APPENDIX III

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INTEGRATED RESOURCE DEVELOPMENT OF THE SUNDARBANS RESERVED FOREST

BANGLADESH

Beekeeping Manual

by

Cyprian B. Zmarlicki
Apiculturist

United Nations Development Programme

Food and Agriculture Organization of the United Nations
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1. HONEYBEES OF THE GENUS *Apis*

Bees are insects of the order Hymenoptera which feed on pollen and nectar. They constitute a group of about 20,000 species throughout the world, known taxonomically as the super family Apidae. Honeybees of the genus *Apis* belong to the family Apidae, a sub-group of this super-family. Until now, the question of how many honeybee species exist is not solved, but at least four species are commonly recognized : the dwarf honeybee ***Apis florea***, the giant honeybee ***Apis dorsata***, the eastern honeybee ***Apis cerana*** and the European honeybee ***Apis mellifera***. The first three are indigenous Asian species and the fourth originated in Africa and migrated to Europe in prehistoric times. ***Apis dorsata*** and ***Apis florea*** are mostly restricted to the plain areas, while ***Apis cerana*** is generally found also in semi-ever-green and evergreen forests, mostly in hills.

1.1 The dwarf honeybee *Apis florea*

The dwarf honeybee *Apis florea* is the smallest species of honeybee, both in the body size of bees and the size of its nest. A nest of the dwarf honeybee consists of a single comb built in the open, usually suspended from slender branches of trees or shrubs covered with dense foliage. The organization of the comb is as follows : honey storage on the top, below on both sides pollen storage, worker brood in the middle and drone brood in the lower part. The amount of honey which *Apis florea* workers are able to store in their nest is small, usually not exceeding a few hundred grams per colony. In areas where nests of the dwarf honeybees are abundant, honey hunting is common practice among rural families. Fortunately, during the process of hunting the whole colony, together with a queen, can fly away and build a new nest.

1.2 The giant honeybee *Apis dorsata*

The giant honeybee *Apis dorsata* colonies are found mainly in or near forests, although some nests can be observed in villages and towns near forest areas. *Apis dorsata* build a single but very large comb. In general, *Apis dorsata* tends to nest high in the air, from 3 to 25 meters above the ground. Nests of *Apis dorsata* may occur singly or in groups. The apiculturist found in the western part of Timor, Indonesia, a nesting site of *Apis dorsata* with over 100 nests on a large tree. In the struggle for survival *Apis dorsata* has developed the migratory habit. Migration is a response to seasonal lack of food resources. Colonies from one area move to another in order to take advantage of the flowering season and then return to the first.

Apis dorsata has a sophisticated social life similar to that in the other *Apis* species. There are two sexes, the female and the male, but the female is subdivided into two castes - the queen and the worker. In the colony of *Apis dorsata*, there are - one fertile queen, from several to tens of thousand sterile female worker bees and from tens to several hundred fertile males called drones.

In addition, there are about thousand eggs and several thousand immature bees in various stages of their development, called the brood. Of these, some are larvae and the remainder are pupae. The life cycle of the honeybee starts with an egg. It then passes through larval and pupal stage before emerging as an image or a young bee. The nest of *Apis dorsata* colony consists of a single but large vertical comb which hangs from the branch of a tree, cornices of buildings or on a cliff face. The width of the comb is from 30 up to 160 cm and the height is usually about half the width. The comb is composed of hexagonal cells. There are two types of comb cells : the smaller, called worker cells, and the larger, called drone cells. However, the difference between drone and worker cells is not as great as in other *Apis* species. In the upper portion of the comb, which is between 10 and 25 cm thick, bees store honey and pollen, and below this storage area is the brood nest. For reproduction through swarming, the bees build a third type of cell, the queen cells at the lower edge of comb in which queens are reared.

Apis dorsata is the most ferocious among all honey bee species, when its nest is disturbed, the workers can pursue intruders over long distances, often over 100 meters. In spite of this, because of the high honey production ranging from 10 to 20 kg per colony, many attempts have been made to use beekeeping methods for the bee similar to those for *Apis mellifera*. So far none has been successful, because, if put into any enclosed box like a hive, *Apis dorsata* deserts it at once.

Honey collection from the giant honey bee colonies is still practiced in many areas of the tropics and sub-tropics, especially those which are still covered with primary vegetation. In many such regions organized bee hunting exists and honey hunters must pay fees for permits to collect honey in state forests. Honey hunters collect honey at night in order to avoid strong colony defence. Usually at least two men work together. They wait for darkness, and then light a torch made from strips of bark and golpata leaves tied tightly together. When one of them reaches the colony on the tree, he waves the torch under the comb. Most of the bees leave the comb and cluster on part of the supporting branch out of reach of the smoke, but also many fly into the torch and are burnt. Often the queen bee, the most essential to the colony, is killed in the process of collecting honey. Now the honey hunter cuts out the brood area of the comb, throws it down, and carefully puts the honey portion of the comb into the container. Usually for collecting of honey a large funnel-shaped container is used. Harvested honey is squeezed through a cloth and filled into containers or bottles for sale to merchants.

The honey obtained by hunting *Apis dorsata* nests in the Sundarbans is done under very difficult conditions since the forest area is inundated by the tide and the forest floor remains soft and swampy. Furthermore, since the harvesting is done during the day in the reserved forest with a high population of wildlife, every year many honey hunters are killed by the Royal Bengal Tigers.

Honey collected in the Sundarbans due to improper handling during harvesting tends to ferment soon after harvesting because of its high moisture content. This honey also contains much debris, including large quantities of pollen and brood. Honey so produced must therefore be consumed or sold locally as quickly as possible before it ferments.

It should be noted that the traditional methods of collecting honey by honey hunters, causes the destruction of *Apis dorsata* colonies and there is a serious threat to the existence of the species. Already in some areas like for instance in Java, Indonesia *Apis dorsata* is very rare.

1.3 The eastern honeybee *Apis cerana*

The eastern honeybee *Apis cerana* colonies have been kept in hollow logs, clay pots, boxes and wall openings for centuries by rural populations in tropical, sub-tropical and temperate zones of Asia. The wide range of distribution has led to development of variations among ecotypes of *Apis cerana*. The most distinctive differences exist between the tropical and temperate races in the workers body size, nest size, colony population, swarming and absconding behaviour. The temperate races especially from Kashmir, India and Japan with much bigger worker body size, develop more populous colonies and store more honey than the tropical races. On the other hand the tropical races from Thailand and India are more prone to swarm, abscond and they migrate quite frequently in search for food. It should be noted that *Apis cerana* is very good at using scattered nectar and pollen resources which are dominant in many villages of tropical countries. Furthermore, the bees can work at lower temperatures from 8°C in the shade to collect nectar with higher water concentration and consume less food than *Apis mellifera*. Moreover, *Apis cerana* bees are better at defending their colony against wasps and other enemies and are resistant to mite infestation.

In the wild *Apis cerana* bees build their nests in cavities such as hollow trees, on banks and even in the ground. The nests are composed of multiple combs, parallel to each other, with a uniform distance between them, known as the "bee space". In fact the nest of *apis cerana* is very similar to a wild nest of *Apis mellifera* and both species have been domesticated. Unfortunately *Apis cerana* is not as productive a species as *Apis mellifera* and therefore considerable efforts have been expanded in introducing the latter into many Asian countries. But only recently the main obstacle i.e. the inter-species transmission of parasite mites has been solved by efficient control methods, and now beekeeping with *Apis mellifera* is prospering in many tropical Asian countries.

1.4 The western honeybee *Apis mellifera*

The western honeybee *Apis mellifera* colonies were kept in ancient times and at the same time migratory operation was developed along the Nile River. As has already been stated in the wild, the natural nesting sites of *Apis mellifera* are similar to those of *Apis cerana* : caves, rock cavities and hollow trees. The nests are composed of multiple vertical combs with a uniform bee space.

There are many races of *Apis mellifera* distributed throughout Europe, Africa and Western Asia. In the 17th century *Apis mellifera* was introduced to America and in 19th century to Australia and China. Nowadays about 50 million colonies of *Apis mellifera* are kept by, over 6 million beekeepers all over the world. The world production of honey in the last few years exceeds 900,000 metric tons. Some races of *Apis mellifera* develop very strong colonies with populations over 60,000 specimens and in recent years the Italian bee *Apis mellifera ligustica* has become the most common race in many countries all over the world. The Italian bee has been introduced into many tropical Asian countries i.e. Thailand, Burma, Vietnam and Indonesia as well as into Northern India and Pakistan.

2. GENERAL INFORMATION ON IMPORTANCE OF APICULTURE

Apiculture offers a unique opportunity to increase the incomes of small and poor farmers as well as create employment for the rural population, improving their diet and, at the same time, increase agriculture and horticulture productivity through bee pollination of insect pollinating plants. Beekeeping is a form of agricultural occupation that does not require the ownership of farm land. Many farmers are keen to let beekeepers use small plots of land to keep bees, since they know they will benefit from the pollination service performed by the bees. Beekeeping takes up little space and can be practiced even by landless people; it is an exceptionally suitable activity for rural women. Furthermore, beekeeping requires only a small investment in simple equipment and hives, and does not compete for space and resources needed for other agricultural activities. The bees find their own food (pollen and nectar) free of charge, and these natural resources are largely wasted when there are no hives of bees to forage them.

The main aim of beekeeping is the production of honey and other bee products, although in many countries nowadays, bees are kept for the pollination of agricultural crops. In many developing countries beekeeping practiced even on a very small scale at the cottage level - can supplement a family's annual income by up to and over 100 %. It is not a costly or complex activity but in order to be successful, it requires a scientific foundation and a cadre of trained personnel to provide advice and extension services.

2.1 The importance of bees for agriculture

Beekeeping today is a fully recognized branch of agriculture. The most important role of honeybee is their utility in cross pollination of various types of oil-seeds, pulses, vegetables, fruits, spices, legumes, fibre and plantation crops. It has been established that the value of increased crop yield due to bee pollination is 25 to 143 times the value of honey and beeswax produced.

Of all pollinating insects, the honey bees are the best pollinators. This is primarily due to their habit of living in colonies throughout the year, whereas other pollinators live individually and only single females start development of their nests in certain periods. The honey bees collect large amounts of food (nectar and pollen), they visit millions of flowers, which consequently are pollinated by them.

It is of great importance that honey bees as crop pollinators can be transported very close to blooming plants, and hence it is possible to ensure the proper amount of bees for the pollination of selected crops. It is common practice for farmers to rent bee colonies from beekeepers for pollination of particular crops. In the USA, farmers rent over 1 million bee colonies from beekeepers per year.

Almost all fruit trees are insect-pollinated and for their normal bearing, the proper amount of pollinating insects is required. As early as 1885, A. Testard underlined the great importance of insects, especially bees, in pollination of fruit trees. He performed an experiment with one hive of honey bees, which he placed in a greenhouse with a blooming cherry and subsequently observed abundant fruit bearing, whereas during preceeding years there had been just single fruits.

In Bangladesh the dominant species in orchards is the mango tree, so we will observe an example of how mango tree flower pollination and set-up of fruit takes place. The process of pollination involves the movement of pollen, each grain of which is a microscopic male plant in haploid (i.e. half the number of chromosomes of the parent plant) form. This pollen must move from the anther where it is produced, to the stigma of the female parts of a flower. If this occurs within the same flower or plant, it is self-pollination.

If flowers of different plants of the same species are involved, it is cross-pollination. Many plants can self-pollinate automatically and produce a crop. Other plants require cross-pollination. When the pollen has reached a receptive stigma of the right type, pollination is complete and it germinates. The cell nuclei leave the grain and migrate down the pollen tube as it grows, through the female parts of the flower and into the ovary, where the process of double fertilization occurs, involving two nuclei from the pollen and two from the ovule and embryo, then seed and fruit development proceed. Mango requires insect for pollination, but cross-pollination is not needed.

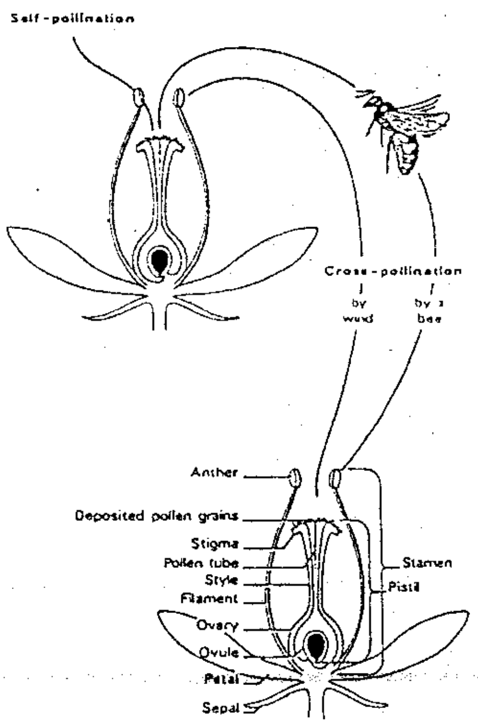


Fig 1 : **Self-pollination & cross-pollination by wind and by a bee.**
Source : *Tropical and sub-tropical apiculture. FAO Agricultural Services Bulletin.*

There is very little information on the pollination biology of important timber trees of tropical and sub-tropical Asia. The forest is the main and the oldest habitat of bees and the importance of forest trees in honey production is well known. It should be noted that honey harvesting and beekeeping have no negative impact on the functioning of forests. On the contrary, because of pollination of the trees (dependant upon insects for pollination) by foraging bees, beekeeping may exert a very positive influence on the forest.

