APPLIED ZOOLOGY
APICULTURE

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Contents:

1. Introduction

Rearing of the honeybees is beekeeping or apiculture. Beekeeping is one of the gentlest agro-industries. Bees and beekeepers are found throughout the world. Honey industry involves honeybee, flowering plants that provide food to the bees and to the beekeepers who manipulate

bees according to the climate and vegetation for their own benefit. Beekeeping creates employment, income and a measure of economic security and well-being.

In India, the association between man and honeybee has a long history, as evidenced by oldest records of honey industry in the form of paintings by prehistoric man in the rock shelters. Honey was the first sweet food tasted by the ancient Indian roaming in these forests. They hunted bee - hives for this gift of Nature.

In India, the common honeybee nests, that have been raided, are those of the giant honeybee, *Apis dorsata*. Tribal populations and forest dwellers in several parts of India collect honey from wild honeybee nests as their traditional profession. The methods of collection of honey and beeswax from wild nests have changed only slightly over the years. Deliberate protection of bee nests in marked tree cavities and periodic harvesting of honey was the first step in beekeeping. The next step might have been to attract bees into hives that have been protected bee gardens.

Bees have been reared by man originally for harvesting honey. Today, honey industry is not restricted to honey alone. It also involves production and harvest of all hive products, like beeswax, bee collected pollen, royal jelly, bee venom and propolis. Honeybees are also involved in pollination and thereby increasing the productivity of agricultural and horticultural crops.

1.1 Beekeeping as a Village Industry – Indian Context

In India as well as several other south-east Asian countries, beekeeping has been mainly forest based. Several nectariferous plant species in moist and evergreen tropical and sub-tropical forests provide forage (nectar and pollen) to honey bees. Thus, to the beekeeper, the raw material for production of honey is freely available in nature. Bee hives neither demand additional land space nor do they compete with agriculture for any input. Beekeeping is, therefore, ideally suited to the farmers as a part-time occupation and can be adopted as village industry. A bee-box is the only essential requirement to start the industry. The output is comparatively very high. It is a source of sustainable income generation to the rural and tribal farmers. It provides them valuable nutrition and traditional medicine in the form of honey, protein rich pollen and brood.

There had been good development of apiculture using the indigenous bee. Attempts have also been made to introduce the European bee, *Apis mellifera* L. into India successfully during 1960s. Later, apiculture using European bee gain popularity.

2. Biology of Honey Bee

2.1 Species of Honey Bee:

Bees belong to order Hymenoptera of insect group that shows evolutionarily advanced features in body structure and in life cycle. Of them, three families of social bees are honey producing: Bombidae, Apidae, and Meliponidae. There are two types of bees:

i) The true honeybees of genus, *Apis* (Family – Apidae)

ii) The stingless bees of genus, *Trigona (Tetragona*) --- commonly known as dammar bees (Family – Meliponidae)

There are at least 6 species of honeybees in the world: *Apis dorsata, A. florea, A. adreniformis, A. cerana,* and *A. laboriosa.* India has four species of *Apis*: *Apis florea, A. cerana indica, A. dorsata*

and *A. laboriosa*. All the *Apis* species have a remarkably similar life cycle. A brief description of characteristics of each species is given below.

Dwarf bee, *Apis florea* (F.)

Apis florea is the smallest honeybees and is called appropriately the dwarf or the little honeybee. It does not sting easily and so mistaken for Stingless bee. It is generally found in plains or low lands in tropics and sub-tropics. It is rarely found in altitudes above 450 m. The nests are built in bushes, densely leaved small trees in gardens and orchards, eaves of buildings or wall niches in urban areas and on closely placed stalks of crop plants like Sorghum (jowar).

The dwarf bee is able to survive in very hot and dry climate. The comb (size 40 x 45cm) architecture is similar to that in other *Apis* species, except the comb shows a distinct honey portion that is situated at the top, and where the support is free from above. The honey cells are constructed around the support. The dwarf bees perform short flight but the maximum distance for foraging is often up to 750 m. In view of this, the honey stored by it is generally unifloral.

Rock bee, *Apis dorsata* (F.)

Rock bees, also known as giant bee, are common in plains and hills tracts up to 1200 m altitude in the country. The nests of the rock bees are built in the open and are fixed underneath a broad support such as a rock cliff, branch of a tree, or eaves of a building. A usual feature of the rock bees is aggregation of their nests (about 100 colonies) on terrestrial and arboreal supports. In thick forests, rockbee colonies are built on branches of lofty trees at heights up to 50 meters. Rock bee's nests are found even on multistoried buildings, large overhead water tanks and towers, ceilings and arches of temples, engineering workshops in towns and cities.

Rock bee hive is the largest hive, often 100 cm broad and 80 cm high, but sometimes measuring up to 200 x 150 cm. The combs are semi-circular, vertically attached to the support above, from where it hangs down. The comb has a midrib and two layers of cells connected to it on either side. The nest population is 60,000 to 100,000 bees in well-developed colonies.

Like the dwarf bee, rockbee is migratory in nature, but the stay of nests in any one place is usually long and often their movement is restricted to two times in a year. It is said that rock bees can forage even during moonlit nights. Its flight range is more than 5 km. Honey hunting in forests is related mainly with rock bees.

Indian hive bee, *Apis indica*

The Indian hive bee is also considered as sub-species of the Asian or Oriental or Eastern hive bee, *Apis cerana* F. In India, two varieties: the hill variety or 'Gandhiana' which is darker and larger and the plain variety and 'Indica' which is smaller and yellow, and various ecotypes are recognized. It makes parallel combs on trees, termtaria, hollows of rocks and all kinds of cavities. It can be domesticated. The Indian bee is often blamed for its desertion or absconding tendency.

European bee, *Apis mellifera*

European bees, originated in Italy, and have been introduced into all the countries of the world where they formed the well-recognized races. In India, it was successfully introduced in 1965; the race is *A. mellifera*. The original stock at Punjab has been multiplied, and the progeny distributed in other states by the All India coordinated Project on Honey Bee Research and Training, ICAR,

Central Bee Research and Training Institute, and Khadi and Village Industries Commission. It can yield 4 - 5 times as much honey as the Indian bee. It makes its nest in enclosed spaces in parallel combs and is endowed with all the good qualities of a hive bee, i.e. it has a prolific queen, swarms less, gentle tempered so domesticable, good honey gatherer and can guard its nests against enemies, except wasps. It has adapted itself well to modern methods of movable frame hives and, therefore preferred for beekeeping industry the world over.

