets out of the cell by chewing the wax capping.

Sealed cells of the three castes have their own unique appearances. Worker cells are the smallest of the three, with their wax capping slightly domed and almost level with the surface of the comb. Individual sealed cells range from light tan to dark brown in color, depending on the age of the comb, and are dry in appearance. Drone cells are wider and deeper than worker cells. Their cappings are “bullet” shaped and protrude noticeably from the face of the comb. Drone cells should appear in groupings, not scattered individually over the face of the comb. Once capped, all cells should remain sealed with no small evident until the young adults begin chewing their way out.

Queen cells are distinct from the other two types because they hang downward from the bottom or face of the comb and when sealed are peanut-like in both color and texture with slightly convex capping. In a normal supersedure situation the workers will build a few queen cells. If many queen cells appear, particularly at the bottom of the combs, the colony is probably preparing to swarm.

The total developmental time for the queen is 16 days, workers 21 days and drones 24 days. The duration of developmental time varies depending on environmental factors and genetic factors. Environment factors include temperature and nutrition. Temperature lower than the normal brood nest temperature of 35 at any stage can delay the emergence for up to five days and under feeding of larvae also will delay development. Brood development at the periphery of colonies takes longer to develop than centrally located brood because of problems in maintaining constant temperature and humidity at these locations.

Chapter 3. COLONY ORGANIZATION OF THE HONEYBEES

Under normal conditions a honeybee colony consists of one queen (reproductive female), several thousand workers (unmated females) and depending on the season, a few to several hundred drones (males). The sex of a honeybee is determined by egg fertilization; generally, fertilized eggs develop in to females and non-fertilized eggs develop in to males. During mating, a queen receives a supply of several million spermatozoa that are stored in the spermatheca, a small spherical organ that is connected to the oviduct by its own small duct. The queen, by releasing or withholding spermatozoa from the sperm duct as an egg passes down the oviduct, is able to selectively fertilize or not fertilize eggs.

Adult workers and queens both develop from fertilized eggs but they are distinct in both their anatomy and behavior. Normally the queen is the main egg layer. Therefore, all of the other bees are her offspring. Workers do not usually lay eggs but, if they do, drones, not workers, are produced. Workers perform most of the tasks in a colony.

Differences in anatomical and behavioral characteristics between adult workers and queens are the result of the food that each receives during larval development. Larvae that are being reared as queens receive a surplus of a special type of food called "royal jelly" throughout their development. Larvae being reared as workers receive royal jelly for only three days after hatching; following this their food is mixed with pollen and nectar from flowers.

The behavior and biology of all its members is directed towards the survival of the colony, not the individual. Although workers and drones live a few months at most and queens for two to three years on average, a colony can survive much longer because its individuals are constantly being replaced. The social order of a colony results in a behavior more like that of a single organism than a group of individuals.

3.1. The Queen

There is only one queen in the hive. She is recognized by her long abdomen, which extends far beyond the tip of her wing in the resting position. Her thorax is larger than that of the worker. Viewed from the front, her head is round. The queen has a sting but is only used to fight rival queens. She has no collecting apparatus like pollen basket, long proboscis for drawing nectar or wax glands to secrete wax to build comb cells. As a queen, she usually does not feed herself.

The adult queen emerges from the cell 16 days after deposition of egg. Immediately after the queen emerges, the queen tours the hive to see if there is any rival queen hiding somewhere. If she finds one the two queens will fight until one is killed. Five days after the queen emerges from her cell she starts fly out of the hive, making an orientation flight of about five minutes. Next she makes mating flight, which lasts about 30 minutes. She flies to an area 6-10m above the ground where many of the drones are present. If successful mating flight, she is mate by about 8-10 drones. A well-inseminated queen carries about 5,000,000 spermatozoa. The type of flight that the queen makes for mating purpose is called nuptial flight. When the young queen keeps unmated for long period she will start to lay unfertilized eggs in worker cells. From these eggs, only drones develop.

New queens are produced under three circumstances:

A. when the colony is planning a reproductive swarming, the bees build 10-20 royal cells, and the original queen lays an egg in each. The new queens born after the old queen has departed with the swarm;

B. when the queen is over-aged and lying badly, or is otherwise failing, the workers build 1-3 replacement or supersedure queen, lives together in the hive with the old queen for a certain time;

C. when the colony loses its queen through accident or disease the workers create emergency queen cells from workers cells containing larvae less than three days old, situated at the central strip of the comb.