2.2 The apiary site

The selection of a good site for an apiary should be made with great care in order to fulfil the needs of the bees and the beekeepers. Bees should be kept some distance away from houses. The most important consideration in the selection of an apiary site is the abundance of the nectar and pollen yielding plants, for the development of bee colonies and storage of honey. A good apiary place should be relatively flat and large enough for proper placement of hives or construction of bee sheds (Fig 1) and sheltered by bushes or a hadge. It is advisable that in tropical or sub-tropical countries the hives should be placed under small trees or under the bee shade. It should be noted that bees are able to produce much more honey and swarm less when they are kept in partial shade during the honey flow.

In order to avoid competition among colonies of *Apis cerana* for nectar and pollen, a good location should not have more than 25 bee colonies and apiaries may be located about 2 kilometers apart.

2.3 How to inspect a bee colony

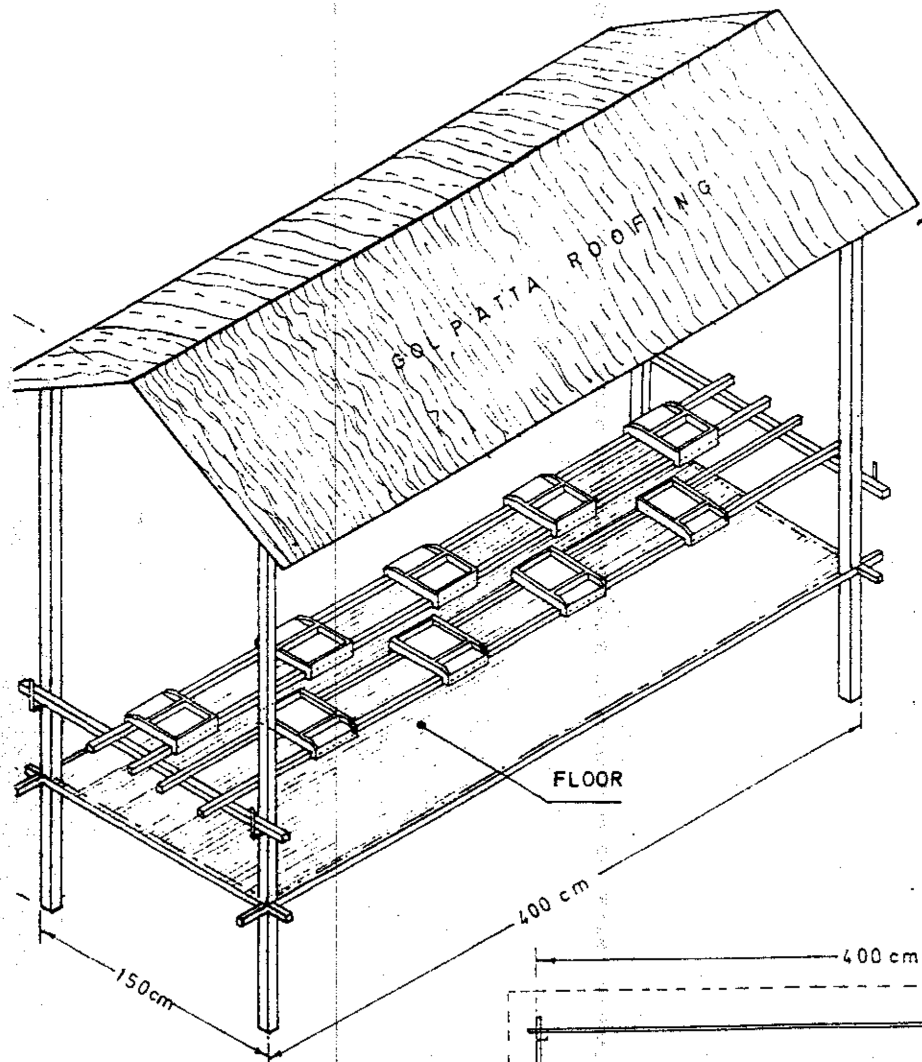
The objective of modern bee management is to guide the bees' natural behaviour into a pattern of activity desired by the beekeeper. In order to manage bees properly, all manipulation must be based on an understanding of their normal activities. The beekeeper should posses a knowledge of bee biology, life history and habits, as well as the proper use of equipment in their management.

Bees react very quickly to each interference from outside. The following may increase the aggressiveness of bees : improper handling, bad weather, lack of honey flow, lack of food in the hive, robbing and disturbance to the bees. They are very sensitive to various smells, e.g. sweat, alcohol, strong perfume, insecticides and some chemicals, i.e. bee repellents.

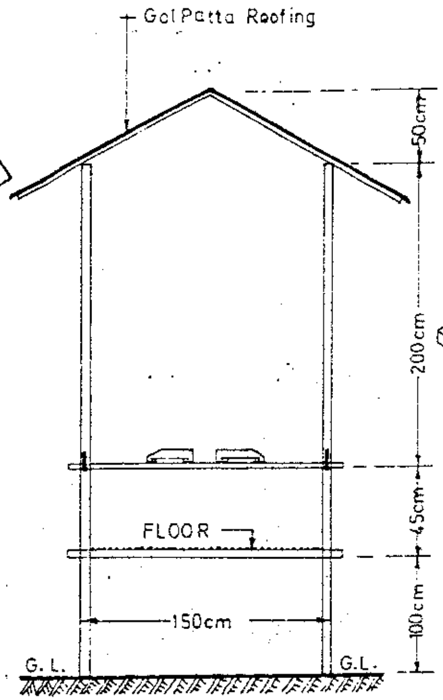
Each bee hive check includes the removal of the combs for inspection. The checking of bees may be carried out at any time of the day, but during the main honey flow period it is advisable to open the hive only in the evening, so as not to disturb the bees at work in the field. When there is no honey flow, it is also advisable to carry out checking in the evening in order to avoid robbing in the apiary. The queen is easier to find before noon, when the majority of worker bees are in the field.

During checking, the combs should not be exposed to direct sunlight as it may cause melting and damage. Combs taken out of the hive should be put into an empty super. If left outside during the dearth period or when there is little nectar in the field, it could cause robbing. Robbing is seldom a problem to the good beekeeper, but when it gets out of control the bees are more apt to sting, especially if they have exhausted the supply of honey they have been robbing.

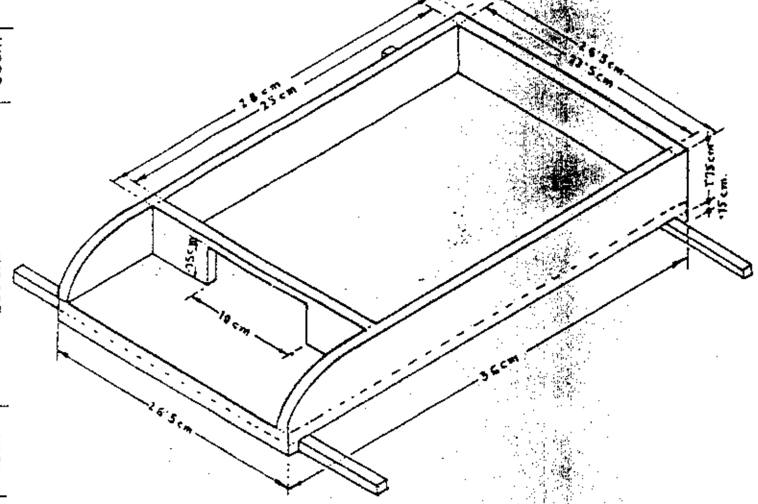
It is very important during checking that the sequence of the combs in the hive is not changed so that arrangements of the brood and correct temperature in the nest (+34 C) are maintained. Outside the brood nest the bees do not control temperature. Each checking should be undertaken rather quickly but avoiding rapid movements and shakes; nervousness



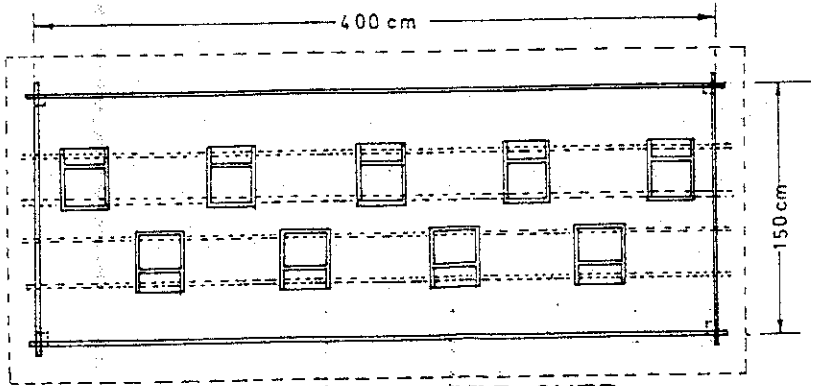
ISOMETRIC VIEW
OF THE BEE SHED



SIDE ELEVATION



ISOMETRIC VIEW PLAN
OF A HIVE BOTTOM BOARD



PLAN FOR BEE SHED

FIG 1

FAO/UNDP PROJECT BGD/84/056

DETAILS PLAN FOR BEE SHED

DESIGNED BY: CYPRIAN B. ZMARLICKI.
Apiculturist.

DRAWN BY: MD. SERAJUL ISLAM.
Arct. Draughtsman.
OFFICE OF THE CONSERVATOR OF FORE
PLANTATION CIRCLE, BOYRA, KHULN

APPROVED BY:

DATE : 23-11-92

should also be avoided since a nervous beekeeper tends to sweat and this odour makes bees angry. Prolonged checking in the hive can disorganize the bees' activities and encourage robbers to attack. Frequent checking of the hive during the main honey flow can considerably decrease the honey yield by as much as 30%.

Checking should commence by giving a few puffs of smoke in the entrance prior to opening the hive. Smoke will cause the bees to gorge the honey and consequently draw them away from stinging the beekeeper, since the worker bee with a full honey sack has difficulty in bending the abdomen to sting. While removing the combs from the hive, it is necessary to use smoke to keep the bees under control and stop them from flying out of the hive, since they may attack the beekeeper. Careless addition or rearrangement of the combs in the hive may cause crashing of the bees which makes the other bees nervous and aggressive and which therefore might sting the beekeeper.

Generally, beekeepers become resistant to bee stings after a period of time and do not swell. However, nobody likes to be stung, especially in sensitive areas of the face such as the nose and eyes. Beekeepers learn quickly how to protect themselves and keep stinging to a minimum. Wearing a bee veil, therefore, is essential in the handling of bees. Often the reaction of people who do not work with bees depends on their sensitivity to bee venom. There are two reactions to bee venom, first spot reaction and the second all-over body reaction. After being stung, most people have spot reaction; in such cases there is pain followed within a few minutes by the appearance of smaller or bigger spot swelling. In every case after stinging it is necessary to remove the sting as soon as possible with either a sharp knife, hive tool or finger nail, but the sting should never be squeezed as this may result in more venom being injected into the body. It is advisable to apply ammonia water or ice to bring relief from pain and swelling. To neutralize the reaction to venom, antihistamine drops can be rubbed on the stung spot.

Hypersensitive people react more seriously; in such cases there may be reaction all-over the body. This may take the form of some disturbances to the functioning of the human organism. Sometimes rashes appear on the body and blood pressure may drop, causing vomiting and even fainting. When the all-over body reaction occurs, the affected person should take cardiol or cardiamid and immediately see the doctor. In some extreme cases, even a single sting may cause the death of a hypersensitive person. In the case of very serious reaction to bee venom, therefore, it is necessary to seek medical attention at once. The doctor usually administrates antihistamine and ice packs. People hypersensitive to bee venom should always endeavour to avoid contact with bees.

3. BIOLOGY OF A HONEY BEE COLONY

A thorough understanding of basic honey bee biology is one of the most important requisites for success in beekeeping. The eastern honey bee, *Apis cerana* has a sophisticated social life and in many Asian countries is still considered as the most suitable bee species for sub-tropical and tropical climates. Fortunately the method of utilizing this species for honey production in modern hives has been recently developed. There are two sexes, the female and the male, but the female is subdivided into two castes the queen and the worker. In the colony of *Apis cerana*, there is - one fertile queen, from several to tens of thousand sterile female worker bees and from a few hundred to about 2 thousands fertile males called drones.

In addition there are from a few hundred to several thousand eggs and from a few hundred to several thousand immature bees in various stages of their development, called the brood. Of these, some are larvae and the remaining are pupae. The life cycle of the honey bee starts with an egg, which hatches in three days. It then passes through larval and pupal stages before emerging as an image or a young bee. The nest of an *Apis cerana* colony consists of several vertical combs. The comb is composed of hexagonal cells. There are two types of comb cells : the smaller, called worker cells, and the larger, called drone cells. In the worker cells in the central part of the nest, the bees rear brood; in the upper part of the nest, they store honey and on the sides of the nest, they store pollen and honey. In the drone cells, the bees rear drones. For replacement of the queen and reproduction through swarming, the bees build a third type of cell, the queen cells, in which queens are reared.

