

Beeswax

Beeswax is a very useful by-product of bee keeping industry. It is yellowish to greyish brown in colour and insoluble in water but completely soluble in ether. Commonly it is a wrong impression to suppose that honey bees convert the pollen into beeswax because beeswax is also a natural secretion of the worker bees and is poured out in thin delicate scales or flakes. Chibnall (1934) has reported that all insect waxes are complex mixture of varying proportions of :

- (1) Even numbered alcohols ranging from C_{24} to C_{36} .
- (2) Even numbered normal fatty acids from C_{24} to C_{34} and
- (3) Odd numbered normal paraffins ranging from C_{23} to C_{37} .

The various beeswaxes differ only due to change in the proportions of these constituents. Large quantities of beeswax produced and exported, come from *Apis dorsata* bees. Indian Standard Institutions have fixed standards for pure beeswax in order to facilitate its export.

Economic importance of beeswax : Beeswax is used in the manufacture of cosmetics, for Catholic churches, face cream, paints, ointments, insulators, plastic works, polishes, carbon paper and many other lubricant. It is also used in the laboratory for microtomy with the common wax for block preparation of tissues.

Bee Enemies

Enemies of the bees harm the colony in different ways so they have attracted considerable attention in the different regions of the country. The wax moths (*Galleria mellonella* and *Achroia grisella*), Wasp (*Vespa* spp. and *Palarus* sp.), black ants (*Componotus compressus*) and bee eaters (*Merops orientalis*) and Kingcrow (*Dicrurus macrocercus*) are common enemies of the honey bee's comb and honey. Man is the last but worst enemy of honey bees.

Before 1958 bees were considered to be free from the diseases though suspected cases of NOSEMA from Punjab and Kashmir were known. But a parasitic mite-*Acarapis woodi* Rennie caused Acarine disease in the adult honey bee in Kulu valley in Punjab in 1956. It was later reported from Himachal Pradesh, Uttar Pradesh and Jammu and Kashmir. This disease was controlled by the scheme in co-operation with the United States of America at the college of Agriculture Ludhiana, Punjab. Now-a-days Indian honey bees are commonly free from any such disease. A strict quarantine measure is being taken to check the spread of any disease from foreign countries. But in European countries bees are commonly attacked by microsporidian which is injurious to bees.

BEE-KEEPING INDUSTRY

Bee-keeping has gained a good position as an industry in U.S.A., Canada and Australia but in tropical countries it is not growing as per need of the people. Before 1953 attention to bee-keeping was paid only by the State Governments but in the same year, all India Khadi and Village Industries Commission, started to pay attention to it and it was controlled by Union Government itself. Due to the functioning of the central organisation, bee-keeping industry was spread in South India and in some northern states also. Now-a-days bee-keeping industry is nation wide and is a good source of cottage industry. Till now limited research and development work has been done in this field which indicates that 'Apiculture' can be raised to the status of a viable occupation in tropical climates provided appropriate scientific and developmental efforts are generated. Because the tropical countries are very rich in bee fauna, the scientific development of apiculture may be helpful in agriculture and may contribute for providing nutrition and employment to rural population and may help in raising the economic status of the people.

Apiculture

Honey

It is truly an insect product of high nutritive value. The food value of honey may be estimated by the presence of about 80% sugar in it.

Production of honey : One should not be confused that honey is a direct plant product because the nectar, pollen and cane-sugar bearing secretions of flowers are ingested by honey bees, get mixed with the saliva and undergo certain chemical changes due to enzyme action. At this stage cane-sugar (sucrose) is converted into invert sugars *i.e.*, dextrose and levulose. At this very time some ingredients of bees are also added to the mixture and reduce the water content. The whole mixture is then collected in the honey sac (crop) until the honey reaches the hive. As the honey bee reaches the hive this compound is regurgitated in the hive cell and is known as the honey. Now honey is concentrated by a strong current of air produced by the rapid beating of worker's wings, crawling over the cells.

Honey is very much sweet in taste and white to black in colour with variable smell in accordance with the juices collected from different flowers.

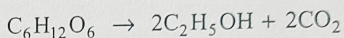
Chemical composition of honey : Honey is sugar rich compound having the following constituents :

(1) Levulose	— 38.9%
(2) Dextrose	— 21.28%
(3) Maltose & other sugars	— 8.81%
(4) Enzymes & pigments	— 221%
(5) Ash	— 1.0%
(6) Water	— 17.20%

Storage of honey : After long duration in the stored condition, the honey may be granulated and fermented.