Stingless bees

Trigona (*Tetragona*) *iridipennis* is the most common dammar bee in the country. Besides *Trigona iridipennis,* that is common all over India, three other species occur in the Khasi hills of Meghalaya: *T.(Tetragona) iridipennis, T.(Tetragona) ruficornis and T. (Lepidotrigona) arcifera. Trigona ruficornis* also occurs in Haldwani, Uttaranchal. Pugh working as assistant agricultural officer in the Assam region before independence identified stingless bees found in Khasi hills as a species of *Melipona*. These are probably *Trigona*, since no *Melipona* is reported to occur in India.

2.2 Social organization of honeybee colony:

Honeybee is a social insect that lives in hives or colonies. Each colony is a society of different castes: the worker bee, queen bee and drone or male bee. There is a perfect co-ordination in the functioning of the following three castes in the colony.

Queen Bee

The queen is a fertile female larger than the other two castes. Her abdomen is swollen with eggs. Each colony contains one queen bee as its head. After birth, the queen stays inside the colony for about 5-10 days to grow to maturity. Later, it goes out of the colony on mating or nuptial flights followed by several drones. During the mating process, the stock of sperms of male bee goes into the spermatheca of the queen, where they can survive for over 3 years. The mated queen returns to the hive and starts its role as the queen mother, i.e. laying eggs. A queen can lay up to 15,000 eggs per day.

It is fed on royal jelly, a highly proteinous, enzyme- and hormone-rich food produced by the worker bees. Egg laying is controlled by the availability of food royal jelly. Although the queen bee can live for 2-3 years, its effective life to lay fertilized eggs for the survival and continuation of the colony is much shorter; usually 2 years. The queen bee can lay fertilized or unfertilized egg depending upon the size of the brood cell. The worker brood cells receive fertilized eggs, while the larger drone cells receive unfertilized egg. The former hatches into worker bee larvae and the later into drone larvae.

A queen bee differs from a worker bee in its morphology, development period, life span, and behaviour. The queen develops reproductive organs, while the worker bee develops organs related to its work such as pollen baskets, stronger mandibles, brood food glands and wax glands. Unlike workers, the queen never participates in any common hive activities.

Worker Bee

Worker bees are infertile female developed from fertilized eggs. A bee colony is called weak or strong according to number of workers it has. A bee colony of *A. cerana indica* has 15,000

workers and a strong one has 80,000. The workers (sterile females) are smaller than drones and queen. These have underdeveloped reproductive organs due to the influence of the pheromones produced by the queen. At any given time, a colony may have 2 or more batches of worker bees, having different male parentage.

A worker bee has a life span of 6 weeks. For about three weeks following birth, they do the indoor duties, like feeding the drones (if they are still need), nursing the young, secreting royal jelly and bee wax, feeding and attending queen bee, cleaning the cells and hive, repairing the damaged combs, construction of new combs, ventilating, cooling, guarding and defence of the colony, evaporating nectar and stored honey. During the next 3 weeks, they take to outdoor field duties of foraging to collect water, nectar, pollen and propolis, and ripening honey in its proventriculus (honey stomach). Older forager bees turn also into scout bees that search for new sources of food and new nesting sites for the hive.

A worker bee does not have an individual existence, as it lives for the good of entire colony. It dies in harness during flight to flowers. The average worker bee can make only one-twelfth of a teaspoon of honey during its lifetime. The worker bees must tap over two million flowers to make about one pound of honey, flying a distance equal to more than three times around the world.

Fig. 1. Various castes of honey bee. (Adopted from UNDP bulletin)

Drone

The drones are male developed from unfertilized eggs parthenogenetically. The male bees are produced in the colony for the purpose of mating and fertilizing the queen bees. The larvae that develop from unfertilized eggs are fed royal jelly and give rise to drones. Worker bees feed and take care of the drone bees till the virgin queen in their colony is mated. After mating with the queen, the drone dies. When queen bee returns mated to hive, the worker bees neglect the drones.

Table-1: Morphological features distinguishing the three caste of a honey bee

Drone	Worker	Queen

1. Eyes meet over head	Eyes far apart	Eyes far apart
2. Abdomen black, rectangular, blunt and without a sting	Striped, triangular with barbed sting	Golden (A. florae) or black (A. cerana indica), triangular but more elongated
3. Life span 3 weeks	Life span 6 weeks	Life span 2-3 years

2. 3. Life Cycle:

During nuptial flight, the queen receives spermatophores from drone and store in its spermatheca. The queen walks over the combs deciphering the cell size (largest of queen, smallest of worker and in between of drone) and depositing one egg in bottom of each cell. The eggs are small, oblong and bluish white. The eggs may be fertilized to produce females or unfertilized to produce drone parthenogenetically, and these are accordingly deposited in the cells of required size. The period of development of larvae and pupa differs amongst the different castes is given in table.

Table-2. Periods of development of different castes

Caste	Duration (in days)			
	Egg	Larva	Pupa	Total
Queen	3	5	7 - 8	15 - 16
Worker	3	4 - 5	11 - 12	18 - 20
Drone	3	5 - 7	13 - 14	21 - 24

The transformation of 3 castes depends upon the amount of ‘Brood food’ or ‘Royal jelly’ produced by pharyngeal salivary glands of worker fed to larvae. The cells of queen, worker and drone are sealed, i.e. capped with wax on 8, 9, 10 day of emergence, respectively. The cap of drone cell is convex with a central hole, and those of worker, queen, honey and pollen are flat.

2. 4. Social behaviour:

The various behavioural features of bees within the hive and in the field are important for the smooth functioning of the colony as a unit.

Swarming and Colony Reproduction

Swarming is a method of reproduction. A part of the colony migrates to a new site to reproduce a new colony. When food is available in plenty, the worker bees take up activities that result in colony reproduction. They build drone cells in which the queen lays unfertilized eggs. These hatch into drones. After this, the bees construct queen cells and fertilized eggs are laid in these cells. The worker bees feed the larvae in the queen cells with royal jelly, larvae develop into fertile females, viz. queen bee. Before a virgin queen emerges from the sealed queen cells, the mother queen leaves the hive with a part of the worker bees as a prime swarm. Then the virgin queen emerges and after a while rushes out of the hive with another batch of worker bees to form

after swarm that establishes itself into a colony at a new nesting site. The swarm settles in a selected nesting site. Worker bees begin to construct combs, forage and gather food, and to rear the brood. As the new worker bees emerge, the hive develops into a full-fledged colony.