3.1 The queen

The queen bee is produced from a fertilized egg similar to a worker bee's. It takes only 16 days for the queen to develop from the egg to adult. The larvae from which the queen is produced, receive special food called "royal jelly" during the entire larval life. This food is secreted by the worker's hypopharyngal glands and is rich in fat and protein. The workers and drone larvae also receive royal jelly but only for the first 3 days after hatching from the eggs, and during their later larval life are fed on a mixture of honey and pollen. At the age of 5 days the queen takes a mating flight; she mates with about 7 drones during one or more mating flights and stores the semen received during mating in a storage organ called spermatheca. She does not mate any more, so the semen she receives must suffice for her entire life. A properly developed queen can live few years, but her best performance is during the first two years of her life.

As already stated, there is only one queen in a bee colony, and she is indispensable for the survival of the colony. She lays all the eggs, which may range from one hundred to almost one thousand a day, provided the colony is strong, the queen well fed and there is sufficient empty comb space to accommodate the eggs. The queen produces a pheromone called queen substance, which consists of about 30 organic compounds which have a stabilizing effect on the colony's social order.

Distribution of queen substance within the colony is considered to be one of the most important factors of the social life of bees. Due to the queen substance the workers are aware of the queen's presence or absence in the hive. Young workers (nurse bees), those feeding the queen, lick the substance from her body and distribute it to other workers within the hive. Young mated queens secrete more queen substance within the hive and, therefore, inhibit the development of the worker's ovaries. However, older queens secrete less substance and development of a worker's ovaries proceeds. Workers with developed ovaries (anatomical laying workers) are responsible for the construction of queen cells.

Under certain circumstances when the queen is old, the appearance in the hive of anatomical laying workers will lead to the replacement of the queen (supersedure), or if she is young and performing well, but the hive space is too small (and bees are congested) for the proper distribution of queen substance swarming conditions occur and the anatomical laying workers will commence the construction of queen cells. Furthermore, a bee colony will rear a new queen (construct queen cells) in an emergency when the queen is lost by accident during inspection of the bee colony. It can be stated generally that the presence in the colony of queen substance will inhibit the development of the worker ovaries and, the construction of queen cells, and lack of the substance leads to the development of the worker ovaries and, consequently, to the construction of queen cells.

3.2 The workers

The workers are infertile female bees, developed from fertilized eggs. It requires 21 days for a worker bee to develop from the egg to the adult. The workers are suited by their physiological and anatomical features to perform all kinds of tasks except reproduction. They possess well developed organs for conducting various types of work, i.e. tongue and honey sack (or honey stomach) for the collection and carrying of nectar, pollen baskets for carrying pollen, and glands to produce food (royal jelly) for feeding larvae, enzymes for making honey, wax for building combs and venom for protection of the nest.

Factors determining the type of task to be performed by a worker include its physiological and anatomical state of readiness and environmental stimuli, as well as the requirements of the colony. The longevity of *Apis cerana* workers during the honey flow is about 4 weeks, but during the monsoon period a few months. Duties of the workers - for the sake of convenience - sometimes are divided into hive (house bees) and field activities (field bees or foragers). Soon after emerging from its cell, a young worker consumes nectar or diluted honey with pollen. During the first few days (from 1-5) of life she feeds older larvae with mixed food (honey with pollen) and also consumes large quantities of food. Such a diet directly affects the development of the worker's hypopharyngal or food glands located in the head. The food glands are most active at the age of 5 to 8 days of the worker's life, but this can be extended according to the need of the colony. During this period, the worker also takes orientation and cleansing flights. At the age of 8 days, four pairs of wax glands, located below the worker's abdominal segments, also develop due to the stimulation caused by the consumption of large quantities of honey. From these glands the worker secretes flakes of wax, used for the building of combs and capping of cells. At the age of 11 days, the worker's salivary glands are fully developed and she is responsible for processing nectar into honey. She receives nectar from field bees, also called foragers, and adds the enzyme invertase, which splits sucrose contained in the nectar into fructose and glucose, the sugars predominant in honey. Using their proboscises, the workers expose the nectar to warm air in the hive to evaporate the excess moisture it contains.

At the age of 14 days, a worker bee becomes responsible for maintaining the correct temperature in the hive through ventilation. The last activity of the house bee is to guard the hive at the age of 18 days. At this age, the worker's poison glands, located at the end of the abdomen, are fully developed and she performs guard duties. Under normal conditions when the worker bee is about 3 weeks old, she becomes a field bee and begins to forage.

When they first start field activities, the workers' bodies are still covered with hair and therefore start to collect pollen, but when the hairs are mostly worn off, they collect nectar, water or propolis, according to the colony's requirements. The life span of a field bee depends on the duration and hardship of the work performed in the field. During the main honey flow the worker lives about 30 days, carrying out hive duties for about 20 days and collecting pollen and nectar for up to 10 days.

It should be noted that the above sequence of duties is carried out under normal conditions, but if the requirements of the colony change due to unexpected circumstances, the young bees can start to forage in the field when they are 3 days old. Also during the intensive main honey flow, the bees are ready to commence field activities from 10 to 20 days, since the gathering of nectar is considered to be the main task for the survival of the colony.

Summary of duties of House and Field Bees :

1 - day old	-	cleaning of comb cells
3 - day old	-	feeding of older larvae with mixed food (royal jelly with honey and pollen)
5 - day old	-	feeding of younger larvae and queen with royal jelly
6 - day old	-	taking cleansing and orientation flights
8 - day old	-	secretion of wax for building combs
11 - day old	-	processing of honey from nectar
14 - day old	-	maintenance of proper temperature in the hive
18 - day old	-	protecting the hive from enemies, performing guard duties.
21 - day old	-	commencement of field activities (collection of pollen, nectar and water).

3.3 The drones

The drones are male members of the honey bee colony reared shortly before the swarming season begins. From a few hundred to several thousand drones may be reared by the colony. Drones are produced from unfertilized eggs which the queen lays in larger cells. It takes 24 days to rear a drone from egg to adult. In queenless colonies, workers whose ovaries have developed as a result of the lack of inhibiting action of queen substance, can also lay unfertilized eggs, from which drones are produced. The only biological function of drones is to mate with the virgin queens. Drones well fed by the workers begin their flight activity when they are 6 days old but are sexually mature only at the age of 12 days. Drones from neighbouring colonies fly to a particular area known as the drone congregation area, to which virgin queens also fly for mating. To ensure successful mating, an abundance of drones must be present in the area, and the queen will mate with about seven drones. The drone dies immediately after copulation.

At the end of the honey flow season, rearing of drones ceases and those remaining are expelled from the hive by the worker bees. However, it should be noted that in queenless colonies or colonies with virgin queens or drone layers, the workers also tolerate the drones out of season.

In modern bee management, the production of drones should be limited to the queen rearing apiaries. In other apiaries, the drone population should be kept to a minimum, since they consume a large quantities of food. One thousand drones, during their life span, can consume large amount of honey. Furthermore, while keeping an excessive number of drones in a bee colony, the production of honey will decrease, since a smaller number of worker bees is produced.

4. BEE MANAGEMENT WITH *Apis cerana*

The seasons in Bangladesh can be divided into the following four periods:

(1) summer monsoon period
(2) post summer monsoon period
(3) winter period and
(4) spring period

4.1 The summer monsoon period

It lasts from the end of May to September and is the worst for the survival of bees due to excessive rainfall and lack of food for bees. Therefore in May, at the end of the honey flow season, enough honey (up to 1 kg) should be left in the hive in order to keep the colony alive during the prolonged monsoon dearth period. The beekeeper will learn by experience how much food (pollen and honey) the colonies will need in particular areas to survive this period.

The colonies during that time must be well protected from direct rain and wind (preferably under the bee shed) as well as from enemies that might try to enter the hive. If a bee shed is not available, at that time the legs of the hive stands should be placed in ant wells (tins containing old diesel oil). Many colonies may abscond from their hives during this period, therefore, in order to prevent this phenomenon combs not covered by bees should be removed during inspection of bee colonies. Since nectar is not available during this period, therefore colonies may be fed with 250 to 500 ml sugar syrup (50% sugar by weight) in the evening. As a rough guide it is suggested that colony inspection and feeding are repeated at two week intervals. Usually at the end of August there are intermittent sunny days and some wild plants appear and a few of them flower so the bees start to collect pollen. The supply of fresh pollen and stimulative sugar syrup feeding enable the bees, to rear brood and construct new combs. On a clear sunny day the colonies should be checked, and any old dark combs that are not covered by bees and show fungus or wax moth damage should be removed, and replaced by good ones or frames fitted with sheets of comb foundation should be used. It should be noted that by ensuring the continued presence of food, sealed and unsealed brood in the colonies, usually prevents the bees absconding from their hives during the monsoon dearth period.

4.2 The post summer-monsoon period

It lasts from September to November and in some areas of the country, like for instance in Khulna district, is very important for the production of honey due to wide spread cultivation of kul trees *Zizyphus jujuba*. The kul honey flow usually starts in the middle of September and lasts until the end of October. In order to utilize this honey flow it is necessary to have strong bee colonies just at the beginning of the kul blooming period. Therefore, preparation of bee colonies for the utilization of this honey flow should commence at least 6 weeks before the honey flow in order to stimulate brood rearing so that the adult bees reared during this period will be ready to forage when the blooming period starts. It should be noted that in the Khulna area there is a lot of coconut trees which, if the weather is good can provide the bees with plenty of nectar and pollen, enough for the development of colonies. However, during this period in some years there is still heavy monsoon and in such rainy season bee colonies should be fed with 250 ml sugar syrup (50% sugar by weight) at least twice a week. In order to equalize the strength of bee colonies, sealed brood combs from very strong colonies may be removed and used to strengthen week colonies.

If bee colonies are managed as described above most of them at the middle of September will start storing honey in the nests. At that time supers of fully built combs are added to such strong colonies. In areas of very good honey flow, after few days the second super may be added to colonies which filled up the combs with honey in the first super.

It should be emphasized that properly prepared bee colonies are able to produce a very good crop of kul honey. In the project experimental apiary at Boyra, Khulna it was possible to extract honey three times during blooming of kul from 24th September to 22nd October 1993 and bee colonies produced an average of over 4 kg of honey. However, some beekeepers in Khulna produced up to 6 kg of kul honey. This is a very good result since bee colonies in spite of stimulative feeding are still not fully ready to utilize this honey flow.

4.3 Winter period

In Bangladesh lasts for over three months from November to mid February and in many areas of the country this is the main honey flow season due to wide spread cultivation of oil yielding crops mainly mustard and rape *Brassica juncea* and *B. napus* (over 300,000 hectares) which are excellent honey plants. The blooming period of these plants due to different times of sowing in different areas lasts for over two months from the beginning of November to the middle of January. Therefore, it is possible to build bee colonies to maximum strength in areas where these crops bloom earlier, and then move them to areas of a later blooming period. In such method of migratory bee management even weak colonies can utilize this honey flow, however strong bee colonies can produce at least two honey crops from the same plant species.

For instance last year at the end of November 1993 the project experimental apiary was moved to Kodla near Noapara for the utilization of mustard honey flow and it was possible to extract honey twice on 17th and 26th December 1993. After extraction of honey at the end of December bee colonies were transferred to Bonga just 8 km away where mustard was still blooming and again it was possible to extract two additional honey crops, altogether over 5 kg of honey per bee colony. During the last extraction of honey all bee colonies were very strong and some had already swarming queen cells.

It should be emphasized that if the colonies were not increased in number and requeened during the previous year this may now be done. A beekeeper with only a few colonies can use swarm queen cells either to increase the number of colonies (by dividing existing strong ones), or to requeen colonies that had old queens. Commercial or semi-commercial beekeepers in order to reduce swarming tendencies of their bees should never use swarm cells, but to use the grafting technique for queen rearing. It should be noted that divided colonies with newly mated queens will have sufficient time in the latter part of season, for brood rearing and for building up pollen and honey stores for the following summer monsoon period. Furthermore these bee colonies in areas with good or moderate honey flow will develop into full strength for the utilization of the til *Sesamum indicum* honey flow. Such strong bee colonies may be moved to the Sundarbans Reserved Forest for the utilization of the honey flow there which usually starts in March.

Undivided strong bee colonies after utilization of the mustard honey flow should be moved to areas with drumstick *Moringa oleifera* cultivations and be observed carefully since during the following few weeks only some nectar and pollen yielding plants are available for the bees (for instance kapok *Ceiba pentandra*) so many colonies may swarm.

4.4 The spring period

It lasts from mid February to the end of May and this is the most active season for the bees in Bangladesh. Bee colonies during this time may prepare to swarm, therefore effective swarm control must be carried out. However, bee colonies which already have swarm queen cells should be divided and swarm queen cells used to provide queens for newly formed colonies. In areas with litchi *Nephelium litchi* trees cultivation which are outstanding honey plants during this period usually at the end of February, the main honey flow commences. Bee colonies which did not swarm, would have already developed into full strength even without the beekeeper's help can now produce a good crop of honey.

