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Toshima Kushram
Department of Entomology, CoA, IGKV, Raipur, Chhattisgarh, India

Mukesh Kumar Sahu
Department of Floriculture and Landscape Architecture, CoA, IGKV, Raipur, Chhattisgarh, India

Pappu Lal Bairwa
Department of Vegetable Science, CoA, IGKV, Raipur, Chhattisgarh, India

Corresponding Author
Toshima Kushram
Department of Entomology, CoA, IGKV, Raipur, Chhattisgarh, India

Review article

Package and practices of apiculture

Toshima Kushram, Mukesh Kumar Sahu and Pappu Lal Bairwa

Abstract
Apiculture, or beekeeping, is a promising field of agriculture that has the potential to contribute significantly to environmental conservation and economic development. Honey bees, as excellent pollinators and producers of honey, beeswax, bee venom, and polishing agents (propolis), are in high demand both nationally and internationally. Apiculture has the potential to open up new opportunities for existing and new apiculture-related businesses. Beekeeping is an agricultural sector with rural development activities such as the production of honey and hive commodities, as well as the preservation of ecological balance.

Keywords: apiculture, beekeeping and honey bee

Introduction
Apiculture (also known as beekeeping) is the practice of humans maintaining bee colonies, usually in man-made hives. It is a scientific way of honeybee rearing. Apiculture is derived from the Latin word apis, which means bee. Apiculture, or beekeeping, is the care and management of honey bees for honey and wax production. In this practice, bees are bred commercially in apiaries, an area where a lot of beehives can be placed. Usually, apiaries are set up in areas where there are sufficient bee pastures – such as areas that have flowering plants.

History
Depictions of humans collecting honey from wild bees date back to 10,000 years ago. In North Africa, beekeeping in clay pots began some 9,000 years ago. Domestication of bees in Egyptian art from around 4,500 years ago.
Beekeeping in India has been mentioned in ancient Vedas and Buddhist scriptures. Honey collection activities are depicted in Mesolithic rock art located in Madhya Pradesh. Scientific methods of beekeeping, however, started only in the late 19th century. Beekeeping was developed through several rural development schemes after India gained independence.
Johann Dzierzon is known as the pioneer of modern apiculture and apiology. His design is used in the majority of modern beehives. Reverend Newton in Kerala made the first successful attempt in 1911–17 when he developed a specially designed hive and began training rural people to extract honey from beekeeping. The "Newton hive" gained a common nickname for the design.

Systemic position
Kingdom –Animalia, Phylum-Arthropoda, Class- Insecta, Order-Hymenoptera, Superfamily-Apoidea, Family-Apidae, and Genus-Apis.

Different species of honey bees
While there are approximately 20,000 bee species, only eight species of honey bee are recognized, with a total of 43 subspecies, although historically seven to eleven species have been recognized. *Apis andreniformis* (the black dwarf honey bee)

- *Apis cerana* (the eastern honey bee)
- *Apis dorsata* (the giant honey bee)
- *Apis florea* (the red dwarf honey bee)
- *Apis koschevnikovi* (Koschevnikov's honey bee)
- *Apis laboriosa* (the Himalayan giant honey bee)

- *Apis mellifera* (the western honey bee) and *Apis nigrocincta* (the Philippine honey bee).
- The only living members of the Apini tribe are honey bees. There are three clades of honey bees today:-
- *Micrapis* (the dwarf honey bees)
- *Megapis* (the giant honey bee)
- *Apis* (the western honey bee and its close relatives)

Only two species have been truly domesticated: *Apis mellifera* and *Apis cerana*. *A. mellifera* has been cultivated at least since the time of the building of the Egyptian pyramids, and only that species has been moved extensively beyond its native range.

There are four well known species of true honey bees (belonging to the genus Apis) in the world:

- Rock bee (*Apis dorsata)*
- Little bee (*A. florea*)
- Asian bee (*A. cerana)*
- European bee (*A. mellifera)*

1. *Apis dorsata*, the giant honey bee, is a honey bee of South and Southeast Asia, found mainly in forested areas such as the Terai of Nepal. They are typically around 17–20 mm (0.7–0.8 in) long. Nests are mainly built in exposed places far off the ground, like on tree limbs, under cliff overhangs, and sometimes on buildings. These are known for their aggressive defense strategies and vicious behavior when disturbed, not for domestication, indigenous peoples have traditionally used this species as a source of honey and beeswax, a practice known as honey hunting.