Nest Site Selection and Nest Construction

Several factors are considered by bees in selecting the nest site, viz. the availability of food source nearby, distance of water source and adequate space to accommodate the nest. Other factors are temperature, humidity, and availability of sunlight, ventilation, and protection from rain, predators and enemies. Among the honeybees, rock bees prefer associations in the nest site, while other species build their nest in independent sites in isolation.

Following selection of nest site, worker bees produce beeswax by consuming nectar or honey. Wax is secreted by the 4 pairs wax glands located on 3rd – 6th abdominal sterna. The wax is secreted in liquid form and hardens into thin flakes or scales. The wax scales are removed from there with the help of legs, kneaded into required shapes by the spatulate mandibles and stuck to the top of nesting cavity and extended downwards bit by bit. Several bees hang like a string to do this job of nest construction. Beeswax is also used to seal the cells with wax cap.

Temperature Regulation

Temperature in the nest is an important factor. It controls hatching of eggs, ripening of honey and other activities of bees. Bees regulate nest temperature to the required level. In hot summer, temperature is brought down to the normal level by setting up wind currents and evaporating water inside the nest. Water or dilute nectar is collected for this purpose. In severe winter, they cluster close together so that the nest temperature does not fall down, and the heat generated by their metabolism is conserved.

Nursing and Food Sharing

Young worker bees normally attend to the duties of nursing and feeding. They can detect the young or old larvae, and feed them accordingly with royal jelly or with beebread (a mixture of pollen and honey). Bees consume pollen and nectar or honey, which helps in secretion of a special highly protein and hormone rich food, called royal jelly. Royal jelly is fed to young larvae till the third day after hatching. Worker larvae are fed thereafter with beebread. Bees feed the larvae, as well as other adult bees including the queen and drones. They exchange nectar or honey with other workers.

Pheromones

The distinctive colony odour resulting from these chemicals helps in recognition of hive mates, and locating their nest on return from forage flights. The chemicals are called pheromones and control the functions and behaviour of other individuals. The queen bee pheromones regulate the smooth functioning of the colony. It inhibits development of ovaries in worker bees, and prevents them from rising into new queen bees. When a virgin queen goes out on a mating flight, its pheromones help the drones to locate and reach her. The brood pheromones induce worker bees to feed the brood, and gather food from outside. Similarly, alarm pheromones induce them to attack the enemy or intruder in the colony. There are several such pheromones produced by the three castes that selectively control the behaviour of the inmates of the hive.

Queen's Retinue

A group of house bees form a circle around the queen and attends its feeding, cleaning and assists her in egg laying. Bees in this retinue constantly lick the queen's pheromones and share this substance with other house bees. The individuals in the retinue regularly are changed, as they leave the retinue to attend to other house duties and new individuals take their place.

Supersedure and Emergency queen

Supersedure is queen replacement without colony division. A failing queen who is unable to lay as many eggs as required, or who begins to run out of spermatozoa and lay a high proportion of male eggs will need to be superseded by supersedure queen. The worker bees are induced to build supersedure cells which are 2 or 3 large queen cells in the middle of the nest, unlike a dozen of comparatively small queen cells build at edges of nest during the swarming period.

In absence of queen substance due to death of queen, the workers are stimulated to get set for producing an emergency queen. The eggs or larvae less than two and half day old in worker cells, which are still being fed on abundance of brood food, are selected. Their cells are enlarged and extended downwards and the larvae are fed in the same way as in queen cells to develop into emergency queen.

Absconding and Migration

Complete desertion of a hive is known as absconding. It may occur due to lack of water, food store, overheating due to poor insulation and ventilation of nest, constant attack of pest and even by excessive interference of beekeeper. Prior to absconding, the bees drink whatever honey their nest has and then migrate leaving behind empty combs. Absconding can be prevented by providing water or sugar solution near the hive particularly in summer. The experienced beekeepers always take this precaution, since absconding is complete loss to him.

Guarding and Defence

Bees have defence mechanisms against enemies and predators. Use of propolis is one of them. Dammar bees use propolis also to regulate nest entrance. Dwarf bees use glue like special propolis to guard their nest from ants. Bees developed stinging behaviour to face threats to the nest from enemies and predators. A batch of old house bees guards the entrance of the hive. They warn the hive mates of an impending danger to the nest, by releasing alarm pheromones. When a guard bee stings or bites an enemy, alarm pheromones are released that alert and instigate other workers to mount a collective attack on the enemy.

Flying and Foraging

Initial flight of bee is restricted to the surroundings of the nest, and is called orientation or play flight. Bees use the play flights also to void themselves of faeces and other waste products of their metabolism. Bees exhibit highly efficient methods of collecting food, learning the intricate patterns of the flowers and of reaching the food. They are excellent navigators and can reach their nest after foraging at long distances.

Nectar foragers suck nectar with their proboscis. The nectar gets into the honey stomach, where it gets mixed with bee's digestive enzymes. When adequate quantity of nectar is collected, the bee returns to the hive. Here, it regurgitates the nectar and gives it to nectar soliciting house bees.

Both nectar and water are carried by separate bees.

Pollen foragers manipulate anthers of flowers to dislodge the pollens. Bees walk quickly or fly over the flowers, getting the pollen on their body parts. Pollen grains on any part of the body are gathered and packed together into pellets with the help of legs that have undergone extensive modification. The tibia of mid legs bears a spine at inner end, which is used to remove wax-flakes from the abdominal sterna bearing wax glands. The tibia of hind legs is broadened with concave outer surface fringed with long curved spines, the lower one of which acting as pollen rakes. The outer concave surface of tibia acts as a pollen basket. The basitarsus has pollen brushes. The pollens collected off the body the fore- and mid- legs are placed in pollen basket. Pollen baskets hold the pellets. When the pellets are big enough, the forager returns to the hive and deposits them in a pollen store cell.

Communication

Bees have a unique language (bee dance) to communicate among themselves about the distance and direction of food source. Experienced forager bees function as scout bees. They search vegetation in surroundings for food source. On locating a good source, the scout bee performs a dance on the surface of the comb. Through this dance, the scout bee communicates with potential foragers in the hive the information about the location in respect to Sun, the quality and amount of food.

Bee dance is of two types: Round dance and Tail-wagging dance. The communication dance is a sequence of elaborate movements of the posterior abdomen and of the bee in circles or other patterns. The vigour of dances and the frequency patterns of movements depend upon the quality, quantity, and distance of the food source.