It should be noted that the Sundarbans mangrove forest with many plant species which are excellent sources of nectar and pollen for the bees has a unique potential for the production of honey. For instance last year at the end of February 1993 and beginning of March 1993, bee colonies of *Apis cerana* from the training and demonstration apiary at Khulna were moved to 6 Forest Stations for the establishment or migratory apiaries in the Sundarbans. In the best location for the bees at Kadamtala Forest Station the honey flow season lasted for about 3 months from the middle of March until the middle of June, and during that period it was possible to harvest honey four times. The first extraction of honey was done on 20th April, the second one 7th May, the third on 26th May, and the fourth on 14th June 1993. Altogether over 6 kg of honey per bee colony was produced, and at the time of the last extraction of honey the condition of all bee colonies were very good.

Unfortunately the majority of *Apis cerana* bee colonies all over Bangladesh swarmed before the litchi started to bloom or commencement of the honey flow in the Sundarbans, and therefore they were unable to utilize these honey flows. In order to avoid swarming of bee colonies the chapter below on the utilization of the main honey flow, swarming, prevention and control of swarming should be carefully studied.

4.5 Utilization of the main honey flow

The main honey flow - this term refers to the period when the most important honey plants of a particular area are in bloom. This period comes at different times in different locations of Bangladesh. For instance, in the Sundarbans mangrove forest the main honey flow commences in March. The knowledge of the period of blooming of important honey plants is essential for proper management of bee colonies. Beekeepers have to know the time and duration of the blooming period of each important honey plant, and make assessment of the supporting capacity of a particular area.

Therefore, floral calendars listing the honey plants should be produced for ecological regions in which beekeeping is practiced. In preparing a floral calendar, the first step is to draw up a list of all the major nectar and pollen plants of the area, together with an indication of their blooming time.

It should be noted that in intensive management, it is necessary to synchronize the build up of the colony with the seasonal increase of nectar and pollen to have the maximal number of forage workers during the main honey flow period. If there is an abundance of honey plants during the two-month period before the main honey flow, the bees will develop well without the beekeeper's help. However, if there is not enough nectar and pollen during that period, development of the bee colonies will be very slow and they will be unable to take full advantage of the main honey flow. The beekeeper can either move the colonies to an area with an early honey flow for colony build up, or leave enough food after the monsoon and stimulate brood rearing in the post summer monsoon period by feeding 250 to 500 ml of thin sugar syrup (1 part sugar + 1 part water) in the evening.

Due to various factors not all colonies develop at the same speed, but from the management point of view it is desirable to have equalized colonies. One of the methods of equalizing the strength of colonies is to transfer combs with emerging brood from stronger to weaker colonies. Some beekeepers equalize the strength of colonies by exchanging the location of a weak colony with that of a strong colony. The foragers of the strong colony will enter the hive of a weak colony and strengthen its population. On the other hand, the greater amount of brood in the strong colony will soon replace the lost foragers. This method of equalizing should be followed during honey flow on a sunny day before noon.

Approximately 6 weeks elapse from the time the egg is laid by the queen until the worker becomes a forager. During the main honey flow the foragers work for 9 to 10 days. Therefore, 51 days before the expected honey flow, it is necessary to start stimulative feeding, to encourage the queen to lay eggs. For stimulative feeding, two times a week, small doses (250 ml) of sugar syrup made of equal parts sugar and water should be used. If there is a lot of sealed honey, it should be uncapped with a hive tool or knife to stimulate its consumption. In areas where there are no pollen-yielding plants, it is advisable to feed bees with protein food. This can be done by securing combs with pollen from the previous season, and use them for feeding, or by feeding bees with stored pollen or pollen substitutes. Bees store pollen in the hive for feeding larvae and this can be collected for future use by fitting a pollen trap to bee hives adopted for this purpose. Feeding should be carried out for 2 to 3 weeks.

Without stimulative feeding the majority of bee colonies will not have the correct proportion of foragers to young workers and brood during the flowering of the major honey plant. There are usually too many young workers and too few foragers able to collect nectar and pollen. Bee colonies are also still weak, with 8,000 to 10,000 workers, but for full utilization of the honey flow there should be at least 15,000 workers in the colony.

4.6 Swarming

In the climatic conditions of Bangladesh in areas with mustard cultivation in the middle or at the end of January honeybee colonies become very strong. The number of young bees in hives increase rapidly and many of the colonies at that time outgrow their hive space. When such a situation occurs, bee colonies are ready for reproduction by swarming. At this stage of development there are many young nurse bees and sealed brood, and simultaneously the amount of open brood decreases rapidly. This stage of development is reached due to an ample and abundant supply of nectar and pollen, good performance of the queen and lack of space for the building of new combs. The biological value of young bees reared in such conditions is very high; therefore during this period of colony development, bees should be managed in such a way that young workers will have plenty of room for the construction of new combs and the queen for egg laying. If the beekeeper does not fulfil these requirements, then a discrepancy between young (nurse) bees and the amount of open brood will arise. Overcrowding and congestion in bee colonies is then enormous. Such a condition can be caused by long and moderate honey flow during which foragers wear out slowly and, therefore, their number can increase greatly.

In such a condition, the young nurse bees accumulate fat in their bodies. In the meantime crowding in the hive increases and contact between young bees and the queen diminishes. Such a condition causes inadequate distribution of queen substance. The ovaries of young nurse bees who do not receive queen substance develop very rapidly. Some scientists call such worker bees, "anatomical laying workers". Development of these workers is considered to be the first stage of bee colony preparation for swarming. These workers are responsible for the construction of drone cells and, subsequently, of queen cell cups. While the queen is laying the eggs into queen cells, the physiological phase of swarming takes place and this lasts for about 9 days. During this period the majority of workers slow down activities and the queen receives less food and loses weight rapidly (even as much as 40%) and acquires the capacity to fly.

Also during this period, the scout bees search for a new home site which the swarm will occupy. After 8 days the first queen cells are capped and from 30% to 50% of the colony's worker population fill their honey stomachs with honey as a food reserve and leave the hive with the old queen. The swarm usually leaves the hive before noon, but sometimes if the weather is bad for a few days, the swarm may also leave in the afternoon. Upon leaving the hive, the swarm settles near the parent hive in a cluster around the queen and after a few minutes leaves for the new home site selected earlier by the scout bees.

When all bees in the swarm have settled around the queen it is good practice to sprinkle the bees with water to discourage them from taking off. Then the swarm should be shaken into the swarm box and put into a cool place for a few hours before hiving.

Seven days after the first queen cell is capped, the virgin queen is ready to emerge and the bees may again be in a hurry to leave the hive as another swarm known as after-swarm.

If the queen in the swarm is old and heavy, the swarm settles on the lower branch of a nearby tree or bush, but if she is young as in an after-swarm, it often settles on a tree top or any other tall object. Sometimes the old queen is lost during swarming and the swarm will return to the parent hive and leave again a few days later (about 9) with a virgin queen who emerged in the meantime.

4.7 Prevention and control of swarming

In modern bee management swarming is undesirable, since a swarmed colony is unable to produce a good crop of honey and also the new swarm utilizes its energy mainly for the construction of combs and brood production. Through swarming the beekeeper is left with one weakened and therefore unproductive colony. If he is lucky and can catch the swarm he is left with two unproductive bee colonies.

It should be noted that complete elimination of swarming is impossible. However it is possible to prevent or reduce swarming of bee colonies by the practice of proper bee management. It is most important to keep bee colonies in full working condition, but if the workers eventually outgrow hive space before the commencement of honey flow, and the queen lays eggs to queen cells, the best method is to divide such a colony into two. Later the newly formed colonies can be again united if justified by a good honey flow. Breaking down the queen cells to stop swarming without changing other hive conditions is useless as it only delays swarming.

The best method of dividing a colony is to find the queen and transfer her with the frame and adhering bees for a few minutes into an empty hive. Then four or five brood frames with honey and a few thousand bees should be transferred from this colony into another hive, the new queen introduced and the old queen returned to her original hive.

To prevent bees from drifting back to their parent colonies, the newly formed hive should be removed to a new location a few kilometers away. Some beekeepers shake more young workers to create new colonies so that the hives can be left in the same apiary, since the young workers who did not take orientation flights will stay in the newly formed hives.

The following measures should be taken to prevent swarming :

1. The bees differ greatly in their propensity to swarm, therefore, the proper strain of bees with no inclination to swarm should be kept in an apiary.

2. Bee colonies with old queens are prone to swarm more than those with young ones. In an attempt to replace an old queen with a younger one under the impulse of supersedure, some bee colonies swarm. In order to avoid such situation queen should be replaced every year or every two years.

3. Some bee colonies have the tendency to swarm, but may be deterred by manipulative practices. The most important is the provision of an adequate hive space for brood rearing and storage of nectar and pollen. Even rearrangement of the brood in the hive can prevent preparation for swarming. The most common practice in many countries where *Apis mellifera* is kept is reversing the lower and the upper super in the spring when the upper super is well filled with brood and the lower one almost empty.

4. After mustard honey flow, when bee colonies become strong, it is good practice to use frames of bee foundation to offer more space to the colony in order to utilize the young bees physiological tendencies to construct new

combs. Furthermore, when frames are provided with full sheets of worker size bee foundation, colonies can be induced to abandon their natural habit of building drone size cells.

5. Bee colonies kept in the sun tend to overheat their nests, which is further enhanced by overcrowding and congestion in the hive. When such conditions occur, the colony is ready to reproduce itself by swarming. Therefore, bees should be protected from direct sunshine by keeping the hives in the shade. It has been found that bees use a lot of energy to maintain the right temperature in the nest of a hive exposed to the sun. Furthermore, bees are able to produce from 10 to 40% more honey when they are kept in the shade.

6. It is very important to apply proper ventilation by adjusting the size of the entrance to the strength of the colony. In some areas, apiaries are often located in the sun due to lack of trees. In such cases, proper ventilation is particularly important, since the temperature during summer, in many parts of the country, exceeds 40°C, whereas the right temperature for brood development is 34°C. Therefore, in such cases, instead of foraging in the field, bees stay in the hive and are occupied in cooling the hive. The individual bee cannot control its body temperature, but a populous bee colony can regulate the interior temperature of the nest. In a normal bee colony the temperature in the brood nest is maintained at a constant level of 34°C. When it is very hot during the honey flow, the workers maintain the proper temperature with the process of ripening the honey. By fanning their wings, they evaporate water from nectar in the proboscis thereby reducing the temperature in the hive. But when there is no honey flow, the workers bring water to the hive disperse drops into the empty cells, with their wings fan air over the drops to reduce the temperature. It should be noted that when water is available, a populous colony can stand an external temperature of up to 60°C.

7. During good honey flow, if the colony has ample space for brood rearing and nectar collection, the swarming tendency can be abandoned almost completely. Therefore, in areas with a meagre honey flow, the control of swarming is always a big problem for beekeepers. Moving the bees to places where honey flow is naturally available, whenever possible, is always the best remedy for the control of swarming.

8. Overpopulated colonies can be moved into the location of weak colonies and vice versa.

9. Overpopulated colonies can be weakened slightly without affecting their honey production capacity, prior to the honey flow, by removing a few frames of brood comb and a few bees to make up new colonies or nuclei (i.e. for queen rearing).

4.8 Extraction of honey

The time to remove the surplus honey depends, to a certain extent, on the extent of the honey flow and the number of supers or combs available. In most areas of the country the honey combs should be fairly well selected before they are harvested. Where there is considerable humidity during the honey flow, bees require more time to thoroughly ripen the honey than at a higher altitude or in desert locations where the air is drier. If the honey is taken off before it is thoroughly ripened, it is likely to ferment after extraction. There is always danger of fermentation when the moisture content of honey is 19% or higher.

After each honey flow it is advisable to harvest the honey crop. As a general rule, the more frequent the extraction, the more honey is likely to be produced. Extra space and newly extracted comb stimulate nectar foraging. An idea of the amount of honey stored in a hive can be obtained by lifting one end of the hive and guessing the weight. The best method for an accurate assessment of the amount of honey stored in a hive is by weighing the hive during the honey flow or by inspection of the combs. Before removing the honey it is necessary to open the hive and check the combs to see if they are ready for extraction. In some countries beekeepers allow the honey to remain in the hive until all combs are at least two-thirds or three-quarters capped. However, by delaying harvesting of honey, after the honey flow one can loose half or even more of the honey crop, if the weather suddenly changes, since at that time often for few days it will be impossible to harvest the honey. It is advisable to harvest the honey combs or honey supers in the morning, before the bees have an opportunity to store any unripened honey in the combs that are to be harvested.

Surplus honey supers or combs should be removed before the bees have the honey capped when there is a cessation of honey flow because then combs that are only slightly capped contain thoroughly ripe honey. If this honey remains in the hive, the bees can use it for brood rearing, often not needed at that time of the year.