2. *Apis cerana*: The eastern honey bee, Asiatic honey bee or Asian honey bee, is a species of honey bee native to South, Southeast and East Asia. The terms *Apis cerana indica* and *Apis Indica* or Indian honey bee, are an historic term, with all Asian hive bees now referred to as *Apis cerana.*

3. *Apis florea*: Is commonly known as the red dwarf honey bee. This species is among the smallest honey bees (body length of 7–10 mm, forewing length of close to 6.8 mm)

4. Western honey bee or European honey bee (*Apis mellifera*): Is the most common and 7-12 species of honeybee worldwide. *Apis* is latin for "bee", and *mellifera* is latin for "honey bearing".

Colony organization and division of labour

Bee colony: A honey bee colony typically consists of three kinds of adult bees: workers, drones, and a queen. Thousands of worker bees work together to build nests, collect food, and raise brood. Each member has a certain assignment to complete that is related to their adult age.

Queen bee

- Each colony has only one queen, except during swarming
- A queen has a much longer body than either the drone's or worker's, especially during the egg-laying period when her abdomen is greatly elongated.
- The stinger on the abdomen is curved and longer than the stinger on the worker's abdomen, but it has fewer and shorter barbs.
- She is the single sexually mature female in the group, and she produces both fertilized and unfertilized eggs.
- A queen can lay up to 1,500 eggs per day during peak production, produce up to 250,000 eggs per year, and possibly more than a million eggs in her lifetime.
- The average productive life span of a queen is 2 to 3 years, but can live for several years, sometimes for as long as 5years.
- The queen also produces pheromones that serve as a social "glue" unifying and helping to give individual identity to a bee colony.
- She only feeds on royal jelly.

Drone

- A drone is a male honey bee, and their sole purpose is to mate with the queen. Parthenogenesis is the process by which unfertilized eggs evolve into fertilized eggs.
- They are 200-300 in number.
- It has a much larger head than the queen or worker, and the compound eyes connect dorsally at the top of its head.
- They are usually only visible in the late spring and summer, when the queen is mating.
- Drones are devoid of stingers, pollen baskets, and wax glands.
- Drones reach sexual maturity about a week after emerging from the cell in a hive, fertilize the virgin queen on her mating flight, and die instantly after mating.
- Pollen/nectar resources become short during cold weather, such as in the fall, and the drones are typically driven out into the cold and left to starve to decrease the hive's load.

Workers

- They are the tiniest and make up the majority of the bees in the colony.
- There are around 39,700 worker bees in a typical colony of 40,000 bees.
- The life span of a worker bee is about 6 weeks.
- They are sterile females and under normal hive conditions do not lay eggs.
- They contain specific features (brood feeding glands, smell glands, wax glands, and pollen baskets) that enable them to do all of the hive's work.
- Their mouths have been altered to allow for chewing and lapping.
- The tongue is lengthy, and it is utilized to ingest nectar and pollen from flowers.
- During comb construction, a pair of mandibles aid manipulation.
- A row of hairs on the fore (front) pair of legs cleans the antennae.
- A pollen comb is a second row of hairs that cleans pollen from the head and mouth and transports it to the rear legs.
- The honey stomach, or crop, is the part of the intestine that stores the nectar collected during the journey.
- They have a sting and a sac of venom located at the tip of the abdomen.
- Cleaning and polishing the cells, feeding the brood, caring for the queen, removing trash, processing incoming nectar, creating beeswax combs, protecting the entrance, and air-conditioning and ventilation the hive are all tasks they perform during their first few weeks as adults.

  They feed for nectar, pollen, water, and propolis later (plant sap).

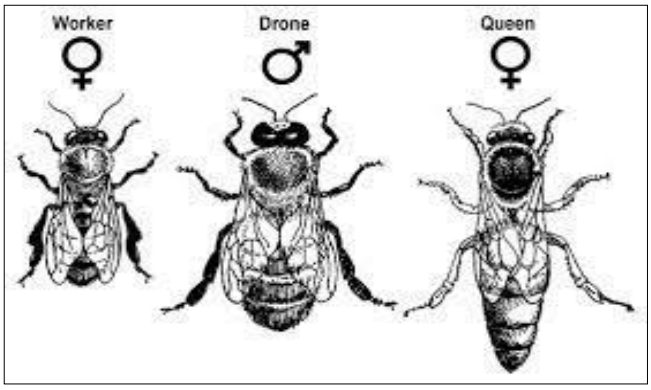

Fig 1: Three kinds of adult bees

Life cycle of honeybee

The egg, larval, pupal, and adult stages of honey bees' life cycle are separated into four stages.