Table. Adult life stages recorded for queens of some races of Apis mellifera.

Apis mellifera	Emerge	Days of first flight	Day mating occurs	Day egg laying starts
Temperate zone	0	5-6	6-9	8-13
Tropical zone	0		5-6	7-9

A good queen lies from 1500 to 2000 eggs a day, and she lives for up to five years, but her best laying period is during her first two years only. Pheromone ones produced by the queen are largely responsible for the coherence of a “queen right colony” the fact that the adult bees stay together as a social unit. In queen right colonies pheromone production from the mandibular glands is greatest in young mated and laying queens, and colonies headed by such queens are least likely to supersede their queens to swarm.

Young workers feed the laying queen, and repeatedly lick her body and brush over it with the antennae. By so doing the workers obtain some amount of pheromones; these pheromones are the translocated on the body surface of each individual bee, and they also spread it by grooming her body. Subsequently she moves around among other bees in the colony, by making physical contacts these other workers obtain a share of pheromone. With the result that all are aware of the queen's presence, it is likely that 9-oxa-decenoic acid is the main queen presence signal within the colony.

3.2. The Drones

The drones are the colony members that show a high degree of laziness. His presence in the hive is of little importance except for mating purpose may also play a small part in raising the temperature A drone is much more broader than a worker but shorter than a queen. The abdomen is not pointed. Their compound eyes, at the top of the head, are twice as large as those of the queen and the workers, and their wings are the largest of those of the three castes; these differences help them to locate the queen in the air and to catch her during the mating flight. Drone has no suitable proboscis for gathering nectar and has no sting to defend itself or the colony. He has no pollen basket and glands to secret wax for comb construction.

The drones emerge 24 days after egg deposition and become sexually mature within 9-12 days or older. Drones release a special pheromone into the air at a congregation site to attract queens as well as other drones to the site, and when a queen enters the site many drones approach her.

Workers control the number of drone in a colony. The extent of drone rearing is very variable, but it is a feature of strong colonies, of colonies nearing the culmination of their population growth, and of prime swarms after 3 weeks in their new nest or hive. In both colonies, in the wild and those traditional hives, workers can increase drone rearing by building more drone cells. Workers also limit the total number of adult drone in their colony. They can restrict the total population of the drones by reducing the number neared when there are already many in the colony, and by not feeding adult drones.

3.3. Workers

Workers are the smallest and most numerous of the bees. Viewed from the front the workers have a triangular shape. The tips of her wings in the rest position cover the end of her abdomen.

The workers are females whose reproductive organs are atrophied; they cannot be fertilized by the drones, as they do not posses sperm reserve capacity. On the other hand, they have organs other than those of the queens and the drones, to enable them to execute all duties in the colony. Their tongue is longer than that of the other caste, to enable them to suck nectar from flowers; they have a special sac for carrying honey and water, pollen basket for carrying pollen, a well developed sting, Their heads contains glands producing royal jelly, salivary gland in the thorax produce enzymes which ripens the honey; and four pairs of wax glands to produce wax.

A large colony can consist of more than 50000 workers. Worker performs different kinds of work within and outside the colon depending upon her age. Workers live entirely within the colony during the early part of their life. They are at this stage sometimes referred to as House bees and carry out a number of activities that are needed to maintain the well being of the colony such duties include: preparing brood food, for defense, building up of the comb with wax. As House bees become older, they are driven gradually out from the brood nest by the pressure of the emergence of new workers.

1. **Activities of House bees:**

Cleaning: The first activity of the worker on reaching maturity is cleaning. She at this time remains in the entrance of the nest, clean and caps the larvae. During this age the glands are not yet active. The comb cells are cleaned to receive eggs laid by the queen who, before laying, examines the comb cell to satisfy herself that it has been properly cleaned. Other duties in this regard are removing dead intruders or dead bees from the hive, and removing debris and other objectionable material. Anything that is too large to carry is often dragged along and pushed outside, while dead snakes, wax moths or what else are encased with propolis inside by field bees.