<u>The honey combs to be extracted should meet the following conditions:</u>

1. They must not contain any brood (larvae)

2. They should contain only ripe honey, since unripened honey ferments quickly.

3. Honey is ripe when moisture content does not exceed 18%. Ripe honey may be easily determined as such by means of the following criteria:

    a) comb is capped by the bees on either side in proportion of at least two-thirds of the total area;

    b) honey on uncapped combs does not splash when the frame is struck;

    c) the amount of moisture in honey, determined by means of a refractometer, does not exceed the limit indicated above (18%).

4. Some colonies cap honey comb only partially and in such cases striking the frames' or determining of moisture is decisive.

5. Unripe honey may be ripened outside the hive by storing the combs in a well ventilated room equipped with a fan flowing dry, hot air at a maximum temperature of 35°C for 1 or 2 days.

It should be noted that in humid tropical areas, because honey is hygroscopic, the moisture content of the harvested honey may be over 19%. In this case the excess moisture can be removed in a vacuum evaporator. Vacuum is required to keep the temperature below 40°C during evaporation to avoid affecting the taste and flavour of honey.

Removal of bees from the honey combs can be done by shaking or brushing the bees off the frames. Often, in small units, the beekeeper first shakes the bees off the frames and the remaining bees on the comb are removed with a handful of grass. In bigger apiaries a soft hair brush to brush the bees off the combs is used. In more advanced apiaries the beekeepers use bee repellents or bee blowers.

Thin bladded knives, electrically heated or heated in boiling water and dried before use, are useful for uncapping honey cells. Honey is removed from the combs centrifugally in various types of honey extractors. The honey extractor enables the beekeeper to save the combs for re-use by the bees. After extraction from the combs, honey is passed through a strainer to remove impurities and stored in airtight and non-corroding containers or bottled for immediate sale. After a certain period of time stored honey will granulate. Before packing the honey into small retail containers, the granulated or crystallized product must be liquified. This process should be done by cautious heating.

a) In order to protect the flavor, nutritious value and antiseptic properties of honey, it should be heated in a water bath at as low temperature as possible (about 60°C), and the period of heating should be as short as possible (30 minutes or until it liquified).

b) Direct fire should never be applied to heat honey. Honey should always be heated indirectly : in a water bath in small containers or in hot air chambers for bulky containers.

c) The heating process should be controlled by a thermostat. The honey should never be exposed to direct irradiation of heaters since at that time HMF is formed.

4.9 Storing of empty combs

After the final extraction of honey at the end of May, the empty combs in supers are put on hives in order to clean the combs by the bees. Since the honey flow is over, therefore the beekeepers should ensure that the bees from another hives have no access to them, otherwise robbing can start. Latter on the dry combs in the supers are stacked, and a dish containing about 30g paradichlorobenze is put on the top super as a preservative against wax moth infestation, and the stack made airtight at the top and bottom with a telescopic hive cover. The combs arranged in this manner and kept in a dry room will be protected until the next honey flow season.

4.10 Some important properties of honey

Honey is the sweet substance (carbohydrate food) produced by honey bees from the nectar of blossoms or from secretions of or on living parts of plants, which they collect, transform and combine with specific substances, and store in honey combs. Honey consists essentially of different sugars, predominantly glucose and fructose with slight amount of sucrose,maltose and melezitose. Besides sugars, honey contains protein, amino acids, enzymes, organic acids, mineral substances, pollen, dextrins, fungi, algae and yeasts.

Honey is a very delicate, relatively high-priced, luxury product and if stored properly it has a long shelf life. The proportions of the two main sugars (glucose and fructose) in honey vary according to a number of factors, and are responsible for honey sweetness; differences in honey taste and color depend on the flora from which the nectar is collected. Honeys in which glucose predominates tend to granulate rapidly, while high-fructose honeys tend to remain liquid.

Unlike other sugars, honey does not flood the blood stream with an overabundance of sugar, because glucose in honey is quickly absorbed by the body. The fructose which is absorbed at much a slower rate, is able to maintain the blood sugar level. In other words glucose provides immediate source of energy and fructose a more lasting one. Honey is acidic (it's P^h is about 3.5), most bacteria grow poorly in acid environments. Honey is bacteriostatic because various pathogenic bacteria are killed when introduced into honey. Part of the acid in honey is gluconic acid, produced from glucose by an enzyme added by the bees as they turn nectar into honey. This enzyme glucose oxidase is responsible for antiseptic properties of honey and originated in the pharyngeal gland of the bee and oxidizes glucose to gluconic acid and hydrogen peroxide. This enzyme, becomes inactive as the water concentration in the honey is lowered, but when the honey is again diluted the enzyme's activity resumes. Therefore, it is advisable to consume diluted honey in lukewarm water in order not to destroy the enzyme. From 30 to 50 grammes of honey should be used twice a day, in the morning at least one hour before breakfast and in the afternoon three hours after meal. Honey may be used to sweeten tea, eaten on bread and any other way the individual may like.

Honey collected in modern apiaries is free from all impurities which usually are present in the honey harvested from wild bee colonies. It is extracted in an honey extractor without any damage to the brood and combs, whereas the honey from wild bee colonies is squeezed by hands and particles of brood, wax and pollen become mixed up with it.

Fermentation is honey's greatest enemy. It is caused by a yeast, which can grow in concentrated sugar solution. In honey the yeast cells grow only when the water content is 19% or more in temperate regions, or about 18% or more in the tropics, where higher temperature tend to activate them earlier.

Furthermore in humid tropical areas such as the Sundarbans, and because honey is hygroscopic, the moisture content of the honey harvested may be over 19%. It should be noted that *Apis dorsata* honey because of its high water content starts to ferment very quickly.

4.11 Beekeeping with European honey bee in tropical and sub-tropical Asia

It is much more difficult to keep bees in a tropical climate than in a temperate climate due to the prevalence of pests and predators. In tropical and sub-tropical Asian countries the main problem with the use of the European honey bee *Apis mellifera* is the incidence of parasites. The chief parasites are mites, *Varroa jacobsoni* and *Tropilaelaps clareae* which occur naturally in indigenous honey bee species (*Varroa jacobsoni* infest *Apis cerana* and Tropilaelaps *Apis dorsata*), but which transfer to European honey bees. The native bees are less affected by these mites than the European honey bee which suffers greatly. Fortunately, in the last few years, a very effective method of mite control has been developed and spreading of the European honey bees in many Asian countries is rapidly growing. For instance in Thailand, almost 100,000 of European honey bee colonies exist in the Chiang Mai region. At present *Apis mellifera* has been introduced to the following Asian countries: Afghanistan, China, India, Indonesia, Japan, Korea, Myanmar(Burma), Nepal, Pakistan, Taiwan, Thailand and Vietnam.

It should be noted that only the European honey bee *Apis mellifera* can be hived, manipulated and moved where it is needed. On the other hand the Eastern honey bee *Apis cerana* can be hived, but the absconding rate among these bees is very high and often after moving them to another place only few bees remain in the hives.

4.12 Migratory beekeeping

The most advanced and profitable type of bee management is the migratory operation. In many of the tropical and sub-tropical Asian countries with an abundance of honey plants, colonies of the European honey bee *Apis mellifera* in migratory operation, are able to produce four to five crops of honey in a year, about 100 kg per colony. However, in stationary operation, usually only one honey crop can be harvested, about 20 kg per colony, and during the remaining period *Apis mellifera* must be left with honey or fed with sugar syrup. It should be noted that a normal bee colony of *Apis mellifera* uses up to 90 kg honey and about 30 kg of pollen for its own activities throughout the year.

In many countries the climatic conditions in the low land areas are entirely different from those in mountain areas. Such conditions are ideal for the development of migratory operation, in order to take full advantage of honey flows in different areas. For instance, Afghanistan has varying climatic conditions according to the altitude and this phenomenon is of importance for migratory beekeeping, since the vegetation in the lower altitudes starts blooming a few weeks earlier than at the higher altitudes, so the bee colonies can be moved from one place to another, thus utilizing two or three honey flows from the same plant species. In China, because of the great variation in climate, there are honey sources available throughout the year. Such conditions are also suitable for migratory beekeeping. Bee colonies are moved south in the winter time from northern areas, and moved back to the north in the spring and summer. China is one of the largest producer of honey. About 50,000 tons of honey is exported annually to Japan, Europe and the U.S.A.

In many areas of Bangladesh mustard and rape are grown extensively as an oilseed crops, they bloom for 3-4 weeks, and as sawing continues for a considerable period, flowering extends over 2 months, this providing excellent opportunities for the development of migratory beekeeping. The Sundarbans Reserved Forest, has unique opportunities for migratory beekeeping which presents a high potential for seasonal honey production.

5. BEEKEEPING EQUIPMENT

5.1 Bee Hive

A bee hive is a box in which a beekeeper keeps a colony of bees. Wood is the most commonly used material for making hives. There are many different types of modern hives used by beekeepers. The hive which has been most widely accepted by Bangladeshi beekeepers for keeping the local honeybee, *Apis cerana*, is the "Newton" hive developed in India on the basis of the "Langstroth" movable frame hive. The Newton hive is comprised of the following parts:

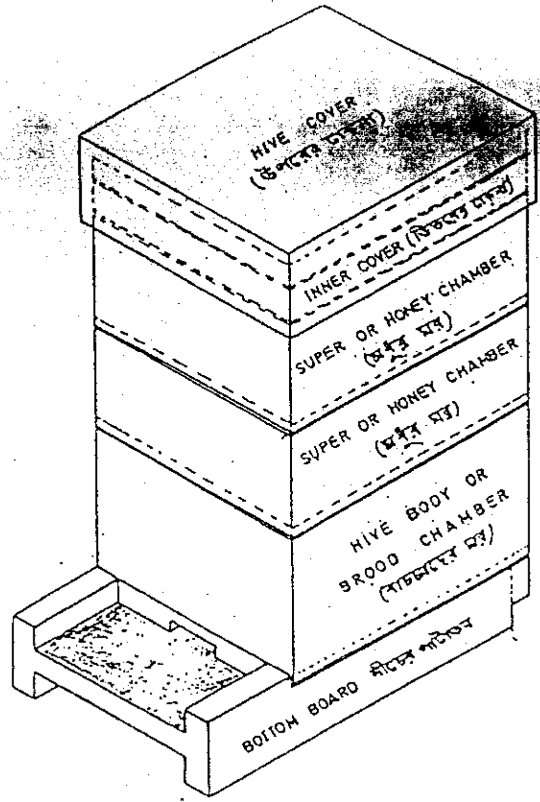
1. a full-depth box called hive body to accommodate frames containing combs of brood;
2. one or two shallow boxes called supers placed above the hive body to accommodate frames containing combs of honey;
3. bottom board;
4. inner cover;
5. cover.

Since *Apis cerana* bees do not use propolis for cealing cracks and fastening of hive parts, therefore the "Newton" hive is suitable only for stationary beekeeping. To adapt this hive for migratory beekeeping-transportation of bee colonies to the Sundarbans Reserved Forest and other bee crops, modifications were made in joining of the hive parts. Fig.2 and Fig.3

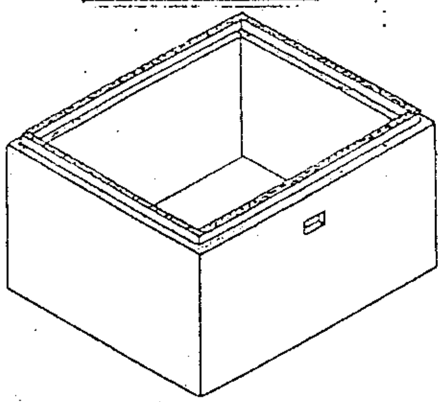
In order to extend durability, hives should be painted or treated externally with a wood preservative e.g. creosote. White or aluminum paints are generally used for painting hives, since these colors are also reflecting heat from the sun.

5.2 Frames

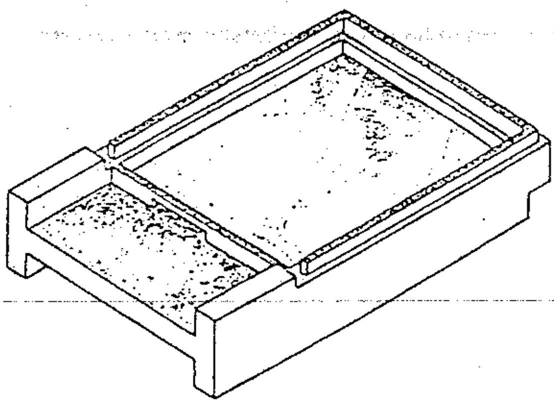
The frames are made of wood or plastic and consist of a top bar, two side bars and a bottom bar, joined at the ends to form a rectangle to hold a brood or honey comb. The whole frame is suspended by the lugs in the hive body or super. The principle of frames is to hold individual combs firmly in the hive. In modern bee management bee foundation, cut to the size of the inside of the frame, is used in each frame. The bees build their comb on this foundation for rearing of brood and storage of honey. Frames of comb can be easily pulled out of a hive and inspected, or if full of honey, removed for extraction. Extraction of honey by centrifugal force of a honey extractor does not damage the comb in the frame, and therefore can be re-used by the bees for honey production or brood rearing.