Stage 1: The Egg Stage

The queen bee is the only bee in the colony that can produce 2,000 to 3,000 eggs in a single day. The egg is positioned upright and falls on the side by the third day. Both fertilized and unfertilized eggs are laid by the queen bee. The fertilized egg develops into female bees or queen bees. The unfertilized egg hatches and male bees are born; they are also known as drone bees.

Stage 2: The Larval Stage

Three days after the egg develops into larvae and six days after the egg is deposited in the beehive, the difference between a worker and a queen bee is determined. During their first three days as larvae, all larvae, including female bees, workers, and drone bees, are fed royal jelly. The larva sheds skin multiple times throughout this stage. Later, the royal jelly is fed only to the female larvae, which eventually becomes a queen bee. Finally, the worker bees cover the top of the cell with beeswax to protect and facilitate the transformation of the larva into a pupa.

Stage 3: The Pupal Stage

The bee has developed wings, eyes, legs, and small body hair to the point where it physically resembles an adult bee.

Stage 4: The Adult Stage

Once the pupa is matured, the new adult bee chews its way out of the closed-cell. From the egg stage to adulthood, the queen bee takes 16 days. Worker bees evolve into adult bees in 18 to 22 days, while drone bees develop into adult bees in 24 days.

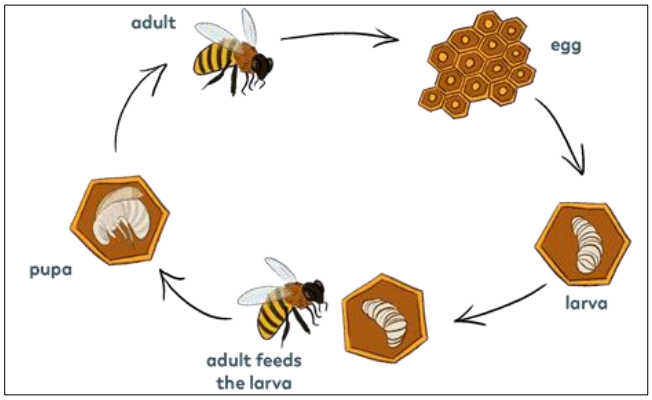

Fig 2: Life cycle of honey bee

Equipment for keeping bees

Bee hive

1. Old or indigenous method:

This is a basic and unplanned apiculture method. Two types of hives are employed in this method:

1. Natural fixed combs prepared by bees on the walls or the branches of trees
2. Artificial or man-made movable hives. These hives are made from wooden logs or earthen pots *etc.*

When the bees are at rest during the night, the indigenous method involves killing or forcing them to flee the hive using smoke. This approach has numerous disadvantages and is unsuitable for commercial honey production on a wide scale. The disadvantages of the indigenous technique are as follows:

1. Honey cannot be extracted in its natural state. The larvae, pupae, and pollen cells are all present in the honey that has been collected.
2. The future honey output is harmed since the colony must be killed in order to obtain the honey. Furthermore, the bees expend a lot of energy when they establish new hives.
3. The new hive cannot be built in the same location as the old one.
4. Natural hives are also vulnerable to predators such as rodents, monkeys, and ants. Climate change has the potential to harm natural hives.
5. Scientific intervention is also difficult in the indigenous technique, making it hard to improve the bee race.

2. Modern method

In 1851, L. L. Langstroth of the United States of America discovered the principle of bee space. This space permits free passage for worker bees and is too small to build a comb by bees or too large for depositing bee glue, *i.e.* propolis.

We can say that Bee space is the optimum distance between two surfaces in a bee hive essential for normal movement and functioning of bees. This principle was a big discovery for modern beekeeping. The modern hive has been designed on the basis of the principle of bee space in which frames can be easily moved. The bee space measures 9.52 mm for *A. mellifera* and this was modified for *A. cerana* to be between 7 and 9 mm.

Stand: To support the bottom board.

Bottom board: It is the floor of the hive having an entrance for bees. On this board brood chamber rests.

Brood chamber: Brood is reared in this chamber. Bees build combs on frames that are placed in this chamber. The size and number of frames differ depending on the hive type. The installation of a wooden dummy board at the end of brood frames is used to limit the size of the brood chamber.

Frame: A top bar, two side bars, and a bottom bar make up each frame. The top bar includes a groove on the inside for securing the comb foundation sheet. The frame is wired through four holes on the side bar.