Feeding the brood: This is the second step, which is carried out by the worker bees age wise. Still during this age she remains in the center and rears, attends and feeds the brood. First she feeds larvae more than three days old with a mixture of honey or nectar, pollen, small quantities of bees milk and some water. After a few days, she starts to feed the younger larvae exclusively on bees milk. The next work undertaken by the young worker is to provide for the need of the queen bee. Whenever the queen needs food she calls for it by stretching out her proboscis towards the mandible or mouth of the nearest worker. The workers are always anxious to satisfy her needs and make a circle or semi-circle around her. The bees at this age are known as the Nurse bees. It is also the duty of nurse bees to bath her with their tongue and mandibles and to carry away her feces.

Queen tending (Taking attention for the queen): Workers attend the queen at about the same time they are participating in brood nursing activities. A circle of six to ten attendant workers is usually formed around the queen with individual attendant rotating frequently. A typical visit lasts less than one minute. The workers are examining the queen with their antennae and forelegs licking her with their tongues and feeding her about brood food secretions by direct mouth-to-mouth food exchange.

Orientation flight: It is one of the criteria of selection to the kind of bee races. The one that makes quick orientation to new place moved is considered best. Quick orientation to new nesting sites and finding the kind of hive entrance help mated queen to set well shortly. On the other hand, the earlier bees make orientation flight, the earlier they first become foragers.

This is not in fact so much a house duty. But the young worker bee must learn how to fly and she must know the vicinity, specially the location of the hive. She therefore first makes some short flights in front of the hive environment. The purpose of orientation flight is to orient to the nest location before workers take trips a field to forage. These flights tend to take place on warm, windless, sunny afternoon. A single orientation flight lasts less than five minutes and successive flights appear to increase in duration and distance from the colony.

Comb building: Though out the nest, the worker bees' wax gland becomes active to secret wax. This gland is best developed and becomes best productive when she is 12-18 days old. The wax secreted as a liquid hardens quickly. The bees normally need large amount of food to produce the wax.

Comb is a back-to-back arrangement of series of hexagonal cells made of beeswax to hold brood, pollen or honey. Comb construction and brood rearing fulfill fundamental biological needs for shelter and reproduction. Beeswax, the material used in construction of the comb is secreted by worker bees (8-17 days old). Worker bees involved in wax secretion form a cluster in order to increase their body temperature because wax-secreting workers requires high amount of energy. In order to attain this high energy, worker bees feed with large quantity of honey.

Nest homeostasis (Thermoregulation): One of the great advantages and challenge of insect social organization is colony homeostasis or maintenance of hive temperature and other environmental factors at relatively constant levels regardless of external conditions. The advantages of homeostasis are many including rearing of brood under stable condition, survival of populous colonies through cold and hot.

Temperature control is one of the important duties of the house bees. When the temperature is low, bees cluster to generate heat for themselves, but when it is high, some of them have to fan their wings to circulate air throughout the hive. The right temperature required is between 33 ^{o}c and 36 ^{o}c, while the brood chamber requires a constant temperature of 35. Honey has to be cured in order to ripen, and this also requires the help of circulating air.

Cell capping: The young workers produce wax and place the wax secretion on the rims of cells, which need to be capped, so that the copious wax production by the young worker capper is not necessary. The capping time is only 20 minutes for one cell by a single worker.

Packing pollen, receiving nectar and elaborating honey: Pollen is packed to about three-quarter full in comb in the brood chamber, sometimes side by side with brood cells. The forager, where she rests and exposes the nectar to the air being fanned by the fanning bees, brings nectar. The air circulation helps reduce the moisture content of the nectar and thus aids sugar concentration. The time required for the nectar to mature into honey depends for the most part on its original moisture content. For example, if the sugar content is high, ripening takes about two hours.

Execution and guard duty: In a colony of honeybees, nest building is one of the most expensive tasks requiring the cooperation of all members of the society. Moreover, another expensive wealth they have in the hive is the brood and essential food stored. These belongings cannot be evaded for attackers by simply running away. Instead, they fight all predators and parasites to the last point. As stated by Tanzen, 1981, they can employ wide array of biochemical, morphological and behavioral weapons.

House bees may protect the colony from hunger, disease and other events. The may also be performed to eliminate strange bees, to kill or drive away old and sick bees, to discourage other hive predators from entering the hive and the like. Guard duty is the final activity of the house bee before she leaves the hive. She at this age inspects all the incoming foragers by smelling their odor. This stage is transitional between nursing activity and field activity. All nurse bees are not involved in the guarding activity because the number of involved bees is related with physiology of worker and number of enemies in that area. Those who do guard the nest perform this activity most frequently between the ages of 12 and 25 days before foraging commences.