(a) Granulation of honey : The stored honey becomes granular after long duration. Such type of granulation property is the best evidence of pure honey. It is considered that 10 parts of dextrose combine with one part of water, hence forms crystals. Due to less solubility levulose is not crystalised and gives cloudy appearance. Crystallization is mainly accelerated by the presence of minute air bubbles, colloids and pollens.

(b) Fermentation of honey : After crystallization honey is subjected to fermentation. Due to crystallization of dextrose 9% moisture is released, which dilutes the remaining levulose of the honey and the action of yeasts present in air, flowers and soils takes place on levulose and dextrose resulting in the fermentation of honey.



Economic importance of honey : Honey is used by human beings in different ways of which the most important is as food and medicine.

(a) Food value : It is estimated that 200 gm of honey provides as much nourishment as 11.5 litre of milk or 1.6kg cream or 330 gm meat. 2.1 gm of honey provide as much as 67 K. cal of energy. Its sugars, minerals, vitamins and other vital elements are readily absorbed by the systems. Honey may be taken by healthy men as well as those who are ill. It can be taken at any time in any season and by persons of all ages even those just born. It is used in the preparation of candles, cakes and bread. In illness it is preferred over milk because more than half of the body energy is provided burning of dextrose.

(b) Medicinal value : Honey is mildly laxative, antiseptic and sedative, generally used in Ayurvedic and Unani systems of medicine. It is quite helpful in building up of the haemoglobin of the blood and also used as preventive against cough, cold and fever, as blood purifier and as a curative for ulcers on tongue and alimentary canal. Its regular use is recommended after severe cases of heart attack for malnutrition, indigestion and diabetes. It is also found that typhoid germs are killed by honey within 48 hours, those of branchio-pneumonia in 4 days and of dysentery in 50 hours.

(c) Other uses : Other than food and medicine, honey is used in numerous ways. It is used in the preparation of bread, cake and biscuits. It enhances their preserving quality. Much amount of honey goes in making alcoholic drinks. In poultry and fishing industries honey is widely used. In laboratory, honey is used to stimulate the growth of plants, the bacterial culture, inoculation of seeds of cloves, in insect diet and in the preparation of poison baits for fruit flies.

making wall and ultimately the cells. Here every sheet of the wax is known as COMB FOUNDATION which attracts the bees and provides the base for the comb preparation on both the sides. The frames are kept vertically in brood chamber which is covered over by other frames having a wire meshing through which the workers can easily pass. The comb foundation helps in obtaining a regular strong worker brood cell comb which can be used repeatedly. The Central Bee Research Station at Pune arranged the manufacture of a comb foundation mill which manufactures, different cell sizes required in several regions of the country. The brood chamber is covered by another chamber known as super.

(d) **Super** : It is also without cover and the base. Super is provided with many frames containing comb foundation to provide additional space for expansion of the hive.

(e) **Inner cover** : It is a wooden piece used for the covering of the super. It has many holes for proper ventilation.

(f) **Top cover** : It is meant for protecting the colony from rains. It is fitted with zinc sheet which is plain and sloping.

2. **Queen excluder** : It consists of a wire-gauze, extraneous guards and drone traps with individual wires placed 0.375 cm apart. It readily permits the workers to pass through it but keeps back the queen in the brood chamber.

3. **Honey extractor** : It is used for the extraction of the honey from the comb and functions on principle of centrifugal force. When combs are centrifuged by this device the pure honey is thrown out without any damage to the comb.

4. **Uncapping knife** : When all of the combs are filled with honey they are sealed by capping with the wax. So, before such capped combs are placed in the honey extractor, the wax sealing has to be removed with the help of an uncapping knife heated by steam before use.

5. **Other equipments** : Most of the useful equipments for the successful management of the bee are locally manufactured which are very cheap. As they are made locally, they may not be

exactly similar to those made at other places. Thus, Indian Standard Institute has standardized some very common equipments for the production of uniform and interchangeable articles. Some materials like protective garments, gum cages, gloves, net veil, bee net, brush etc. are required for easy and well planned handling of the bees.

Advances of Modern Method

In the modern method of bee keeping there are several advantages which encourage the well planned bee keeping.