The frame holds a comb.

Dimensions of hive: In general for *A. mellifera* we use Langstroth hive (named after L. L. Langstroth) and for *A. cerana*, BIS (Bureau of Indian Standard) hive A and B type.

In 1995, BIS introduced a C-type hive based on the Langstroth hive, for *A. melifera*.
For high-quality bee hives, well-seasoned wood such as Kail, Toon, teak, or rubber might be utilized. No wood with a strong odour is used. The following are the dimensions of various types of bee hives used in India:

Super: Dimensions may be the same as or half of those of the brood chamber (depending on type of bee hive). This is the place where bees keep their extra honey.

Inner cover: A piece of wood that serves as a barrier between the brood/super chamber and the roof.

Top cover: Over the inner cover, A type of lid that acts as a roof.

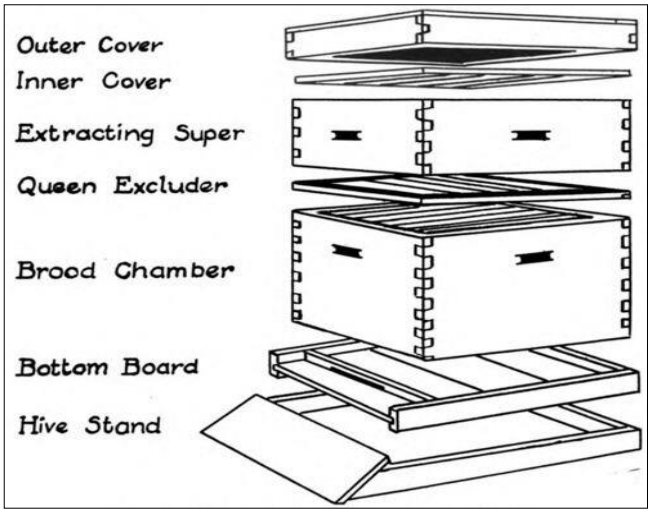

Fig 3: Movable frame hive

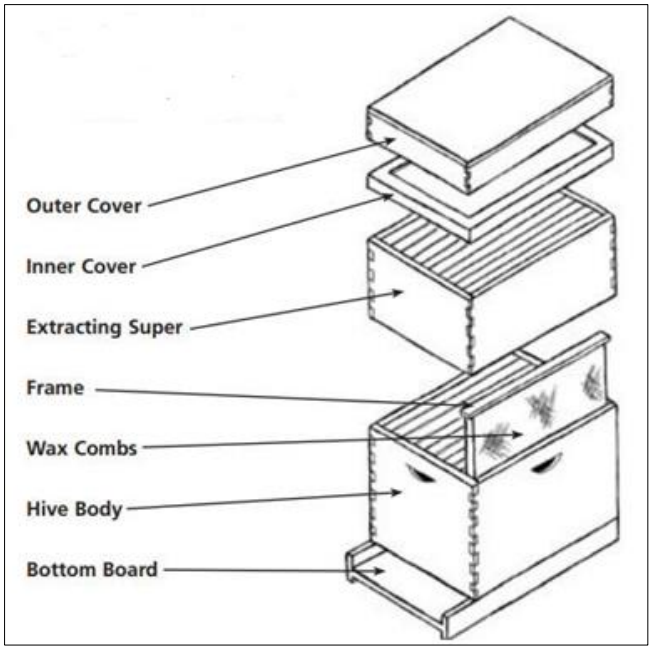

Fig 4: Movable frame hive

Composition of honey
- Water: 13-20%
- Fructose: 40-50%
- Glucose: 2-3%
- Minerals: Traces%
- Vitamins: B1, B2, C (minute quantities)