Guarding workers can be recognized by their characteristic posture entrance where they stand on their four hind legs with antennae held forward and front legs lifted. Each guard bee patrols a limited area around the nest-inspecting workers with the antennae and determining their odor and behavior whether they are colony members or not. More workers assume guarding duties when the colony has been under attack or during periods of forage dearth, when robbing is more likely.

2. Activities outside the colony nest: The bees, which are involved in activities related to outside the hive, are called field bees. The final task performed by workers before their death is foraging. Although workers occasionally revert to other tasks as colony needs dictate. Foragers leave the colony to collect four resources: nectar, pollen, propolis and water.

Chapter 4. SEASONAL HONEYBEE COLONY MANAGEMENT

Beekeeping follows seasonal periods/cycles and the management practices are classified accordingly. In temperate regions, these periods are usually well defined, with only one of each period per year. In the tropics, however, the periods are variable, and more than one of each can occur in a yearly colony cycle. In the tropics because of the peculiarities of climate and vegetation in different ecological zones, there is seasonal variation in bee forage and water.

In temperate regions, the dearth period is associated with cold. During this period, there is a total absence of resources. Honeybees pass the period living from stores in the hive. However, in warm climates there is never an absolute absence of resources. The dearth period is often associated with either heavy rainy periods or the flying weather is poor. But, sometimes there may be prolonged dry season.

Based on this the seasons are divided into: -

- Build-up period
- Honey-flow period
- Harvesting period
- Dearth period

4.1. Build-up period

- This is a time when bee plants start flowering and bees start to bring in pollen and nectar. During this period all the stores are used for comb building, egg laying and brood rearing.

What to do during this period?

- Help the bees to expand their brood nest by putting an empty super
- Swarm prevention and control:

1. Swarm prevention: with reproductive swarming, the term swarm prevention is often used to mean preventing preparations for swarming by a colony including the production of swarm queen cells. To prevent reproductive swarming, conditions that can stimulate a colony to rear queens in preparation for swarming must be avoided. These include:

Colonies with older queen: queen's egg-laying ability decreases as she gets older. When queens egg-laying ability is decreasing, colonies are more likely to swarm than are colonies with a young queen. Pheromones produced by the queen which inhibit the workers from rearing new queens, are produced in smaller amounts as the queen ages, so when the colony grows large there may be insufficient for all workers in the brood nest. Inhibition is then not complete, and workers build swarm queen cells.

Overcrowding: Such overcrowding can be prevented by adding empty honey supers above a queen excluder.

Poor ventilation: During the height of the active season inadequate hive ventilation can result in overheating of the brood nest and other parts of the hive. The bees increase ventilation in the hive by creating air currents, and can do so most effectively if there is a large flight entrance at the bottom of the hive.

2. Swarm control: This term is used to mean preventing the issue of a swarm from a colony, which is found to contain swarm queen cells, i.e. it has already started swarm preparations. Bees start treating a larva as a future queen, and building a queen-type cell round it, almost as soon as the larva hatches from the egg; the adult queen emerges from the cell 12 to 14 days afterwards. The swarm is likely to leave the hive some days before this, so colonies liable to make swarm preparations must be inspected for queen cells every 9 to 10 days during the swarming season.

4.2. Honey Flow period

- Bee plants are in full bloom during this period.
- Bees bring in nectar and pollen in greater quantities for their daily requirement and therefore utilize the period for storing.
- There will be a daily increase in stores if the colony was properly prepared in the build-up period. Otherwise the colony will use the honey flow period to build-up instead of collecting excess nectar and pollen.

What to do

- At this time the queen should be restricted to the brood area (by using a queen excluder) to leave the other combs to be used for storage.
- Give extra supers when the colony is ¾ full, in case of a Langstroth hive and harvesting in the case of a Kenya Top Bar Hive. This will serve both for the distribution of the colony population, which will control swarming, and to store excess food.