DESIGN OF BEE HIVE
মৌবাক্সের নমুনা

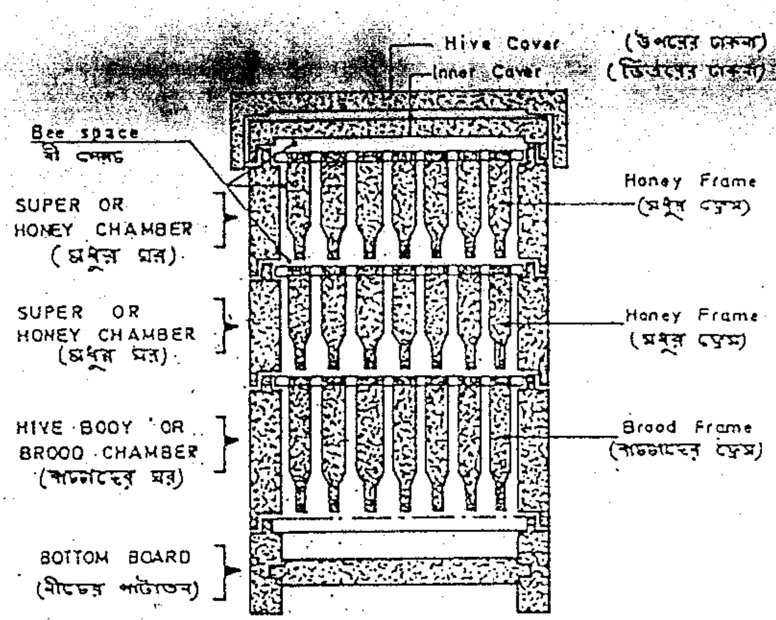


DESIGN OF HIVE BODY OR BROOD CHAMBER
(ব্রুড চেম্বার) বাচ্চাদের ঘরের নমুনা



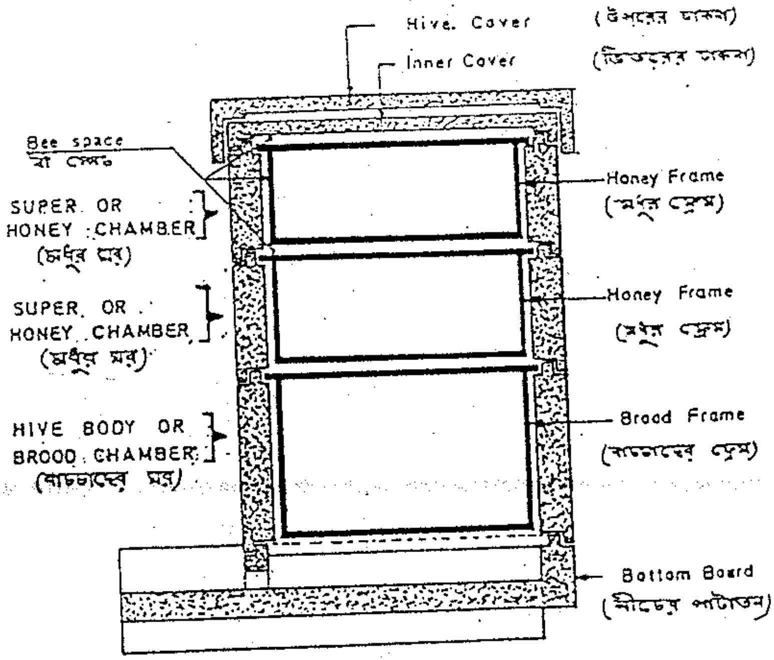
DESIGN OF BOTTOM BOARD
(নীচের পাটাতনের নমুনা)

Fig 2



Section Of Front View

(প্রস্থচ্ছেদ কাটা অংশ)



Section Of Side View

দৈর্ঘ্যচ্ছেদ কাটা অংশ

Fig 3

5.3 Bee smoker

A device to create smoke used to calm bees; the bee smoker, consists of a metal fire-pot with a funnel-shaped cover, and a bellows. A smoke releasing fuel (e.g. coconut husks, jute sacks, dried leaves, wood shavings, decay wood, etc.) is burned in the fire-pot, and air is injected into the pot by pushing the bellows; the smoke is then puffed over the bees to subdue them. The best model of smoker is equipped with a wire screen around the fire-pot for protection against the heat.

5.4 Hive tool

A metal tool with a scraping surface at one end and a flat blade at the other. It is a multipurpose piece of equipment used to open the hive; remove a frame for inspection, clean the bottom board and for scraping excess of wax from hive parts.

5.5 Queen excluder

Queen excluder is a grid with openings large enough to let worker bees pass but too small for the queen or drones (for *Apis cerana* the openings are 0.325 cm). The main purpose of the queen excluder is to confine the queen to the brood nest while allowing the worker bees to have access to the honey super, in order to ensure that the honey combs contain no brood. The most common queen excluder is designed to be inserted horizontally between the brood nest and the honey super of a multi-storey hive. In some countries horizontal hives are common and at that time vertical queen excluders are used, which are placed between combs of brood and honeycombs. Queen excluder may be made of perforated zinc, plastic or a wire grid bound with metal or wood.

5.6 Bee veil

A bee veil is a protective device against bee stings. Beekeepers are aware that they will be stung while handling the bees, but nobody likes to be stung. Therefore in order to protect the head and especially sensitive areas of the face such as the nose and eyes from bees, wearing of bee veil is essential when handling bees. Bee veils should be made to fit snugly around the hat or to cover the head, and to fit tightly to the shoulder, leaving enough space between the screen and the face. Black cotton tulle or wire screen are the most suitable for veils, because these materials provide the best visibility.

The best bee veil fits over the top of a hat, fits snugly around the neck, and keeps the bees away from the face.

5.7 Bee brush

A soft hair brush to remove bees from their combs or parts of hive. A bee brush is very useful for harvesting of honey combs, especially in small-scale apiaries.

5.8 Bee gloves

Some beekeepers may feel more secure in handling bees if they are wearing gloves.

Bee gloves will give some protection to the hands of a beekeeper from bee stings, but when wearing them it is much easier to crush bees and make them more aggressive, therefore professional beekeepers seldom use gloves. Thin leather gloves are the best for handling bees, but rubber or smooth material gloves may also be used. The most commonly used gloves cover the forearms up to the elbows.

5.9 Overalls

Additional protection from bee stings may be obtained by wearing overalls. These should be made of light-colored materials such as cotton with a zip for easy dressing and undressing.

6. EQUIPMENT FOR EXTRACTION OF HONEY AND RENDERING OF WAX

6.1 Uncapping Knife

Honey combs are covered (sealed) with a thin layer of wax which must be removed before the combs are placed in the honey extractor for extraction of honey. This is done by the use of an uncapping knife. There are many different types of uncapping knives, but the most common are heated by hot water, steam or electricity. The most important factor in uncapping is that the knife should be sharp and hot in order to cut the cappings without damaging the comb. Some beekeepers use normal very sharp long-blad knives for uncapping the honey combs.

6.2 Honey extractor

The honey extractor is a machine to remove honey from the comb by centrifugal force. The machine spins the combs so rapidly that this causes the honey to fly outwards against the tank wall and run down to the bottom of the extractor. Many different types of extractors are available, ranging from the electrically operated radial ones accommodating many frames to the simple manually-operated two-frame extractor. The best extractors used by professional beekeepers are made of stainless steel.

6.3 Honey strainer

Freshly extracted honey should be strained in order to remove impurities such as wax from cappings, pollen and others. In small apiaries a large funnel lined with layers of fine wire mesh can be used for straining of honey. However, in commercial apiaries usually OAC strainer (developed in Ontario Agr. College) consisting of a honey tank in which there are three baskets made of different mesh sizes, fitted one within the other, is used. Honey passes through all the baskets starting from the 12-mesh and then through the finer ones.

6.4 Storage container

Honey is a delicate and perishable product, therefore immediately after extraction it should be properly stored. If honey is bottled for sale soon after extraction, containers made of stainless steel with a tap for easy filling of jars should be used. The beekeeper should be aware that honey is hygroscopic so it can absorb moisture from the air. It is acidic and therefore reacts with metals and it changes color and taste when exposed to light or heat for long periods of time because then hydroxymethyfurfural (HMF) is formed. It should be noted that HMF is formed from sugar at high temperature or after longer storage at about 30°C, which can result in the same HMF content as a short exposure to high temperature. HMF in excess spoils the quality of honey, making it darker and presents a health hazard to consumers. Extracted honey should therefore be stored at proper temperature in non-corroding, air tight containers, for instance glass-lined steel drums, galvanized iron cans or polyethylene cans.

6.5 Solar wax-melter

Beeswax is a valuable bee product and it should be handled with great care. The simplest device for rendering wax is the solar wax-melter made of wood, lined with a galvanized metal plate and a glass cover. The melter should be airtight and can be painted black to absorb more heat. On a sunny day, the wax-melter is put in the sun with broken combs or cappings. After few hours the temperature in the melter reaches about 60°C then the wax melts down and flow into a container below the galvanized metal plate. However, when using solar wax-melter it is only possible to recover about 50% of wax from the old combs, therefore a press is needed for getting as much as possible of the remaining wax in these combs. There are many different types of wax presses used by beekeepers, but the most simple is the screw-type press. In commercial apiaries steam-heated or hydraulic presses are used for rendering of wax.

7. IMPORTANCE OF HONEY PLANTS FOR BEES

Honey bees depend on honey plants for their survival. The bees visit flowering plants to obtain nectar and pollen. The nectar is the source of honey and pollen provides protein food for development of brood. Many plants species posses, inside their flowers, near the base of the petals, glands called nectarines. Nectarines are of two general types : floral which occur in the flower, and extra-floral which occurs outside the flower. The best example of a plant with extra-floral nectarines is the rubber tree *Havea brasiliensis*. Nectar is basically a solution of sugar in water, with minor amounts of other substances such as amino acids, minerals, essential oils and organic acids. The concentration of sugars in nectar depends on species and on environmental conditions and it may vary from 4 percent to 60 percent or higher. As a rule, flowers with a higher sugar concentration in their nectar are more attractive to bees than these with low concentration of sugar. The conversion of nectar to honey is a result of two factors :

1. Decrease of water content due to the manipulation of the nectar by the bee which at the same time is adding enzymes, before deposition in the cells.

2. Evaporation of the remainder of the excess moisture by fanning.

Ripe honey is stored by bees in combs and it serves as a reserve of carbohydrates for the colony's energy requirements. Honey bees must have an abundance of honey plants in the vicinity of their locations, because only at that time a good crop of honey from bee colonies can be harvested by the beekeeper. The beekeeper should know whether the bees have to depend on cultivated plants or wild vegetation and whether there will be a succession of bloom during the whole season. For proper colony management it is most important to know the dates of the normal flowering periods of honey plants in the vicinity of operation, and, to assess the supporting capacity of a particular area. The best agricultural area can support not more than 50 bee colonies in one location, during the whole year but 25 bee colonies is the optimal number.

In tropical and sub-tropical zones, bee colonies usually rear brood throughout the year, with sporadic interruption during bad weather or a dearth period. For this reason bee management has to be adapted to each ecological region in order to take advantage of different honey flows. The efficient beekeeper should establish a calendar known as his seasonal management plan, based on the dates when the major honey flows occur and the extent to which these dates may vary from one year to the next. In preparation of a floral calendar, the first step is to draw up a list of all the major nectar and pollen plants of the area, together with an indication of their blooming time. The seasonal management plan tells the beekeeper when changes are likely to occur within the hive or in the environment, allowing him to manage his colonies in advance of the time when they are needed. The most important factors for successful bee management are climate, forage availability and a proper management scheme for a particular area.

8. QUEEN REARING

8.1 Introduction

This chapter has been prepared for the production of *Apis mellifera* queens, but the basic principals of queen rearing are the same as for *Apis cerana*.

In modern bee management, to produce a good crop of honey, it is necessary to have young, prolific queens in all bee colonies. This requires the securing of a large number of young queens for replacement and expansion of the operation. A beekeeper with only a few colonies can use swarm cells to obtain young queens, but it should be noted that the bees propagated by this method have a strong tendency to swarm. Commercial apiaries must produce their own queens by using the grafting technique for queen rearing. The grafting method of queen rearing was developed on the basis that from all female larvae, less than three days old, queens can be produced depending only on the food and care given to them during their early larval stage. Grafting is a transfer of larvae from worker cells to artificially-built queen cell cups. The larvae for grafting should be taken from the best colony in the apiary or from colony with tested queen. This colony is called the queen breeder colony and should be:

1. a good honey producer;
2. resistant to bee diseases;
3. gentle;
4. not inclined to swarming and robbing.

It should also possess the ability to develop large populations in a short period of time in order to take full advantage of different honey flows. A good queen should be able to produce a large number of eggs.