A. Pests of honey bees

1. Wax moths

The greater wax moth, *Galleria mellonella L.* (Galleriidae). It is one of the most observed throughout the year but more common and severe during July to October and November to December. Combs of all the species of *Apis* are freely attacked. It is one of the most dangerous bee colony foes, causing severe damage.
As they pierce the wax layers, wax particles loosen and fall into the cells and hive. The presence of loose, loosened particles in the hive is the first sign of an attack. The comb becomes entangled in silken webs holding several black caterpillar excrement particles when the infestation is severe. Exposed or partially covered combs, as well as weaker colonies, are frequently injured. The colony of bees is abandoned in such situations.
The adult female moth enters the hive at night, or in the case of weak colonies, during the day, and deposits eggs in the hive's cracks and fissures. Over the course of a fortnight, a single female lays about 200—800 eggs in groups. The smaller wax moth, *Achroia grisella* F., could be found at higher elevations. The caterpillars primarily feed the combs' dirt. The larvae of another wax moth *Achroi innotatalankella* C. & T. occur both inside the combs and on the floorboards of working colonies.
These wax moths at times decap the sealed cells exposing the pupae inside and this diseased condition is referred to as bald brood. The insect can be controlled by frequent examination of all the crevices of the hive and removing all debris. The excess of the hive not covered by the bees are removed and stored after fumigation with ethylene bromide. In the store rooms the spare should be stored in tightly closed containers.

2. Ants

The black ant, *Camponotus compressus*, the-household red ant, *Dorylus labiams* and *Monomorium* spp. are dangerous enemies of the bee. They attack weak colonies and carry away the honey, pollen and the brood. By providing ant pans around the bases of the stand or oil bands over the stands ants can be kept away. Underground ant nests are eliminated by pouring of 0.1% chlorpyriphos solution.

3. Wasps

The yellow banded hornet, *Vespa cincta* F., is a large wasp with a broad transverse yield band on the abdomen. It is a social insect constructing papery nests in hollow spaces. It waits area the entrance of the hive, catches bees as they come out, macerates them for feeding the juice to its young
By reducing the width of the alighting board of the hive, the wasps can be prevented from sitting near the entrance. Wasp nests should be destroyed by burning them. *V. tropica* vat, *haemotoides* B. is also known to attack bees in India.

4. Wax beetles

The tenebrionid beetle, *Platybolium alvearium* B., is found in the hives under unhygienic conditions feeding on the debris and on old combs in weak colonies. Periodical examination of empty combs and regular cleaning of the bottom boards will control the enemy.

5. Birds
King crow *Dicrucus* sp. and the bee cavers *Merops* spp. capture bees and devour them.

6. Tracheal mites
Acarine illness in adults is caused by the tracheal mite *Acarapis woodi.* Adult mites infest and complete their life cycle in the prothoracic tracheae, the first pair of tracheae found on the thorax. They feed on blood (hemolymph) by piercing the tracheal walls with their mouthparts. It creates 'K' winged bees, which are unable to fly because their wings are maintained at an unusual angle. Crawling bees can be observed in front of the hive.

7. Parasitic mite Varroa destructor
Both Indian and Italian bees are attacked by these mites, which are ectoparasitic. It eats lava and prepupa in the early stages. All of the above mites can be controlled by dusting micronized sulphur on the frames or using a fumigant like Folbex strips (Bromopropylate) within the hive. Mites can also be kept at bay by soaking absorbent cotton in a solution of 65 percent formic acid.

8. Brood mite, *Tropilaelaps clareae*
These mites are significant ectoparasites on Apis mellifera brood and adults. They assault the brood, killing the larvae. On the brood cells, there are perforations. Adult mites are bigger than brood mites.

9. Other enemies
Acherontia styx, the 'death's head' moth, enters the hive and consumes honey. Cockroaches may penetrate weak colonies and leave a bad odor in the hive. The Robber bee, the leaf cutter bee *Megachile disjuncta*, dragonflies and praying mantis capture bees and feed upon them. Lizards, frogs, toads capture bees at hive entrances. Bears destroy colonies and consume honey, pollen, brood, and bees.
Termites eat the wood in the hive, thus the stands should be coated with coal tar to prevent this. Termite mounds near the apiary can be killed by spraying a 0.1 percent Chlorpyriphos solution into the nests. The nymphs and adults of the Arachnid, *Ellingsenius indicus C.*, cling to adult workers in hilly regions.

Diseases of honey bees
In India, there are a number of diseases that impact honeybees. Acarine and Nosema infections in adult bees, as well as brood diseases in larval stages, are among the most common diseases that plague honeybees.

1. Nosema Disease
Nosema apis, a protozoan, causes this sickness. Dysentery is caused by a Nosema infestation. Because the flies are unable to fly, they urinate on the combs, frames, and ground in front of the hive. It has the greatest impact on flight during cold weather. Fumagillin, an antibiotic, is effective in treating the infection. The medicine is given as a continuous feed of 100 mg fumagillin per colony in 250 ml sugar syrup for ten days.