2.5. Diseases and Enemies of Honey bees:

i) Brood diseases: Brood diseases are characterized by discolored larvae, dark punctured and sunken capping, scattered brood inside the cells and the foul smell. These are caused by various viral, bacterial and fungal pathogens. These are five types:-

- Ø American foul brood: - It is caused by *Bacilli* bacteria.
- Ø European foul brood: - It is also caused by bacteria, *Bacillus* and *Streptococcus.* Incidentally these two diseases are not reported from tropical country.
- Ø Chalk brood: - It is caused by the fungus, *Pericystis apis,* which converts larvae into chalk-white masses of mycelium.
- Ø Stone brood: - It is also a fungal disease caused by *Aspergillus flavus* . The spores of this fungus germinate in the alimentary canal of larvae and adults.
- Ø Sac brood: - Disease is viral. The larvae become sac-like with tough skin and die.

ii) Nosema disease: - The causative agent is the sporozoan, *Nosema apis.* This pathogen infects the lining of stomach causing dysentery. The spores of pathogen passed out with faeces of infected bees. The disease occurs in winter and quickly depletes the bees' population.

iii) Amoebic Disease: - The causative agent of this disease is *Malpighamoeba mellificae*. It infests malpighian tubules. The cysted amoebae passed into intestine and thence to exterior with faecal matter. It also results in dysentery. Sterilization of brood boxes and frame hives with

glacial acetic acid fumes or 40% formaline solutions can be taken as preventive measure for both the protozoan diseases.

iv) Acarine disease: - It is also known as 'Isle of Wight'. The mite infests the tracheae and feeds upon the body fluids. The eggs are laid and reared inside the tracheae that get clogged and ultimately mortality of bee occurs.

Enemies of honey bees:

A large number of desertions of hives by bees are due to enemies, which may be robbers that take away honey, brood, pollen or may be breeders that make the hive their breeding ground. Several moths and beetles are the enemies of these two categories. Several species of the wasps, *Vespa*, are predacious on bees. Also the several species of ants (*Componotus* sp., *Dorylus* sp. and *Monorium* sp.) visit bee colonies and take away honey, brood, pollen, dead bodies and other debris). Lizards and many birds being insectivorous prey upon bees. Mammals like bears, badgers and of course man also comes in the category of enemies.

3. Flora for apiculture

Apiculture is concerned with the efficient use of natural resources to produce natural material useful to man. The materials required for honey industry come from the flowering plants. Plants provide pollen and nectar having all the essential nutrients for their growth and survival of honeybees. These materials are processed by bees into honey, beeswax, royal jelly and other items, for immediate consumption or for storage and for later use.

Beekeeping in India has been by and large forest based. Our country, India, has large area and varied geographical characteristic. The natural flora of Indian forests is more varied because of the climatic conditions. There are several thousands of species flowering plants indigenous to India and many more have been introduced as crops of economic importance, or as ornamental plants. The forest natural vegetation of Western and Eastern Himalayan, the Western Ghats, the Sunder ban and the Assam region are more suited to bee life.

Beekeeping with the European honeybee (*A. mellifera*) that introduced in India in 1965 depends mainly on cultivated crops. Among such species are coconut, areca nut, red oil palm, date palm, cacao, mango, custard apple, jujube, cinnamon, clove, cashew, fodder legumes, coriander, cumin, dill seed, fennel, fenugreek, garlic, turmeric, ginger and other spice crops. The road side plantations like eucalyptus, karanj, tamarind, gulmohar, peltaphorum and soap nut also contribute to honey production. Hedges and fence plants like mehndi (Indian privet), duranta, mulberry, justicia and jatropha do also add to the bee forage value.

Many pulse and oilseed crops are also good sources of bee forage. Among the plantation commercial crops, coffee, orange and other citrus fruit, apple and other pomaceous fruit species, cardamom and rubber tree are important from the beekeeping point of view. The rubber plantation in southwestern and northeastern parts is the single largest source of nectar in India. Next in importance is litchi tree. The entire north India has large areas under litchi orchards that constitute an excellent source of nectar during March to May. Cereal crops, in general, are not very useful as sources of bee forage. However, jowar, bajra and maize are valued for their pollen.

4. Methods of beekeeping

4.1. Traditional beekeeping

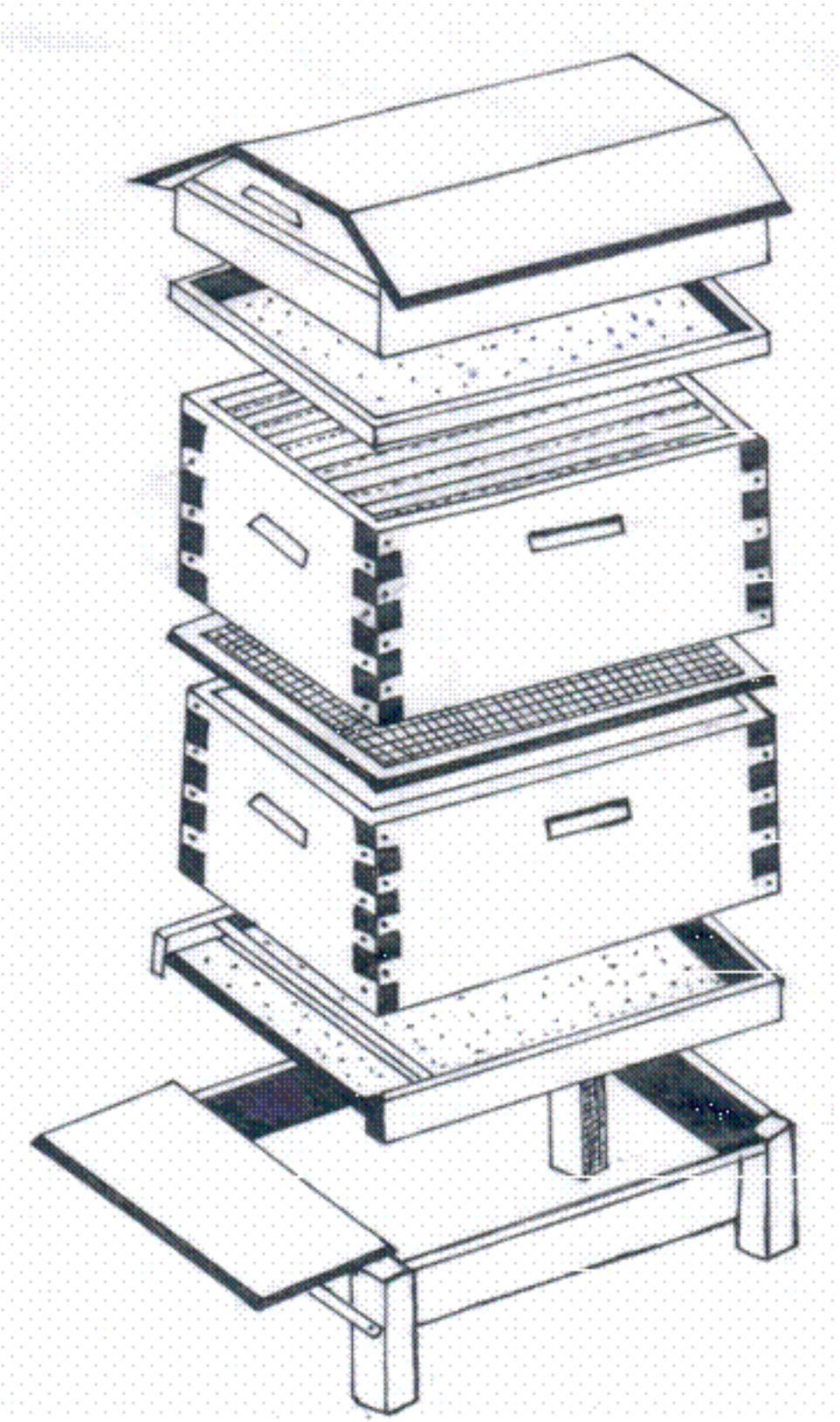
Traditional beekeeping is a natural consequence of forest beekeeping. The different traditional hives are used for the purpose. Rural people in southern India have been keeping bees in clay pots. A few such pots with holes and smeared beewax inside are kept in the garden as decoy hives, i.e., devices that attract swarms of bees. Swarms occupy the decoy hives. When the colony becomes strong, one or two shallow pots serving as super are kept inverted over it one above the other. When the monsoon sets in, the pots are overturned, the combs are taken out and honey is extracted.