The queen's reproductive organs comprise a number of structures, but, for the queen producers, the most important are the ovaries, made up of many tubular ovarioles in which eggs develop. It is considered that the more ovarioles in the ovaries the more eggs the queen can produce. However, egg production in the queen is closely correlated with many environmental factors, among which are the temperature and space in the hive, the quality and quantity of the food with which the queen is fed, the number of nurse bees, the availability of pollen and nectar, and the stock of honey and pollen in the hive. During the peak period of colony development, the queen of Apis mellifera can lay from 1800 to 3000 eggs a day. During this period, the queen must consume every day more royal jelly than her weight. The weight of the eggs laid in one day can exceed her body weight.

According to experiments carried out in many countries, the best time to rear queens is when pollen and nectar are abundant, i.e. during the continuous honey flow. If there is a break during the honey flow, the bees should be fed with sugar syrup and the combs provided with pollen.

8.2 Making of artificial queen cell cups

The queen cell cups for *Apis mellifera* are made by dipping a forming stick, 8.5-9 mm in diameter, (for *Apis cerana* 7.0-7.5) into cold water and then into melted, but not too hot, bees-wax to the desired depth of the cell (9-10 mm). Before grafting, it is necessary to fasten 10-15 queen cups with melted wax to each cell bar of a wooden frame. Usually two or three bars are used. One hour before grafting larvae into queen cups it is advisable to place them in the cell building colony for polishing. It is very important that polishing be done by the young bees who later will feed grafted larvae. Therefore the frame with fastened queen cups should be inserted into the centre of a cell building colony.

8.3 Grafting of larvae

A grafting tool or spoon is used for grafting. A grafting tool may be made of stainless steel, plastic or wood. The end of the tool must be smooth to prevent damage to the larva, and should not be more then 1 mm across. The simplest grafting spoon can be made from a match stick. During grafting, the point of the spoon is inserted into the larval food beneath the larva not older than 24 hours, so as to lift the larva with a small amount of food between the larva and the spoon. The point of the spoon is then immersed into small drops of royal jelly in the cell cup, which causes the larva to float off the spoon. Great care should be taken in this operation so that the grafted larva is not damaged. The majority of queen producers prime each cup with a drop of fresh royal jelly obtained before grafting from emerging or swarming queen cells. Such royal jelly can be kept in a refrigerator and, before priming the cell cup, is diluted with clean water in the proportion of 1:1. For the beginner it is very important, to distinguish the right age of larvae used for grafting in queen rearing.

On the basis of experiments carried out in various countries it has been found that the younger the larva taken for queen rearing, the better the queen produced.

Table-1, below indicates the characteristics of the larvae.

TABLE-1: Characteristics of Larvae

Age in hours	Length of larvae in mm		Position in the cell	Food received
	Smallest	Largest		
12	1.5	3.0	Almost straight.	Royal jelly.
24	2.5	4.0	Slightly bent.	Royal jelly.
36	3.0	5.5	More bent.	Royal jelly.
48	5.0	7.5	Much more bent.	Royal jelly.
72	8.0	12.0	Ends of larvae almost meet together.	Honey with pollen.

Some queen bee producers use double grafting of the larvae in queen rearing. Double grafting is the removal of the larvae from accepted cells one day after grafting and their substitution with larvae not older than 24 hours. Thus reared queens become larger and have more ovarioles in their ovaries. It is most important that the larvae for queens be provided with an abundance of royal jelly from the moment of hatching until the feeding period is finished and the cells are capped.

8.4 Selection and preparation of queen cell building colony

The queen cell building colony should consist of young bees, have plenty of stored pollen and honey, and be fed continuously to stimulate the production of royal jelly and secretion of wax. The queen cell building colony can be queenless or queenright depending on the method of queen rearing.

According to data in Table-2 fewer but better queens can be obtained in queenright colonies.

TABLE-2 : Queens produced in Queenless and Queenright Colony

Conditions of rearing queens	Number of queen cells		Number of queens obtained	Average number of ovarioles in ovaries
	Introduced	Accepted		
Queenless colonies	225	172	113	280
Queenright	225	146	106	309

The queenless cell building colony can be from any strong colony prepared in advance by adding combs of emerging broad. It has been found that, when queens rereared in a queenless cell building colony, it is necessary to render the colony queenless at least 2 hours before introducing larvae to have good acceptance, but the best results can be obtained when the cell building colony is queenless for about 4-5 hours. It is most important that the cell building colony be without open broad, otherwise the bees will construct emergency queen cells and acceptance of the introduced queen larvae will be inferior. However, it has been found that the larvae introduced in the cell building colony with open brood are better fed and the weight of capped queen cells up to 422 mg. On the other hand, in the cell building colony with capped brood only, the weight of capped queen cells reached only 360 mg.

The strength of the nurse colony has a great influence on the quality of reared queens. The data in Table-3 shows the correlation between the strength of a colony and the quality of the reared queens.

TABLE - 3 Queens Produced in Strong and Weak Colonies

Strength of a cell building colony in Kg of bees	Number of ovarioles in an ovary	Weight of a queen in mg
2.5 Kg	178	195
1.0 Kg	135	182

From data shown in Table-3 it can be seen that in strong cell building colony, heavier queens with more ovarioles are raised. It is advisable to feed the cell building colony three to four days before commencing grafting. At least two hours before giving the first cups with grafted larvae (not more than 30) to the cell building colony, the comb of larvae at the center should be removed without nurse bees from the hive. The nurse bees, which had been feeding the larvae which were removed, cluster in this space and are eager to feed the larvae in the queen cell cups given to them. The next cups with grafted larvae are given to the cell building colony every fourth day. In large commercial operations it should be remembered that new larvae should be given to the cell building colony only when the preceeding grafted larvae are at the sealing stage, and no longer require feeding by the nurse bees.

The queenright cell building colony may be two-or three-storey colony and must be very strong. It is most important that the queenright cell building colony has an abundance of bees of all ages and especially a lot of nurse bees. Such colonies should be strengthened with emerging brood and bees at least one day before giving them the larvae in queen cell cups. In the two storey cell building colony, the queen should be left in the lower body below the queen excluder, with combs of honey, the emerging and the capped brood. The uncapped brood should be put in the second body to force the nurse bees to the area where larvae have to be fed. A comb of honey and pollen should be placed on each side of uncapped brood in the upper hive body with the youngest brood in the middle, where grafted queen cell cups will be put later. A comb of pollen can also be placed in the middle, so it is readily available to the nurse bees. The cell building colony should be fed continuously and the honey left in the lower body to stimulate self-feeding, since the bees preparing the space for the queen's egg laying transfer the honey to the upper body. A very strong cell-building colony can accept up to 30 larvae in queen cell cups every 3-4 days. At weekly intervals the combs of larvae from the lower hive body should be placed next to the frame of the newly grafted cells and at the same time the capped and emerging brood transferred from the upper to the lower hive body.

Some queen producers use three-story cell building colonies when the queen is in the lower body below the queen excluder; then the second hive body is placed with the capped and emerging brood. Another queen excluder is put above the second hive body, and the sequence of combs in the third body is similar to that in the two-story cell building colonies. It is necessary to maintain the proper strength of such a colony by adding capped and emerging brood combs at weekly intervals. The main problem with very strong three-story queenright cell building colony is to keep them in good working condition and prevent them from swarming.

It should be emphasized that the number of larvae introduced in the cell building colony has a great influence on the quality of reared queens. The fewer the larvae introduced in the cell building colony the heavier and larger are the queens produced. According to experiments carried out in various countries, well-developed large queens give a better performance of their colonies.

Data in Table 4 shows the correlation between the size of the queens and the performance of their colonies.

TABLE - 4 Influence of the Size of the Queens on the Performance of Colonies

Size of the queen	Number of ovarioles in an ovary	Quantity of brood before honey flow (in thousands)	Yield of honey (in kg)
Very large	170	28.4	27.6
Large	165	25.4	25.5
Medium	162	24.3	25.3
Small	147	23.3	24.4
Very Small	109	22.5	19.2

From the above it can be seen that very small queens give an inferior performance of their colonies. Therefore, good queen breeders always disqualify small queens.

8.5 Preparation of starter colony

In order to ensure a better acceptance of the larvae, many commercial queen bee producers, instead of placing the grafted larvae directly in the cell building colony, introduce a large number of larvae first in a starter colony for 24-48 hours and then in a finishing colony or cell building colony.

A starter colony is a strong, queenless colony in which up to 120 newly-grafted larvae are placed for the first 24-48 hours. Two types of starter colonies are commonly used: the confined queenless colony and the free-flying queenless colony. The most common confined starter colony made is the swarm box. A swarm box is a five-frame nucleus hive, but 10 cm deeper and screened in the lower part to provide ventilation. The cover should have a hole in the middle to accommodate a feeding jar. Two combs with honey and pollen should be placed against the side walls and a comb with pollen in the centre, leaving a space for the newly-grafted larvae on each side of the comb with pollen. Two hours before grafting, about 3 Kg of young bees from brood combs, of a strong colony should be shaken inside and put in a cool place (cellar). The swarm box should be fed continuously with sugar syrup. Two frames with maximum 120 larvae can be given to the swarm box for 24-48 hours. One or two days later, the accepted cells should be transferred to finishing colonies (up to 30 per each finishing colony). Finishing colonies can be queenless or queenright both of which are described in the chapter, "Selection and preparation of a queen cell building colony".

8.6 Dealing with mature queen cells

Ten days after grafting the youngest larvae, queen cells are mature, and queens should emerge after 1-2 days. The ripe queen cells are carefully removed from the bars with a sharp knife. All small or poorly built cells are discarded. The ripe queen cells should be handled with great care, since the development of the queen may be disrupted and the wings and legs of the pupa can be injured. Therefore, queen cells should never be shaken before removal from the bar and bees adhering to the cells should be brushed off very gently.

There are two methods of dealing with the ripe queen cells. The first is to transfer them into nuclei or queenless colonies. When transferring the ripe queen cells into nuclei, it is not necessary to protect them from damage by the bees. In the 2nd method they are introduced into queenless colonies. Here they should be protected in nursery cages until they emerge. The best nursery cages in which to introduce the ripe queen cells are made of spiralled wire. They do not need to be supplied with food since the bees of the colony will feed the queens through the holes in the cages.

The nucleus is a small colony made up of one or two combs of emerging brood with adhering bees, one comb of honey, one comb of pollen, and one empty comb. Later, a few thousand workers are shaken into the hive. In each such nucleus one ripe queen cell is attached to the side of brood or empty comb and placed in the middle of the hive.

After one or two days the virgin queen will emerge from her cell. A few days later, at the age of 5 or 6 days, she will make orientation flights and then mating flights, when she will mate with an average of seven drones. Two to three days later, she will start laying eggs. The semen she receives during the matings is stored in her spermatheca and should last until her death. If she uses all semen earlier, she becomes a drone layer. It means that she will lay unfertilized eggs, from which drones will develop. Laying queens from nuclei can be used for sale, for requeening, or to increase colony numbers in the apiary.

In some European countries the Zander method of queen rearing is the most common. In this method the ripe queen cells are left for emergence in the cell building colony. Later baby nuclei are made (about 1500 workers) from all bees in a colony, as many as emerged queens. One virgin queen is introduced without any protection into each baby nucleus formed. It is necessary to keep baby nuclei in a cool place (cellar) for about 3-4 days and then place them in the mating yard for mating. Using this method of queen rearing it is possible to produce up to 30 mated queens from one colony.

The baby nucleus is a very small hive (colony) with one or three frames with comb and bee foundation, comprising one or two thousand worker bees, and about half a kg of queen candy as a food reserve. Virgin queens in baby nuclei usually mate and lay eggs within 10 to 12 days after their emergence from the cells. When laying queens are taken from the baby nuclei, then ripe queen cells or virgin queens can be introduced to nuclei. However, the most common practice is to unite nuclei with the strongest nucleus where the queen should be left.

Since it is much easier to find marked queens and know their age, it is good practice to allow the queens to emerge in nursery cages, and then mark them before they are introduced in the mating nuclei. However, marking of queens after mating is safer and more efficient. To mark the queens, fingernail polish or automobile lacquer are most commonly used.

The queen is usually shipped in a mailing cage, which consists of a wooden, screen-covered cage with three compartments, one of which is filled with queen cage candy. She is accompanied by about 15 worker bee attendants. Such a cage may also serve as an introducing cage, but the attendants should be removed before the introduction of a queen.

9. BEE DISEASES, PESTS AND PREDATORS

9.1 Introduction

Bee diseases can be divided into infectious and uninfectious. The formation of uninfectious bee diseases is caused by living conditions of the bees. It depends also on the ecological conditions in which bees are kept. Uninfectious bee diseases are not so serious and usually invade single colonies. These are caused for various reasons, e.g. defects of queen bees or improper management. On the otherhand, infectious diseases are caused by pathogens such as bacteria viruses or parasites. Infectious diseases can be spread easily and are very dangerous. Not only are they dangerous for the invaded bee colony but also for the entire apiary and often all neighboring apiaries. Therefore, efficient bee diseases, pests and predator control is one of the most important aspects of profitable beekeeping. Most of the information concerning prevention and control of the microbial diseases of ***Apis cerana*** are based on the experience obtained from research with ***Apis mellifera***. However, the major pathogens can affect both ***Apis mellifera*** and ***Apis cerana*** therefore it is advisable for the beekeepers in Bangladesh to acquaint themselves with the most dangerous bee diseases, pests and predators.