2. Brood Diseases
A variety of diseases affect honey bee broods. The colony's strength suffers when the brood is lost. Brood illnesses do not damage adult bees, although they can transmit the causal organisms. Adult diseases are less severe than brood diseases. Below are descriptions of bee brood illnesses.

a. European foul-brood
b. American foul-brood
c. Sac foul-brood
d. Thai Sac brood virus (TSBV)
e. Chalk foul-brood and stone brood disease

Out these brood diseases, the European foul-brood disease and the Thai Sac-brood disease are common in India.

a. European foul-brood disease, *Streptococcus pluton*
Streptococcus pluton, a non-spore-forming bacterium, causes the disease, with *Bacillus alvei* as a secondary invader. All castes of larvae are affected by the sickness. The larvae become watery, yellow, brown, and finally dark brown in colour. The tracheal system is exposed, and the larva dies in a coiled state, emitting a horrible odor. A hempy non-elastic thread is created in the advanced phases. Dead larvae are typically discovered in unkept cells with no discernible odor. Scales and larvae can be found in a variety of positions. The disease strikes when brood rearing is in full swing. Cells are not well capped and are mixed together with healthy cells.
Terramycin, an antibiotic, is the most effective treatment for the condition. Ethylene oxide fumigants can also be used to control the disease.

b. American Foulbrood, *Bacillus larvae*
Bacillus larvae is the cause of American foulbrood, which is a disease that affects bee larvae. Many tropical and subtropical countries are affected by the disease. The pathogen is a flagellate, motile, rod-shaped bacillus that is heat, desiccation, and disinfectant resistant. Worker, drone, and queen larvae are all infected after ingesting spores with their meal. The spores germinate in the gut, enter through the gut wall around pupation time, and reach the haemolymph, where they multiply rapidly. The most sensitive larvae are those that are still young. They turn dark and putrefy, giving off an unpleasant fishy odour. When they dry, the cell cappings turn black and sink inwards. Adult bees are now repairing the cells. Nurse bees cleaning the cells spread the infection. The larvae which are reared in cells previously occupied by diseased have also become infected. Total annihilation of the infected colony, including the hive, frames, bees, and honey, can be used to control the disease. Some strains resistant to have emerged in western countries.

c. Sac-brood disease (SBV)
Sac brood is a viral infection that affects *Apis mellifera*. The sick larvae resemble sacs, therefore the name. However, no cases of this ailment have been reported in India thus far.

d. Thai sac brood virus (TSBV)
Causative agent is Thai Sac-brood virus. *Apis cerena indica* is the species targeted by this virus. The propupal but sealed stage of the dead brood is found. At the back end of the pupae, it transforms into a sac-like structure filled with a lemon-colored liquid.
The larvae's appearance changes from yellowish to brownish to black in the advanced stage. There is no bad odor. TSBV killed many Indian bee colonies in South India in the early 90s, causing significant losses to the beekeeping industry. There is currently no effective way to control this condition. It is better to isolate the infected colonies. Combs from diseased colonies should not be used further.

e. Chalk brood disease and stone brood disease

Chalk brood is caused by the fungus *Ascosphaera apis*, which infects exclusively larvae. When spores are consumed, they germinate, and mycelia quickly spread throughout the body, penetrating the epidermis and covering the pre-pupa. The sick larvae are mummified as a result.

Honey, bees wax, royal jelly, bee venom, propolis and pollen are the important bee products. Honey is harvested at the end of a flowering season.

Royal Jelly

The glands of juvenile worker bees secrete royal jelly. Nurse bees provide the jelly to the up to three-day-old larvae, whereas queen bees eat it solely. This specific meal determines whether the larva will hatch into a worker or a queen bee. Beekeepers gather royal jelly when the honeycomb cells contain the most of it. The production of large quantities of royal jelly, on the other hand, is extremely difficult.

Propolis

Propolis, in particular, is a unique resource of the beehive since it is a natural antibiotic. While feeding larvae, bees collect resin from a range of plants and shrubs and mix it with pollen pellets. It has already been found to contain over 360 chemicals.

Wax

Wax is produced by worker bee glands and is used to construct honeycomb and seal the tops of honey-filled cells. Fatty-acid esters are the major component of beeswax, which contains nearly 300 naturally occurring substances.

Bee Venom

Bees are also known for their sting, which most people are familiar with. Bee venom is used in medicine to desensitize persons who are allergic to bee venom. Bee venom is also utilized to cure a variety of ailments and illnesses all around the world, but only under medical supervision. Bee venom has recently gained popularity in the cosmetics business. Creams and serums include it.

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