Tree trunks or Logs (40 x 60-100cm) are hollowed out by removing the inner wood and used as log hive at altitudes above 1800 m. Wall Hives are empty spaces, left in east side wall of houses The wall hives are quite common from Jammu & Kashmir to the north-eastern Himalayan states. In addition, packing cases, empty wooden boxes, wicker –work and woven bamboo baskets of suitable size are also used as hives through the country.

4.2. Modern beekeeping:

Modern Hives

In modern beekeeping, bees are kept away from their natural homes in man-made hive as comfortable as possible. Modern hive is a wooden rectangular box and it is movable from one place to other. In modern hive, frames are kept parallel to each other, have free space all around them that is twice the body size. This is called the **bee space**. It was Langstroth who took notice first in 1851 about the bee space and originally designed the frame hive. Bee space is the major practical concept in the modern hive. The eggs, larvae and pupae are together called brood. The frames used for rearing brood are called brood frames and wooden box holding the frames are called as brood chamber.



Various types of frame hive varying in number of frames and bee space are used: Smith, British commercial, Langstroth, Modified Dadant, Newton, Honavar, Sodepur, Villager type etc. In 1956, Indian Standards Institution (ISI) constituted an Apiary Industry Sectional Committee to consider and bring out standards for bee - hives and other equipment. Based on the

recommendations, two types of hives - ISI Type A and ISI Type B - were adopted.

A movable hive has the following parts:

i) **Stand**: It is four legged structure with dimension to support the floor board.

ii) **Floor Board**: It is a tray with all its four sides raised by side runner. In the front, side runner is replaced by alighting board.

iii) **Brood box**: It is a rectangular box without top and bottom. One inch scooped shelves are cut along the length core of brood box to receive the ends of top bar of hive frames.

iv) **Hive frames**: These frames are wooden. The sides or chore named as top-, side-and bottom-bars. The ends of top bars extend beyond to rest on the scooped rabet of brood box and undersurface is grooved to receive the edge of comb foundation. There are four wires fixed between side bars to support the comb foundation which act as mid rib. Bee constructs their cells on both side of frame. These frames are spaced apart to leave the bee space (ranging from 6-9 mm depending upon type of bee to be reared).

v) **Queen Excluder**: It is wire frame with suitable size perforation that enables the worker to pass through but not the queen. It excludes the queen to stay in the brood box. It is placed in between the brood chamber and super chamber.

vi) **Super Chamber**: A hive could have 2-3 supers depending upon strength. The supers also have hive frames similar to brood box except in the shorter height. In super chamber frames only honey is stored. Hence, this chamber also called as Honey Chamber, and the frames in it as honey frames.

vii) **Covers**: On the top, there are two covers: inner and outer. Inner cover is a wooden plank of the size of box. It has one or two holes in middle that allow bee to go out but not to re-enter. The inner cover protects the bee nest and helps to regulate temperature and humidity within hive. The top or outer cover fits telescopically and acts as a roof for the hive to protect from sun and rain. Generally, it has two slopping planks. Ventilation holes are present on planks.

4.3. Beekeeping practices

Capturing

Capturing of the colony consists of removing the combs and bees from the natural nest and hiving them in the moveable frame hive. This is done early in the mornings or in the evenings when sun is not severe and the weather clear. After ensuring the presence of worker bees, brood in various stages of development and the queen bee, the combs are carefully cut one by one with a knife. These are tied to the frames and the frames are then kept in the brood chamber. Alternatively, receptacles called decoy hives are kept in suitable places on trees in forests, where swarms of bees are likely to settle. These are called decoy hives. After a swarm occupies the decoy hive, it is taken down and the colony transferred to a normal bee box. The presence of queen is necessary, because the workers do not stay in the hive without queen. In the case of beekeeping with the European bee, a colony can be procured from another beekeeper and hived in a bee box. The colony so procured should have worker bees and a young laying queen bee.

Queen rearing and Requeening of colonies

Normally mated queen bees exhaust their sperm supply within a year, and queen begins to lay

unfertilized eggs. This brings down the strength of the colony and its normal working. It is uneconomical to maintain such colonies. The colony can be revived by replacing the old queen with a new young and vigorous mated one. This process is called requeening. Beekeepers are advised to requeen about half of the colonies every year.

In a colony, Queens are produced under the swarming or supersedure impulse or under emergency condition. In the commonly adopted method of grafting for queen, a combination of these impulses is created and queens are raised from larvae of selected stocks. The grafting technique involves preparation of queen cell cups into which young larvae are grafted, and these are given to strong colonies from which the queen is removed a day earlier. Under the queen less condition, the bees accept the grafted larvae and raise them into queens.