- (1) A proper watch on the activities of the bees can be had.
- (2) A strong colony can be developed by providing sugar, syrup, pollen substances to honey bees.
- (3) Swarming of bees is checked by modern hive.
- (4) The same hive is used again and again so the workers pay their attention more for the honey and not for the hive formation.
- (5) Under adverse climatic conditions the hive can be transferred from one place to the other for the protection of the bees.
- (6) Comb can be protected from the enemies.
- (7) Pure honey in large quantity can be obtained.

Precautions : For the proper management of bee keeping programme following precautions should be taken :

- (1) The hive should not be kept more than half a mile away from the place from where the bees have to collect the nectar and the pollen.
- (2) People must know about the bee keeper for proper contact.
- (3) The boxes must be kept under shade at cool places.
- (4) Industry should be near the road for proper transport facilities.
- (5) Fresh water reservoir should be near the hive.
- (6) Good flora for the collection of pollen and nectar should be there.

Products of Bee Keeping

The chief products of bee keeping industry are :

- (i) honey and (ii) bees wax.

Apiculture

controlled. (v) The hivation of bees on the same place is only matter of chance. (vi) The honey robbers, like, rat, ant, wasp and monkeys may affect the hive easily. (vii) The race improvement programme may not be applied, so no possibility for the selection of the best bee is there. (viii) The hazards created by climatic factors can not be controlled.

Modern Method of Apiculture

To overcome the drawbacks of indigenous method an advanced method based on scientific facts has been developed. It has opened a new era for the cottage industry in India and has also given an opportunity for lakhs of unemployed persons to keep them busy in this business. From this cottage industry programme the routine agricultural work may not suffer. First of all care was taken to improve the texture of the hives and during this race hive patterns were introduced in India. The Newton model with 7 to 10 frames (21×14.5 cm) in the brood chamber with a shallow super (21×6.5 cm sized frames) has been most popular in south, east and central India. Longstroth hive containing 10 frames (44.8×23 cm) has been used as a standard hive in Himachal Pradesh, Jammu and Kashmir and Punjab. In Uttar Pradesh another type of hive has been in use which was evolved at Jeolikote apiary and contained 8 frames (30×18 cm). After gaining experience from the above mentioned hives, Indian Standard Institute has standardized the hives of small and big sizes accommodating frames 21×14.5 cm and 31×20.4 cm respectively.

Now-a-days a typical type of movable hive is constructed which is capable of expansion or contraction according to the requirement of the place, season and climatic conditions.

Appliances for Modern Method

- (1) Typical movable hive
- (2) Queen excluder
- (3) Honey extractor
- (4) Uncapping knife
- (5) Other equipments

1. Typical movable hive : An artificial movable hive is constructed by wooden box based

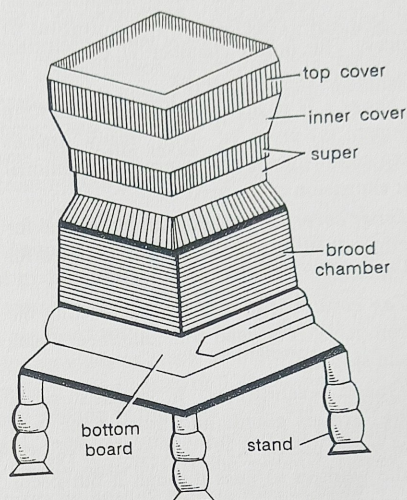


Fig. 3. Typical movable hive.

on bee space theory (Fig. 3). The size and number of frames are variable from hive to hive according to the need. A small space is enough to permit the entrance and exit of workers and drones but queen once placed in hive never comes outside the hive. The perforation size on zinc sheet is only of 0.375 cm but the thorax of the queen is 0.43 cm to 0.45 cm, so the queen can never pass through this pore. This typical hive consists of 6 parts as given below :

(a) Stand : It is the basal part of the hive on which the whole hive is constructed. The stands are adjusted to make slope for the hive. Due to this slope rain water comes down quickly.

(b) Bottom board : It is situated above the stand and forms the proper base for the hive having two gates in the front position. One gate functions as an entrance while the other as exit.

(c) Brood chamber : The bottom board carries the brood chamber which is the most important part of the bee hive. It is large in size provided with 5 to 10 frames. In each frame a wax sheet bearing hexagonal frames is held up by a couple of wires in a vertical position. Along with the margin of every hexagonal mark, the bees start

but in other species brood cells are of 3 types viz., WORKER CELL for workers, DRONE CELL for drones and QUEEN CELL for the queen. Queen cell can not be used again while the rest are used a number of times. There are no special cells for lodging the adults which generally keep clustering or moving about on the surface of the comb. The cells are mainly intended for the storage of honey and pollen specially in the upper portion of the comb while those in lower part are for brood rearing (Fig. 2).