6.3. Harvest period

Beekeepers should inspect their apiary regularly to know when the colonies are ready for harvesting. This is the most certain way of telling hive that's ready for harvesting. A colony ready for harvesting will have the following signs

- The bees become aggressive in guarding the hive, and can sting at the slightest provocation.
- Presence of worker bees outside the hive in large numbers

What to do

- Removing full supers: When honey supers are ready for harvesting, the bees are removed from them, and the supers are taken to the extracting room free from bees. By then the honey should be ripe and ready for harvesting. The comb should be sealed with thin wax layer to say it the honey is ripe or matured. There is always a danger of bees consuming the stores if harvesting is delayed.

4.4. Dearth period

This is a time of the year when nectar and pollen are not available to the bees. Egg laying activities decreases or stops as there is no food to feed the brood. Dearth period may be caused by:

- Prolonged dry season which will not permit flowering
- Very heavy rains, which prevent bees from foraging.
- Very cold weather which prevents bees from going out to forage; instead they cluster to produce heat.

What to do

- In hot areas, put the hive under shade so that bees have time to search for their food source instead of wasting time trying to cool the hive.
- Shelter hives to keep them dry where rains are heavy and provide proper ventilation
- Enhance pest control measures since the colonies are most vulnerable at this time.
- Provide water if there is scarcity and feed the colony if necessary.

Chapter 5. BEEHIVE PRODUCTS

Introduction

Apart from the importance of honeybees as the basis of Agriculture in the pollination of seed, fruit, vegetable and legume crops, they are also of immense importance to the beekeepers in production of honey, beeswax, pollen, royal jelly, propolis, bee venom, etc. Whatever found in the hive, which have direct or indirect contact with bees are called hive products. All of them have potential value in bringing economic return to the owners and they have very essential role in human medicine, human diet and in economy building. Natural products carried into the hive by honeybees and subsequently processed within the hive are: nectar, honeydew, pollen, propolis and water.

5.1. Honey

5.1.1. Honey composition and properties

Honey is basically a highly concentrated water solution of two sugars, dextrose and laevulose, with small amounts of at least 22 other more complex sugars. Many other substances also occur in honey but the sugars are by far the major components. The principal physical characteristics and behavior of honey are due to its sugars, but the minor constituents, such as flavoring materials, pigments, acids, and minerals are largely responsible for the differences among individual honey types.

Honey, as it is found in the hive, is a truly remarkable material, elaborated by bees with floral nectar, and less often with honeydew. Nectar is a thin, easily spoiled sweet liquid that is changed (ripened) by the honeybee to a stable, high-density, high-energy food.

Colors of honey form a continuous range and the variations are almost entirely due to the plant source of the honey; although climate may modify the color somewhat through the darkening action of heat. The flavor and aroma of honey vary even more than the color. As with color, the variations appear to be governed by the floral source.

A. Composition of honey

A.1. Water content: The amount of moisture is a function of the factors involved in ripening, including weather conditions and original moisture of the nectar. After extraction of the honey, its moisture content may change, depending on conditions of storage. It is one of the most important characteristics of honey influencing keeping quality, and granulation.

The water content of honey varies greatly ranging between 13 and 25 percent. If honey has more than 17 percent moisture and contains a sufficient number of yeast spores, it will ferment.

A.2. Sugars: Honey is above all a carbohydrate material, with 95 to 99.9 percent of the solids being sugars. Contributes to the flavor and in part responsible for the excellent stability of honey against microorganisms. Sugars are classified according to their size, or the complexity of the molecules of which they are made. Dextrose (glucose) and laevulose (fructose), the main sugars in honey, are simple sugars, or monossacharides. Dextrose and laevulose account for about 85 percent of the solids in honey but 22 other sugars more complex than the monosaccharides; dextrose and laevulose are also found.

A.3. Acids: The acids of honey account for less than 0.5 percent of the solids, but this level contributes not only to the flavor, but is in part responsible for the excellent stability of honey against microorganisms. Several acids have been found in honey, gluconic acid being the major one. It arises from dextrose through the action of an enzyme called glucose oxidase.

A.4. Proteins and Amino acids: The amount of nitrogen in honey is low, 0.04 percent on the average, though it may range to 0.1 percent. Of the eight to eleven proteins found in various honeys, four are common to all, and appear to originate in the bee, rather than the nectar. Little is known of many proteins in honey, except that the enzymes fall to this class.

A.5. Minerals: When honey is dried and burned, a small residue of ash invariably remains, which is the mineral content. It varies from 0.02 to slightly over 1 percent for a floral honey. Honeydew honey is rich in minerals.