Uniting

Colonies are united when these are too weak to continue as efficient units. In uniting two colonies, the older queen is removed a day earlier. The two colonies are gradually brought near to each other; the weaker queenless is placed above the brood chamber of the other colony, with a newspaper in between them. The newspaper is smeared on both sides with sugar syrup and small holes are punched in it. Bees enlarge the holes and mingle with each other without fighting. Small pieces of paper outside the entrance and absence of dead bees in front of entrance indicate successful uniting.

Swarm - prevention and control

Swarming is the natural process of reproduction. But, it is uneconomical to beekeepers. In swarming, nearly half of its work-force of foragers leaves the colony with the swarm, and the colony thus made weaker, is no longer able to gather nectar and make honey.

During the season of swarming, the strong colonies are inspected frequently to check for any queen cells. The queen and brood combs of the colony are removed. The queen is removed, it is kept in a queen cage in its own colony, and all queen cells are destroyed. Presence of the queen within the colony encourages food gathering. The queen is released after about 10 days by which time the swarming fever passes, and the colony concentrates on food gathering activities.

Desertion control

Bees desert their hive due to starvation because of the absence of floral sources in the area, continuous disturbance by pests and enemies. The time of desertion varies from place to place and from season to season. During floral dearths, brood rearing ceases. Bees abscond or leave the hive in search of a place where food is available. In such cases, providing artificial feeds, i.e. sugar syrup, can prevent desertion. A more beneficial and economical method is to migrate colonies to places where food is available.

Migration

For a beekeeper interested in honey production, migration of colony is undertaken during floral dearths or adverse climatic conditions, to areas where bee forage is available, or the environmental conditions are more favourable. The Central Bee Research and Training Institute, Pune developed appropriate schedules for migration of bee colonies for different agro-climatic regions of the country.

4.4. Harvesting of honey:

There are two main sources of honey in India: (i) Forest honey that is obtained from wild colonies in forests, including honey produced by traditional methods of beekeeping and (ii) Honey produced in apiaries. Harvesting of honey from these sources is described below:-

Forest honey from rock cliffs

Rockbee hives and wild nests of the Indian hive bee are the usual sources of forest honey. More than 90 per cent of the forest honey is collected from the rockbee colonies generally by tribals and other forest dwellers called honey hunters. Honey is an important minor forest produce. The honey hunting expedition is undertaken once or twice in a year, usually at the end of spring or in late summer or in autumn. The hunting operation is safer in night only, as bees cannot see in the dark. The hunting group leaves in the evening with the following equipments needed for honey hunting:-

1. A fiber rope ladder (50m long) or other strong fibered climbers.
2. Narrow bamboo sticks
3. Bamboo baskets or plastic vessels to collect comb pieces
4. A sharp and long knife with long handle.

A fire is lit on the ground below the nest location, and smoke is generated. When the nest site is quite high, a smoke torch is used in place of the ground fire. A sufficiently long rope is tied to the torch. A fire is made in the torch and as the smoke billows out from it, the torch is let down to reach the nest. The smoke continues to emanate for 30 to 45 minutes, during which time the hunter completes the operation.

The smoke and heat from the fire below confuses the bees. Bees get disoriented, leave the comb temporarily and hover around the nest area. The hunter first cuts away the brood portion and then the honey portion. A basket made of bamboo or reeds, or a vessel is used to collect the honey and comb pieces.

Forest honey from arboreal nests

Arboreal nests are common in tropical and sub-tropical forests with large trees. Here, the collection work is done in the daytime. The hunters first locate the nests and mark the lofty trees with several nests. Strong fiber rope is slung over a strong branch near the nests. The end of rope is tied to a tree trunk and the hunter climbs up the rope to reach the nests. Using the smoke torch the bees are brushed aside, the brood part of the comb cut off and sent down for making beeswax. The honey portion is cut by scraping. The comb pieces are put in the basket and sent down. The pollen and brood parts may be cut separately. The hunter generally cuts only the honey-bearing portion, and leaves the remaining comb intact. Bees repair and build a new honey-comb within a few days. When hunting is completed, the work of squeezing honey from the combs is done. Honey then drained through a cloth and filtered honey is filled in tin or plastic vessel.

Honey extraction in traditional beekeeping

A few puffs of smoke applied on the nest. In the case of pot hive, the pot is broken to get the combs inside. In all the cases, the honey filled combs are removed. They are pressed in a piece of cloth and honey is extracted.

Honey harvesting in Modern beekeeping

The honey or super chamber is an important provision in the modern moveable frame hive. Ideally, when all the combs in the super chamber are full and the honey in them is being ripened, another super is kept below the filled super and immediately above the brood chamber. When the second super is full, a third is given in the same way. This facilitates ripening of honey in a natural way.

Combs with a majority of cells sealed indicate that honey is ripe and can be extracted. A little smoke is given while handling the bees to subdue them. Bees on the comb are dropped down into the hive by a sharp jerk of the frame. Honey frames from all colonies are collected and brought into a room for the extraction operation.

Each frame of honey is held in one hand, and with a long uncapping knife the sealing of the cells is cut, just above the level of honey. The frames after uncapping are kept in the honey extractor. The extractor is operated by a handle at a speed of about 300 r.p.m. The frames are rotated in the process and honey comes out of the combs by the centrifugal force. The combs remain intact, and frames are returned to hive for use again. There are two types of honey extractors used: Radial and Tangential.

4.5. Harvesting and extraction of beeswax

Wax is also a valuable commodity of beekeeping. It is used by the beekeeper to form the foundation, but it also has high commercial value in domestic and international market. The beekeeper should save all old combs and aim to replace about 20 percent of brood combs each year. Capping, wild deserted combs and squeezed combs from honey hunting should be collected for wax extraction.

The combs are cut into small pieces and boiled in water for wax melting. The boiling mixture is then poured into a gunny cloth bag strainer. Pressure is applied over the bag with a pair of wooden rollers to squeeze out clean fluid. The liquid is received into a vessel having cold water. As the liquid cools the wax solidifies as a cake at the top of the water. Further purification is done by melting the wax cakes again in boiling water; liquid wax floating over the water is drained into a vessel containing cold water. Pure wax hardens into a cake that floats above the water. It may be also poured into suitable molds made of tin.

In modern apiculture, a commonly recommended extractor is **solar wax extractor** that uses natural sunlight for melting beeswax. It is a rectangular wooden box with a lid of double glass panes. The ratio of the area of glass to volumetric capacity is important and will determine performance. The extractor should have sloping sides and, when in use, should be positioned with the sloping sides facing the path of the sun. The extractor contains a metal tray with sloping sides in which to capture the wax. The molten wax gets filtered by the strainer as it flows down from the tray into a receptacle below. This lower receptacle contains water. Wax floats on the water and solidifies.