Flora for Apiculture

Although honey bees can collect nectar and pollen from quite a long distance but the flora for apiculture is also important. The flora may be of wild or cultivated type. The more nectar yielding plants are neem, jamun, soapnut etc. The other plants like maize, rose and sorghum are good sources of pollen. Some plants like plum, cherry, apple, sheesham, coconut, guava, mustard etc., are good sources for nectar and pollen both.

Selection of Bees for Apiculture

For running a good apiary, selection of honey bee is of much importance, so the following should be kept in mind at the time of selecting honey bees for apiculture :

- (1) Honey bees should be of gentle temperament.
- (2) Honey bees should have capability to construct strong colony.
- (3) It should have ability to protect from enemies.
- (4) Honey bee should have energetic and industrious workers.
- (5) Workers can suck juice from numerous varieties of plants.
- (6) Bees on the whole can produce more and more honey from its comb.
- (7) Bees can from their comb easily at any place.

The apiculture scientists engaged in genetics are trying to find out such cross races which would not be of ferocious nature but be a good honey producer. In India, *Apis indica* is the best bee for apiculture industries due to its gentle nature and having efficient and prolific workers.

METHODS OF BEE KEEPING

The ultimate aim of bee keeping is to get more and more honey in pure form. The old method commonly used by old apiculturists is very crude, cruel and of unplanned type. This old method is called as Indigenous method.

Indigenous Method

1. Hive : Two types of hives are used in indigenous method of bee keeping e.g., wall or fixed hive and movable hive.

(a) Wall or fixed hive : It is purely natural type of comb because the bees themselves prepare the hive at any space on the wall or trees. There is an opening on one side through which bees come out of the hive.

(b) Movable hive : It comprises of hollow wood logs, empty boxes and earthen pots etc. placed in verandas of houses. There exist two holes, one is for entrance and the other for exit of the bees. The swarmed bees usually come to the box on their own accord. Some bee keepers use to take the clusters of the swarms from a tree and keep them in the hive.

2. Extraction of honey : For honey extraction, burning fire is brought near the bee hive at the night as a result of which bees are either killed or they escape off. Further the hive full of honey is being removed, cut into pieces and squeezed to get honey. Sometimes smoking is done so that the bees may escape from their hives.

3. Drawbacks of indigenous method : The indigenous method of bee keeping suffers from a number of drawbacks due to which it is not recommended by present day panel. These drawbacks are : (i) Honey becomes impure because at the time of squeezing, the brood cells, pollen cells, honey cells and larvae are also extracted. (ii) The colony becomes weak due to killing of the eggs and the larvae at the time of squeezing. (iii) Formation of new hive by the escaped bees requires extra energy which effects the yield. (iv) The activities of the bees can be

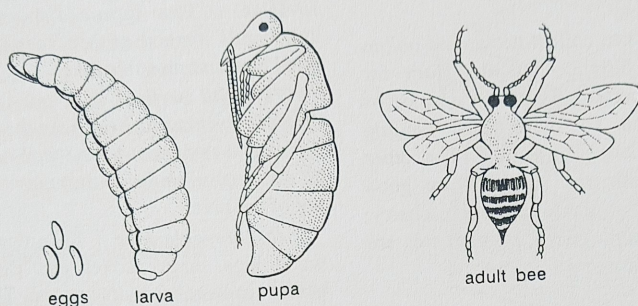


Fig. 1. Life history of *Apis indica*.

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

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

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

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

Hive

The house of honey bees is termed as hive or comb. It consists of hexagonal cells made up of wax secreted by the worker's abdomen. These hives are hanging vertically from rock, building or branches of trees. Each hive has thousands of hexagonal thin walled fragile cells arranged in two opposite rows on a common base. The resins and gums secreted from the plants are used for the repairing of the hives. The young stages are generally occupying the lower and central cells in the hive which are the 'BROOD CELLS'. In *A. dorsata* broad cells are similar in shape and size

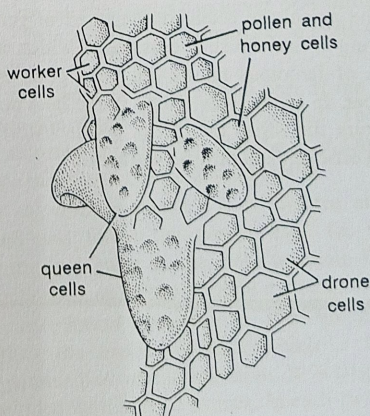


Fig. 2. Hive of *Apis indica* showing various cells.