A.6. Enzymes: One of the characteristics that sets honey apart from all other sweetening agents is the presence of enzymes. These conceivably arise from the bee, pollen, nectar, or even yeasts or microorganisms in the honey. Those most prominent are added by the bee during the conversion of nectar to honey. Some of the most important honey enzymes are invertase, diastase, and glucose oxidase. Invertase, also known as sucrase or saccharase, splits sucrose into its constituent simple sugars, dextrose, and laevulose. Although the work of invertase is completed when honey is ripened, the enzyme remains in the honey and retains its activity for some time.

Diastase (amylase) digests starch to simpler compounds but no starch is found in nectar. What its function in honey is not clear. Glucose oxidase converts dextrose to gluconic acid, the principal acid in honey. As with other enzymes, the amount varies in different honeys. In addition it forms hydrogen peroxide during its action on dextrose, which has been shown to be the basis of the heat-sensitive antibacterial activity of honey.

B. Properties of honey

Because of honeys complex and unusual composition, it has several interesting attributes.

B.1. Antibacterial activity: Honey is not a suitable medium for bacteria for the following reasons: it is fairly acid and it is too high in sugar content for growth to occur. Another type of antibacterial property of honey is that due to inhibine. This material, well known for its antiseptic properties, is a byproduct of the formation of gluconic acid by an enzyme that occurs in honey, glucose oxidase. The amount of inhibine (peroxide accumulation) in honey depends on floral type, age, and heating.

B.2. Food Value: Honey is primarily a high-energy carbohydrate food. Because its distinct flavors cannot be found elsewhere, it is an enjoyable treat. The honey sugars are largely the easily digestible "simple sugars", similar to those in many fruits. Honey can be regarded as a good for both infants and adults. The protein and enzymes of honey are not present in sufficient quantities to be considered nutritionally significant. Several of the essential vitamins are present in honey, but in insignificant levels. The mineral content of honey is variable, but darker honeys have significant quantities of minerals.

B.3. Granulation: Dextrose, a major sugar in honey, can spontaneously crystallize from any honeys. This sometimes occurs when the moisture level in honey allowed to drop below a certain level. Since the granulated state is natural for most of honey produced, processing is required to keep it liquid.

B.4. Deterioration of Quality: Fermentation of honey is caused by the action of sugar-tolerant yeasts upon the sugars dextrose and laevulose, resulting in the formation of ethyl alcohol and carbon dioxide. The alcohol in the presence of oxygen then may be broken down into acetic acid and water. As a result honey that has fermented may taste sour.

The yeasts responsible for fermentation occur naturally in honey, in that they can germinate and grow at much higher sugar concentrations than other yeasts. The water content of a honey is one of the factors concerned in spoilage by fermentation. The others are extent of contamination by yeast spores (yeast count) and temperature of storage.

Honey with less than 17 percent water will not ferment in a year, irrespective of the yeast count. Above 19 percent water, honey can be expected to ferment even with only spore per gram of honey. When honey granulates, the resulting increased moisture content of the liquid part is favorable for fermentation.

5.1.2. Honey Processing

The primary objective of all processing of honey is simply to stabilize it. This means to keep it free of fermentation and to keep the desired physical state, be it liquid or finely granulated. The primary operation in the processing of honey is the application and control of heat. If we consider storage to be the application of or exposure to low amounts of heat over long periods, it can be seen that a study of the effects of heat on honey quality can have a wide application.

A recommended temperature for pasteurization of honey is 145^{o}F for 30 minutes. The damage done to honey by heating and by storage is the same. For the lower storage temperatures, simply a much longer time is required to obtain the same result. It must be remembered that the effects of processing and storage are additive. It is for this reason that proper storage is so important. People who store honey must select conditions that will minimize fermentation, undesirable granulation, and heat damage. Fermentation is strongly retarded below 50 ^{0}F and above 100 ^{0}F. Granulation is accelerated between 55 ^{0}F and 60 ^{0}F. The best condition for storing unpasteurized honey seems to be below 50 ^{0}F.

5.2. Beeswax

The wax of western hive bee (Apis mellifera) differs from the beeswax produced by the Asian species of honeybee (A.dorsata, A. Florea, and A.cerana). Wax of the Asian species is called Ghedda wax and is less desirable than that of the western hive bee for international marketing purposes.