4.6. Other Beekeeping Equipments

- **Ant well**: The four legs of hive stand are placed in the ant wells filled with water. This prevents ants and other crawling insects entering the hive. Ant wells are simple tin or

Aluminium bowls (15 cm in diameter).

Ø ***Nucleus Box***: It is a small bee box having about 4 frames and used to house a nucleus colony -- a small man-made colony of bees. As the nucleus colony grows, it is transferred to a normal bee box.

Ø ***Dummy Board***: It is a wooden board of the size of a frame and used to reduce the size of the bee nest in a hive. Dummy board is used to reduce the free space in the hive that helps the bees in containing heat within the nest.

Ø ***Feeders***: It is simple Aluminium bowls are used to provide sugar syrup as feed to the bees during periods of nectar scarcity.

Ø ***Queen Cage***: It is used for transport of queen with a few attendant worker bees in packages.

Ø ***Queen introduction cage***: The *queen introduction cage* is made of simple woven wire mesh, (3 mm size). The mesh is bent round in the form of a square section tube of about 9 cm length and 2.0 x 1.3 cm cross section. One end of the tube is plugged with a wooden block, and the other end is open.

Ø ***Wire embedder***: This is used for embedding wire in the comb foundation to give strength to the combs.

Ø ***Hive tool***: It is a flat piece of steel of varying design and size used to separate the brood and super chambers, to loosen the frames for taking them out, or to scrape hive corners, frames and other hive parts.

Ø ***Smoker***: It is appliance to produce and apply smoke to the bees while handling them. There are different designs of smokers and different methods of smoking.

Ø ***Bee veil***: This is an essential wear of the beekeeper for protecting face from bee stings during the handling of bees. In principle a bee veil should have a cloth hood with an arrangement to hold a hat, and a screen in front of the face to allow free vision of the bees and colony.

Ø ***Gloves***: These are used soft leather gloves with canvas gauntlets to the elbow are the best for use to protect hands and arms, while inspecting and handling colonies.

Ø ***Swarm net***: It is used to hold a swarm of bees and transport it to the apiary. It consists of a mosquito net bag about 50 cm long and 40 to 45 cm wide, with one side open. The open side has a rope to close the bag after capturing the swarm.

Ø ***Bee brush***: It is a soft hairbrush to remove bees from honeycombs taken out for extraction of honey.

Ø ***Uncapping knife***: It is used to cut off capping of honeycomb before putting it in the honey extractor. Two types of uncapping knife, cold- and steam-uncapping knife are in use.

Ø **Comb cutter**: With comb cutter, old and worn out corns are cut and removed.

Ø **Scraper**: It is a flat piece of steel with one end broad and sharpened and the other end with a wooden handle. It does the same work as hive tool, but more efficiently.

5. Products of Bee keeping:

Honey

Honey prepared from the nectar of a single flower source is called unifloral or monofloral honeys, while honeys prepared from nectars of several sources is called multifloral. Honey is extremely variable in its properties and composition It has characteristic flavours and aromas depending upon the plant source. Freshly extracted honey is a viscous liquid and hygroscopic. It is the low surface tension of honey that makes it excellent humectants in cosmetic products. Colour in liquid honey varies from clear and colourless (like water) to dark amber or black and depends on the botanical origin, age and storage conditions. Crystallization is another important characteristic. The crystallization results from the formation of monohydrate glucose crystals.

Average composition of ripened Indian honey is given below:

Component	Percentage (Approximate)
i) Water	20.89 % (Apiary honey), 18.9 – 24.2 % (Rockbee honey), 16.5 % (Dwarf bee honey) and 24.1 % (Stingless bee honey)
ii) Levulose (Fructose)	41 %
iii) Dextrose (Glucose)	35 %
iv) Sucrose	1.9 %
v) Dextrins	less than 2 %
vi) Ash (Minerals)	0.185 – 1.4 %

In addition, rare sugars (maltose and raffinose) are also present in small quantity. Honey contains about 0.1 % N that exists in the form of protein derivatives and amino acids, and various vitamins that are important for human nutrition. Free acids (ex. Gluconic acid) and Enzymes – Diastase, Invertase, Catalase, and Glucose Oxidase are also reported to be present. Honey also contains several species of sugar tolerant yeasts.

Use

- In virtually every culture, evidence can be found of its use as a food source and as a symbol employed in religious, magic and therapeutic ceremonies.
- A major part of the production is presently consumed as food or food ingredient. About 10 per cent of the production is used in industry mainly in Ayurvedic preparations, pharmaceuticals, bakery, and confectionary and tobacco industries.
- It is valued for its nutritive value, giving energy, health, strength and vigour. It facilitates better physical performance, resistance to fatigue, higher mental efficiency. It also serves as a general tonic for newborn infants, the young and the elderly, the convalescent.
- A recent scientific study on human, that honey is reported to slow down the oxidation of LDL (low density lipoproteins) and checks atherosclerotic plaque deposition in blood vessels.
- Honey is a potential dietary antioxidant to counter reactive free radicals.
- Honey is used in preparation of pickles, jams, jellies, marmalades, squashes, sauces and ketchups, and sweetmeats like tarts, pancakes, pastries, pries and pudies and confectionery like sweets, candies, toffees, eclairs and chocolates, and in bakery products, like breads, biscuits, cakes and cookies.
- Traditionally, honey has been used as vehicle in Ayurveda, Siddha, Unani, and other

indigenous systems of medicine. It is anti-microbial and antiseptic and helps in healing of wounds and burns in a natural way.

- ü It has a mild bleaching action on skin and used in facials, shampoos and other cosmetics.

Beeswax

Beeswax is a metabolic product of honeybees. Worker honeybees of less than two weeks of age produce beeswax in a process of synthesizing esters in the fat body behind the wax glands. Rockbee wax is usually dark yellow to brownish in colour. Beeswax from the hive bees is white to pale yellow in colour. The melting point of rockbees is -59.6ºC, and that of the stingless bees, 66.5ºC, and that of the European bee is 62.5ºC.

Beeswax is a highly complex mixture of hydrocarbons and esters of monohydric alcohols combined with straight chain fatty acids and hydroxy-acids. The total unsaponifiable matter (hydrocarbons and alcohols) is about 58 per cent in both the Indian and European beeswax.