The total weight of 100 eggs is equal to her body weight. In the whole life span of two to five years a queen lays about 15,00,000 eggs. When the queen in a colony loses its egg laying capacity, another worker of the same colony starts feeding on queen's diet *i.e.*, Royal Jelly and develops into a new queen and is provided with the facilities of real queen. At the same time old queen may be driven out but sometimes some workers object that as to why the mother of the colony be driven out so ultimately they also come out with the mother. Sometimes when 2 to 3 queens are developed in a colony, only one takes the position of the real queen and the others come out with some workers to establish new colonies.

Workers : Although the workers are the smallest of the three castes but they function as the main spring of the complicated machinery like honey bee colony. Like the queen, they are also produced from the fertile eggs laid by the queen and live in a chamber called as 'WORKER CELL'. It takes 21 days in the development from the egg to the adult and the total life span of a worker is about 6 weeks. The workers are atrophid female which sacrifice themselves for the well-being of the colony. The total indoor and outdoor duties of the colony are performed by the workers only. That is why they are provided with some special structures for particular work.

- (1) Long proboscis for sucking the nectar.
- (2) Strong wings for fanning.
- (3) Pollen baskets for the collection of pollen.
- (4) Powerful sting to defend the colony against any attack.
- (5) Wax gland for wax secretion.

The workers which are engaged in outdoor duties, collect the nectar, pollen, gum and water which are received and stored properly by the house bees. The indoor workers are further sub-grouped for specific duties. Some of them which are very sincere, attend the queen while some others look after the nursery called as NURSERY BEE. Some produce wax for the formation of the new hive and are known as BUILDERS. The repairing of the comb is done by the REPAIRERS. The dead body and other impurities are removed from the hive by the

CLEANERS. The fanning in the hive is performed by the wings of the FANNERS. Several other functions like honey storage and ripening are also done by the workers. The guard bee always watches at the gateway. It is said that upto half of their life period workers perform indoor duties and later on become engaged in outdoor duties.

Drone : The drone is the male member of the honey bee colony which fertilizes the queen so called as KING of the colony. They take 24 days to develop from the egg to the adult stage. The sting and the wax glands are absent but in the males the reproductive organs are very well developed. They are reared from an unfertile egg in large DRONE CELLS. Drones are totally dependent on the workers and have been seen begging for honey from the workers. The sole duty of the drone is to fertilize the virgin queen. At the time of swarming the drone follows the queen, copulates and dies after copulation.

Life History

After mating the queen generally lays one egg in one brood cell. The eggs are pinkish coloured, elongated with cylindrical body generally attached to the bottom of the cell. Larvae emerge out from both the fertilized as well as unfertilized eggs. Thus, the larvae from the unfertilized eggs form the drones while the workers are developed from the larvae of the fertilized eggs. Amongst the larvae of the workers one is fed on the royal jelly, a special diet secreted by the young workers in the colony and becomes the queen of the colony. The royal jelly consists of digested honey and pollen, mixed with a glandular secretion into the mouth of the workers. After 5 days of feeding the cell is sealed and the larvae undergo pupation. It spins a thin silken cocoon and pupates completely. Emergence of the young ones takes place after three weeks and they get busy in the indoor duties for about 2 to 3 weeks. Later on they are sent for the outdoor duties. All the bees pass through a complete metamorphosis with the various changes in the life-cycle taking place within the comb (Fig. 1).

Swarming : The process of leaving off the colony by the queen is termed as swarming. It

do not rear the brood. In spring seasons *i.e.*, at the time of flowering they prepare a strong colony with honey rich combs. They exhibit polymorphism and good division of labour. The bee hives with thousands of individuals are observed hanging down from the branches of the trees and ceilings of houses. The workers communicate informations for the location of the food sources through the 'Waggle Dance', a phenomenon called as 'Language of the bees', by the eminent biologist Karl Von Frish. He has mentioned that the rate of dance is directly proportional to the distance of the food.