Pure beeswax is harder and has a higher melting point (64 degrees celcius) than most other waxes. These properties make it more desirable for certain applications. Beeswax is used industrially in cosmetics, pharmaceuticals, polishes, and candles. Uses for beeswax on a small-scale include: Candle making, Lost-wax casting of metals, Polishes for wood and leather, Strengthening and waterproofing thread for sewing, Treatment of cracked hooves of domestic animals and Making of comb foundation or wax starter strips for beehives.

All old combs and pieces of wax should be saved for rendering into wax blocks. Old combs should be rendered separately from newer ones since the newer combs yield a higher quality wax. Dark combs contain propolis and cocoons, which lower the quality of the wax.

Comb stored in pieces is highly susceptible to wax moth damage. With a solar wax melter, small pieces of comb can be rendered easily as they are cut from the hive and made into blocks. Comb to be rendered can be stored for short periods in sealed plastic bags to prevent from wax moth damage. Check the stored comb periodically for evidence of wax moth larvae.

In Ethiopia, wax is one of the exporting commodities. There are two sources of beeswax: 1. from traditional beekeeping: crude wax is obtained which has an inclusion of pollen, honey and brood. Of the total honey produced traditionally, 10-12 % is crude wax. 2. Modern beekeeping: even though the distribution and intake rate is very low, wax can be obtained from capping, brace combs, and old combs.

Rendering Wax: The process by which wax combs are converted into clean, block wax is commonly known as rendering or wax extraction or wax processing. The common methods of rendering wax include: solar wax extraction, hot water bath wax extraction and steam wax extraction. Some precautions in rendering wax include:

A. Never use iron, steel, zinc, or copper containers for beeswax, as they discolor the wax. Use enameled or aluminum containers

B. Be careful with melted beeswax, since it is highly flammable. Do not allow the beeswax-water mixture to boil vigorously, Boiling beeswax lowers its quality by making it more brittle

C. Blocks of rendered beeswax can be stored in cool, dry places for long periods without harm. They should be wrapped in paper or plastic

D. Never store beeswax near pesticides. Beeswax absorbs many such chemicals, and they can kill bees if this wax is used to make comb foundation

Hot water bath method: In the absence of a wax-melter, the hot water bath process now in use by some African beekeepers may be adopted. This is the quickest method of obtaining the wax, but it can only be employed after the combs have been crushed and the honey removed.

Equipment: A cooking pot, Sackcloth or a sack, String (2-3 meters), a stick or a discarded top bar, a large spoon or ladle and a mould for the wax

Procedure:

1. Put water (amount depending on the quantity of bee combs) in to the cooking pot and heat over a fire.
2. Wash crushed bee combs to remove dirt and honey and place in the sack.
3. Make a good package by tightening the string around the sack.
4. By now the water should be quite warm. Put the package into the pot and use the stick to push it down to the bottom.
5. When it reaches a temperature of about 59 ^{o}c, the wax begins to melt and a waxy scum begins to form on top of the water.
6. Use the stick to press the package. More wax will float to the top of the water.
7. Use the ladle to skim off the melted wax and pour it into a mould. Continue this process until wax no longer rises to the surface.

The solar wax-melter: This is a simple devise and can be made by local craftsmen. The melter is made of wood, lined with a galvanized metal plate and has a glass or clear plastic cover. The base is airtight. The melter can be painted black to absorb more heat. On a sunny day, the wax extractor is capable of generating a temperature of 61^{o}c, enough to melt down a bee comb so that both honey and beeswax flow into a container inside the box.

Steam wax extraction: is expensive to buy the materials

5.3. Pollen

Bees gather it by visiting number of plants that flower. They do collect every day. It is part of their food type. Pollen is a male germ plasm of plants. Pollens are natural food to the honeybee colonies. Worker bees collect pollen from specific plant at a time and carry it by their hind legs.

Pollen has only recently been thought as a hive product for human consumption. The interest in pollen as food is usually found only in large urban centers where there is a specialized market for natural foods. In Apiculture it has two important counts: 1. Chief source of protein, fats and minerals in honeybee diets and, 2. as surplus hive products, which generate cash revenue.