Use

- ü Beeswax is consumed by beekeepers for the making of wax foundations, which are given to the bees as a guide for construction of their combs.
- ü Its very special characteristics like medicinal benefits, plasticity and aroma ensure its continuing use. Beeswax is in high demand for commercial purposes.
- ü Being inert, beeswax is safe for human consumption as an ingredient in human food. It is used for coating for drugs or pills and also to fill capsules with equal amounts of drugs or other ingredients of various granule sizes.
- ü High quality beeswax obtained from capping is compatible with cosmetic ingredients and frequently used in ointments, cleansing creams cold cream and lotions, emollient and barrier creams, depilatories, lipsticks, nail creams, sun protection products, eye and face make up, and foundation creams.
- ü Beeswax is used in preparation of candles, in metal castings and modeling because due to its plasticity.

Royal jelly

Royal jelly is a special liquid food, rich in proteins, hormones, vitamins, organic acids and minerals, secreted by the hypopharyngeal gland of young worker (nurse) bees. Royal jelly is whitish in colour with yellow tinge with a pungent phenolic odour and a characteristic sour flavour. It is partially soluble in water. It is acidic (pH 3.6 to 4.2). About two thirds of it is water. By dry weight, proteins (73.9%) and sugars are the largest fractions. A total of 29 amino acids and their derivatives have been identified. A number of enzymes are also present including glucose oxidase, phosphatases and cholinesterases. The lipid fraction consists of free fatty. The major mineral salts of K, Ca, Na, Zn, Fe, Cu and Mn.

Use

- ü The spectacular fertility and long life-span of the queen fed on royal jelly, has suggestively led people to believe that royal jelly may produce similar effects in humans too. People have experienced it as a general tonic and stimulant improving general well-being, resistance to fatigue, learning capacity and memory, appetite, and general health improvement.

- Royal jelly improves immune response and general body functions.
- Royal jelly is used as ingredient in medicine-like products. It is usually mixed with medicines, tonics, beverages and cosmetic products soon after its production or sometime it is freeze dried.
- A mixture of royal jelly in honey (1-3 % royal jelly) is probably the most common way in which royal jelly is used as a food ingredient.
- Probably the largest use of royal jelly is in cosmetics and dermatological preparations.

Pollen

In India, Rock bees collect enormous quantities of pollen. The Central Bee Research and Training Institute, Pune made pollen supplements using rock bee pollen. After harvest from bee colonies, pollen loads are carefully air-dried or fresh-frozen for preservation and packed in airtight glass bottles. Pollen is also sold as tablets, in capsules mixed with honey.

The major components are proteins and amino acid, lipids and sugars. The minor components are more diverse including flavonoids, carotenoids, vitamins, minerals, terpenes, nucleic acids and nucleosides, enzymes and growth regulators. All essential amino acids are found in pollen.

Use

- The major use of pollen today is as a food or food supplement. Tribals eat the combs pollen while harvesting honey.
- Pollen is used in medicine for treatment of diseases like chronic prostatitis, bleeding stomach ulcers, respiratory infections and in control of allergy reactions.
- There is good number of non-scientific reports of benefits, cures or improvements in athletic performance, digestive assimilation, rejuvenation, general vitality, skin vitality, appetite, hemoglobin content, and sexual powers by use of bee-collected pollen.
- Pollen has only recently been included in some cosmetic preparations with claims of rejuvenating and nourishing effects for the skin.

Propolis

Propolis is a mixture of the beeswax and the resins collected by honeybee from plants. In the process of collection of resins, it is mixed with some saliva as well as with wax. Propolis is used by worker bees to line the inside of nest cavities, brood combs, to repair combs, seal small cracks in hive, reduce the size of hive entrances and to seal brood cells. These uses are significant, because they take advantage of the antibacterial and antifungal effects of propolis.

Propolis ranges from yellow to dark brown in colour. At temperatures of 25 to 45^{o}C, propolis is a soft and very sticky substance. Typically, propolis will become liquid at 600 to 700^{o}C, but for some samples the melting point may be as high as 1000^{o}C.

Use

- The Greeks, Romans and Egyptians already knew that propolis would heal skin abscesses. In sub-Saharan Africa, propolis is still used today in herbal medicines.
- In Africa, it is still used today as a medicine, an adhesive for tuning drums, sealing cracked water containers or canoes.
- It has been incorporated in special varnishes.

- Its anti-bacterial, anti-fungal, anti-viral, anti-acne, anti-inflammatory and anti-oxidant characteristics provide many benefits of its applications in medicines, dermatological and cosmetic treatment. The antioxidant, antimicrobial and antifungal activities of propolis also offer scope for its applications as a preservative in food technology.

Venom

Honeybee venom is a clear, odourless, watery liquid. Honeybee venom is produced by two glands associated with the sting apparatus of worker bees. Sting is evolved from ovipositors. Its production increases during the first two weeks of the adult worker's life and reaches a maximum when the worker bee becomes involved in hive defence and foraging.

About 88% of venom is water. The glucose, fructose and phospholipid contents of venom are similar to those in bee's blood. At least 18 pharmacologically active components, including various enzymes (Phospholipase A2, Hyaluronidase, Acid Phosphomonoesterase, Lysophospholipase and B -glucosidase), proteins and peptides (Melittin, Pamine, Mast Cell Degranulating Peptide - MCD), Secapin, Procamine, Adolapin, Protease inhibitor, Tertiapin, and various small peptides), and amines (Histamine, Dopamine and Noradrenalin) have been described in venom.

Use

- Bee venom has long been used in traditional medicine for the treatment of various kinds of rheumatism.
- Ointments can be prepared by thoroughly homogenizing bee venom with white Vaseline, petrolatum or melted animal fat, and salicylic acid, in the ratio of 1:10:1.
- Its use in cure of the diseases, like arthritis, chronic pain, epilepsy, rhinosinusitis, polyneuritis, neuralgia, migraine, multiple sclerosis, asthma, and tropical ulcers etcis reported.

6. Apiculture and Agricultural Production

An important aspect of modern apiculture is pollination of crop and orchard plant species and increasing their yields. The value of the increased yields in these cultivated plant species is several times the value of the honey and other bee products. Bee pollination as a new agricultural production strategy has immense possibilities. Economic crops that are specifically dependent upon or are benefited by honey bee pollination include almond, apple, citrus, coconut, grape, guava, mango, papaya, mustard/rapeseed, sesame, sunflower and cotton and the seed crops like berseem, carrot, coriander and other spice crops, cucurbits, lucerne, onion, radish, safflower, soybean and turnip, and also fruit crops like apricot, cherry, cashew, litchi, peach, pear, plum, raspberry and strawberry.

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