Species of Honey Bees

Four species of honey bees are reported.

1. *Apis dorsata* F : (Rock bee). This is the largest bee, about 20 mm. in length, so named as GIANT HONEY BEE. SARANG and BOMBARA are other names of this bee which yields maximum amount of honey in comparison to other species. A single comb may yield 60 pounds of honey which is the maximum amount for a comb. The workers are very smart and active which may pollinate 12,000 flowers daily. But due to its ferocious and irritable nature, specific hive and migratory habit it is very difficult rather practically impossible to domesticate them for the bee keeping industry.

2. *Apis indica* F : (Indian bee). Commonly found in forest and plain regions of India. This is slightly smaller than *A. dorsata*. They prefer to live in dark places and construct several parallel combs about one foot across the protected places like cavities of tree trunks, mud walls, earthen pots, thick bushes, wells and walls of the buildings. This species is very gentle in nature, so can be domesticated easily. The production of honey is much less *i.e.*, 6 to 7 pound per comb.

3. *Apis florea* F : (Little bee). This is smaller than *A. indica* and yields very small amount of honey. The bees are not of gregarious nature and form a single comb. Due to its docile nature and rare stinging behaviour the combs can be removed easily for the honey extraction.

4. *Apis mellifera* F : (European bee). Although this bee produces less honey yet it is

found to be the best species from the commercial point of view. Due to their docile nature they can be domesticated easily and can be improved by breeding for several hundred years. Out of its several varieties, the Italian variety is reared every where in Europe and America in artificial hives for honey.

Social Organisation of Honey Bee

A highly organised division of labour is found in the colony of honey bees. A good and well developed colony of bees had 40 to 50 thousand individuals consisting of 3 castes *viz.*, QUEEN, DRONE and WORKER. The queen after fertilization lays fertilized and unfertilized eggs both. From unfertilized eggs male bees emerge which are known as DRONES whereas from the fertilized eggs worker bees are produced. The workers when feed on ROYAL JELLY, develop into QUEEN.

Queen : It is a well developed fertile female provided with immensely developed ovaries. Commonly one queen is found to be present in each hive and feeds on Royal Jelly. She is the queen in real sense as the Mother of the Colony, guarded by a number of attendants and never allotted any duty except egg laying. Egg laying is the sole function of the queen throughout her active life span. The queen is 15 to 20 mm in length and can be easily distinguished by her long tapering abdomen, short legs and wings. Structurally she is unable to produce wax or honey or gather pollen nectar. By the combination of ovipositor-cum sting, a structure is developed which aids in egg laying. It is said that the queen gets mated only once in her life but in a single chance of mating, drone releases 2 crore sperms which are sufficient for the fertilization of the eggs at the time of laying by the female throughout her life span. In recent researches in U.S.A. it has been reported that out of 110 queens only 55 mated twice before egg laying. It is also a fact that queen lays fertile and unfertile eggs both in accordance to her will but the factors governing such selective activity are still not known. One queen lays about 1,500 to 2,000 eggs in a day depending upon the seasonal variation and other ecological factors.

Man had started the use of animal products since time immemorial even at the cost of animal's life. Honey has been under use in human civilization since prehistoric period as mentioned in our religious literatures like Vedas, Purans, Ramayan, Mahabharat and Charak Sanghita. Some foreign travellers like Fahiyen and Whensson had also discussed the use of honey as medicine. People were very much dependent upon honey for medicines and essential nutritive elements of the diet.

The highly evolved social organisation of bees had been established before the existence of human race. Bees teach us the lesson of work-work and work with co-operation. We can easily imagine about the hard-working of the bees by the simple fact that for one pound of honey, a single honey bee travels about double the distance of the circumference of the earth's globe. Previously, the method of extraction of honey from the honey comb was very much crude but after the invention of artificial hive by Longstroth (1951), it became scientific and commercial. The bee keeping in United States, Canada, Australia and New Zealand has achieved out-standing success. In India people do not take interest in bee keeping from commercial point of view but only for their routine use. Since honey is produced by the honey bees, a detailed study of the biology of the bees is essential for successful implementation of apiculture programme.

HONEY BEE

Phylum	Arthropoda
Class	Insecta
Order	Hymenoptera
Family	Apidae
Genus	<i>Apis</i>

Habit and Habitat

Honey bees are highly organised social insects reported from all over the world. Although they are active throughout the year but in winter season they do little work and (Z-67)