Chemically, pollen is rich in lipids; contains amino acids, carbohydrates (sugar, starch and cellulose), reduced sugar (fructose, glucose, sucrose and others), mineral (Ca, Mg, Fe, Na, K, Al, Mn, S, Cu), vitamins, vegetable oil, water, rich in nitrogen. Pollen has some non-measurable properties like human growth hormone (HGH), which are very essential in its effect on life of insect and humans.

Pollen traps equipped at the entrance of beehives are used to collect fresh pollen loads (these traps cause only the pollen loads on the outside of worker bees hind legs to fall through tiny holes). About 10 to 40 kg of pollen are collected a year from a hive. This pollen is consumed as a health food.

Pollen is collected by forcing the returning foragers to pass through a mesh grid. The pollen pellets are scraped from the pollen baskets on the workers hind legs and fall into a collecting tray covered with a smaller mesh wire to prevent the bees from retrieving the pollen. Several designs of pollen traps are used. Pollen collection is not recommended for most mall-scale beekeepers. The colony needs pollen to rear brood, thus only limited amounts can be removed or the colony will become weak. This entails monitoring the colony closely. Trapping pollen is more efficient in areas where there are intense flows. In most areas of the tropics, pollen collecting is difficult since the flows are weaker and the yields are low. Pollen also spoils quickly. Once the pollen is collected, it must be quickly dried or frozen. The problems involved in collecting and processing pollen, coupled with its limited market, make it an impractical product for most small-scale beekeepers.

5.4. Bee brood

Bee brood is a potential hive product for local use. It can be used as animal feed (ex. For chicken) or as human food in areas where insects are accepted in the human diet. Brood is the developing adults of the colony, so only drone brood should be used. For human food, the brood can be eaten raw or dried, or skewered and roasted.

5.5. Propolis

Bees collect the sticky substance off bark or buds from a variety of plants to make propolis, which they use alone or with beeswax as a cementing substance for their nests. Propolis is made of resin and balsam (50%), wax (25%), and fatty acids and polyphenols (25%). Pigments in propolis from various plants give it a variable color, which may be reddish, brownish, or yellowish.

For retail sale, the quality of propolis is evaluated with respect to its: 1. Appearance, color, odor, flavor and consistency; 2. Wax content must be less than 30%; 3. Oxidative compounds must be less than 22% and 4. Impurities must be less than 20%.

5.6. Bee Venom

A bee stores venom in a poison sac, which will be deposited during stinging. A diet devoid of pollen impairs venom production. The production is induced when bees are shocked electrically. Venom is used in the treatment of rheumatic diseases. However, some humans are allergic to the bee poison.

To produce venom: The colony used to produce bee venom should be strong and populated with adult bees. Venom can be safely extracted in the laboratory using a venom extractor box. 3000 bees are placed in the venom collector box. A current of 6A is sent for 30 seconds. Once stimulated the bees repeatedly sting the black muslin cloth and release the venom, which is collected on the glass plate. The bees are shocked three times in two hours, then returned to their colonies. The mortality of bees should be less than 1%.

The bottom glass plate is removed and venom spots checked carefully. Bee venom crystallizes as soon as it comes in contact with air. A fine blade or scraper is used to collect the venom from the plate. It is stored in the refrigerator for further use. One gram of bee venom can be extracted from 70,000 bees and sold for USD100-120.

5.7. Royal jelly

Royal jelly is the secretion from the two types of glands that young worker bees (nurse bees) have at their head (hypo pharyngeal glands and mandibular glands). Given an ample supply of royal jelly, the larvae of queen bees grow to large-sized adults in a shorter period of time. They also livelong and keep a vigorous egg laying capacity since they continue to eat royal jelly all their lives. If you make queen cell cups from plastics and transplant young larvae of worker bees in the colony in the cups, you can artificially produce royal jelly. The quality of royal jelly is mainly based on the content of protein and 10-hydroxy decenoic acid, a unique fatty acid in royal jelly.

Royal jelly is produced by making a colony brood less and queen less. After one day, frames with bars of artificial cell bases (queen cups) containing one –day-old larvae are given to the colony. Because of the queen less condition of the colony, the young bees are stimulated to rear queens. To harvest the royal jelly, the larvae are removed from the cells after a few days, and the royal jelly scooped out.

5.8. Bee colonies: In high-tech beekeeping bee colonies are sold by their weight.

5**.9. Bee bread:** is also other product of hives