9.2 Microbial diseases

9.2.1 American Foulbrood (AFB)

AFB, the most widespread throughout the world and the most destructive of the contagious brood diseases, is caused by a spore-forming bacterium ***Bacillus larvae***. The spores of ***Bacillus larvae*** are extremely resistant and are still alive after a couple of years. The infection of AFB usually occurs during a period without honey flow, because bees, while searching for nectar and pollen, rob honey from infected or dead colonies. Spores cannot be killed in 70% alcohol in which they can survive for 69 hours, but can be killed if exposed to rays of sunlight for 28 to 41 hours, in 10% solution of caustic soda, or boiling water after 14 minutes. In addition, this disease can be transferred with hives or beekeeping equipment which has been in contact with an infected colony. The best conditions for the development of the disease occur during the most intensive brood rearing.

The symptoms of the infection are visible only after 3-6 weeks. The most characteristic symptoms are: dark spots on the cells with bee brood and sinking of the sealed cells in which bees bite small holes. The infected larvae turn into gluey substance with a characteristic smell similar to that of joiner's glue. If a comb of capped brood has irregular holes in some of the capping, these cells as well as those which are sunken and darker should be opened and the contents examined. If a tooth-pick or match stick is pushed in and come out with a sticky mass attached, and drawn out in a thread, AFB is to be suspected. After some time dead larvae dry up making a brownish scab attached to the bottom of the cell, and at that time this test cannot be applied. Young bees, occupied with the cleaning of the cells, try to remove them and hence carry the bacteria to the healthy larvae.

Treatment of the disease is very difficult and laborious and therefore in many countries veterinary regulations recommend burning infected bee colonies to decrease spreading thereof. In other countries, it is advisable to cure the infected bee colonies by shaking off the bees together with a queen, first to swarm boxes and later to disinfected hives with new combs. Hives and bee equipment are disinfected in a 10% solution of caustic soda or they are scorched with a blow lamp. Bees are deprived of food for 24 hours in swarm boxes and placed in the apiary in the same place where they stood before the treatment. Later, the bees are transferred to a disinfected hive and then they are fed with 1 liter of sugar syrup for 5 each of days, with the addition of sodium sulfathiazole or Terramycin (oxytetracycline).

In some countries Terramycin is applied as a dust, by using powdered sugar as a carrier. Such treatment is quick, easy and does not cause robbing. Infected colonies after treatment should be rechecked. It is very important that wax from infected colonies should not be used for making foundation, and honey or combs not fed to other colonies. All drug treatment should be terminated from 4 to 6 weeks, before the honey flow, to avoid contamination of the harvested honey.

9.2.2 European Foulbrood (EFB)

The second very dangerous diseases of bee brood is EFB caused by the bacterium *Melissococcus pluton*. It is widespread in many parts of the world and in some countries is more serious than AFB. The disease occurs usually during cool weather, when larvae suffer from the cold or are under-fed. It is spread by nurse bees. EFB infects the larvae in the early stages and usually larvae die about 4 days after hatching, while they are still in the coiled stage in uncapped cells. The disease is spread from colony to colony by robbing from infected bee colonies.

The most significant symptom of EFB is the colour change of larvae. The infected larvae change colour from white to yellow or even brown. Often the infected larvae are unnaturally positioned in their cells. The smell of larvae killed by EFB varies with the different secondary invading bacteria. ***Bacillus alvei*** is one of the many secondary invaders and is often found in the brood killed by EFB.

EFB rarely kills but weakens the colony and, as a result, decreases its productivity. Requeening of the infected colony with a young vigorous queen and strengthening the colony is often sufficient to control the disease. Strong colonies are usually able to clean out mild cases of EFB without difficulty, because ***M. pluton*** does not form spores. In many countries, streptomycin or oxytetracycline is fed to infected bees in solution of sugar syrup.

9.2.3 Viral Diseases

In recent years viral diseases affecting *Apis cerana* were found in some Asian countries. The most common is the Thai strain of sacbrood virus discovered in Thailand which affects the brood and the symptoms of infestation are similar to the sacbrood virus of *Apis mellifera*.

The Thai strain of sacbrood is a disease caused by a virus. The disease is spread from colony to colony by robber bees, but in the colony by the nurse bees. The sacbrood disease infects only the older larvae which usually die in the early stages of pupation. The infected larvae gradually change colour from pearly white to pale yellow or grey, and finally to dark brown or black. The head of infected larvae first changes colour and becomes dark brown. When such a larva is examined it appears that she is in a sac full of greenish fluid, hence the name sacbrood.

The nurse bees are contaminated with the virus while cleaning out brood cells in which the sac was damaged. It is believed that the virus multiplies in the head of the nurse bee and is transmitted with the food during feeding of larvae. Such infected bees have a shorter life span. There is no chemotherapeutic agent known to be effective in the control of the Thai strain of sacbrood disease. It usually occurs in weak and without food colonies kept under stress conditions, therefore, it is advisable to strengthen weak colonies, provide them with extra food, and in heavily infested colonies, replace the queens. When a large number of dead larvae are observed in the combs these should be destroyed. It is very important to observe strict sanitary conditions in the infected apiary.

Besides the Thai strain of sacbrood there are two more viral diseases which affect the adult bees. The Kashmir bee virus and the Apis iridescent virus, both were discovered in India, where they are causing damage to *Apis cerana* colonies. Infected bees are unable to fly and they crawl on the ground in front of the hives. Since there are no drugs for treatment of these viruses, only preventive measures as in the case of the Thai strain of sacbrood, are recommended.

9.3 Adult Bee Diseases

9.3.1 Nosema Disease

Nosema disease is one of the most serious and widespread of all adult bee diseases. It is caused by a protozoon, *Nosema apis*, which infects the midgut of adult bees. Workers, drones and queens are susceptible to infection by the nosema disease.

Nosema disease occurs mainly in weak bee colonies unable to maintain a normal brood rearing temperature. The disease is most dangerous during the late monsoon and winter period. Bees become infected through ingestion of spores that germinate in the midgut and invade the cells that line it. If many cells of the midgut become infected and destroyed, the digestion is weakened and the bee dies earlier than normal. The spores often pass out with undigested faecal matter in the hive and infect other bees which clean the cells. The life-span of infected workers is shortened and their food glands deteriorate, causing a rapid decrease of colony strength. In heavily infected colonies, bees are unable to fly and even their walking capacity is greatly reduced.

It is possible to make a rough diagnosis for nosema disease in the apiary. The most visible symptoms are: weakening of bee colonies in spring and a large number of swollen bees crawling in front of the hive entrance. The field analysis of swollen bees is made by pulling out the gut with sting apparatus, if white and enlarged, infection is very likely. However, the only reliable diagnosis of the disease is made by microscopic examination of the crushed abdomens of suspected swollen bees.

It should be noted that the best method to prevent and control nosema disease is to keep only strong colonies in apiaries with good ventilation and under the bee shed. The most effective control procedure recommended is to feed the bees with sugar syrup with fumagillin (Fumidil -B) during the monsoon and winter seasons. Since nosema is spread to healthy bees through contaminated combs, it is necessary to disinfect combs by heat treatment and fumigation. Heat treatment involves keeping contaminated combs for at least 24 hours at 49°C. The combs should be fumigated for about 10 days with steam of 80% acetic acid, when the outside temperature is over 15°C. The dry combs are stacked in supers and a pad of cotton soaked with acetic acid is put on the top super. The stack is closed airtight at top and bottom with telescopic hive covers.

9.3.2 Parasitic Bee Mites

Varroa jacobsoni is a native parasite of the eastern honeybee *Apis cerana* and Tropilaelaps Clareae of the giant honeybee *Apis dorsata*. Both honeybee species are resistant to these mites, whereas *Apis mellifera* introduced to Asian countries is not.

In the last 30 years, beekeepers have unwillingly transferred bees infested with Varroa from Asia to Europe, America and Northern Africa, where many thousands of *Apis mellifera* colonies have been destroyed by this mite. Fortunately, in the last few years, a very effective method of mite control has been developed, and at present spreading of *Apis mellifera* in many Asian countries is rapidly growing.

As has been stated *Apis cerana* is to a great extent resistant to Varroa mite due to grooming behaviour and chewing of the mites. Since the mite reproduce only in drone brood of *Apis cerana*, removal of infested brood is the best method to keep the mite population under control. The apiculturist during his stay in Bangladesh checked capped drone brood of many bee colonies and did not find Varroa mites.

9.3.3 *Varroa jacobsoni*

The biology of *Varroa jacobsoni* described below is based on the experiments with *Apis mellifera.*

Adult female mites are reddish brown, oval (1.1 mm long X 1.7 mm wide) and flat. The female mite enters the cell with the larva just before capping, and lays 5-6 eggs after the larva is capped. It takes 7-8 days for female mites to develop from the egg to the sexually mature stage, and 5-6 days in the case of males. Some females reach sexual maturity before the emergence of drones and mate with males while they are still in the cell. During all stages of their development, *Varroa* feed on the hemolymph of either the brood or the adult bees. If one or two mites infest the pupae, the size of the worker or drone will be reduced, but if 3-4 mites infest it, the result will be an abnormal adult bee with rudimentary wings and legs. When more than 5 mites feed on the pupae, the pupae die. Adult bee developed from a pupae infested with 1 or 2 parasites are smaller and have a shorter life span. Adult female mites infest adult and feed on their hemolymph, also causing a shorter life span.

In tropical and sub-tropical countries, brood rearing in bee colonies is continuous throughout the year. In such conditions many chemicals against *Varroa* mites are ineffective since the majority of mites are hidden in capped brood cells. Therefore, in areas where brood rearing is contiguous, only chemicals like the Apistan (fluvalinate) and Bayvarol (flumetrin), should be applied which are active for over 30 days.

Fortunately, the apiculturist checked drone brood in many *Apis cerana* colonies in Bangladesh and did not find Varroa mites, therefore for the time being there is no need for treatment.

9.3.4 *Tropilaelaps clareae*

Tropilaelaps clareae is a native parasite of the giant honeybee ***Apis dorsata***. This mite causes little damage to its natural host, but similarly like *Varroa jacobsoni* is very destructive of ***Apis mellifera*** and, in some Asian countries, even much worse than ***Varroa***.

The adult female mite is light reddish-brown in colour and oval in shape (0.97 mm long X 0.45 mm wide X 0.30 mm thick) and slightly flat. The reproduction biology of ***Tropilaelaps*** to some extent is similar to that of ***Varroa***. It takes only 6 days to develop sexually mature females. Therefore they can produce two generations in one brood cell. Hence, when bee colonies are infested with both mite species, in all cases ***Tropilaelaps*** repress the ***Varroa***. The most important difference in the biology of ***Tropilaelaps*** in comparison with ***Varroa*** is that the adult mites are unable to feed on the hemolymph of adult bees; therefore they can survive only up to 2.5 days outside the bee brood. Considering that ***Tropilaelaps*** cannot tolerate a break in brood rearing, a method of control without using drugs was developed. In this method it is only necessary to deprive bee colonies of all brood. This can be done by caging queens for 21 days or removal of all brood from infested bee colonies. Bee colonies of ***Apis mellifera*** are usually infested with both ***Varroa*** and ***Tropilaelaps***. Therefore, chemicals effective against ***Varroa***, like Apistan and Bayvarol can be used for the control of Tropilaelaps clareae.

9.3.5 Acarine "Disease"

Acarine "disease" is caused by the microscopic mite ***Acarapis woodi***. The mite invades the bodies of young workers and queens and accommodates itself in their thoracic tracheae or breathing tubes. The mites multiply in tracheae, feeding on the hemolymph until the tubes become congested and destroyed causing the death of worker. Mature female mites emerge from the tracheae of the dead bees and search for a new host. The "disease" is spread from bee to bee by female mites which enter through the spiracles to the tracheae of young bees. The most common causes of the spreading of the mites is drifting, robbing or introduction of infested bees on queens.

Externally, there are only few signs of acarine "disease" in the early stages of infection. Most frequently, during the dearth period, when the bees have been confined to the hive for a long time, crawling bees are seen in front of the hive. Some bees climb up the hive and fall down when they attempt to fly. Many bees have one or both hind wings sticking out at right angels from the body. In the advanced stage of the "disease", affected bees have disjointed wings and are unable to fly. This "disease" can be positively diagnosed only by the microscopic examination of the tracheae.

The most common treatment of the acarine "disease" is an acaricide drug-chlorobenzilate-sold under the trade name of "Folbex". Recently, "Folbex VA", in which an active ingredient is bromopropylate, was recommended for the treatment of the acarine "disease" as well as for other parasitic mites. In some countries crystalline Menthol or Menthol dissolved in 80% ethyl alcohol are used for treatment of acarine "disease".

Acarine "disease" has been reported to be present in some Asian countries (India, Pakistan) and destroyed thousand of *Apis cerana* colonies. It is believed that *Apis cerana* are more susceptible to the tracheae mite than colonies of *Apis mellifera*. Fortunately until now the tracheae mite has not been reported in Bangladesh.

9.4 Other Pests

9.4.1 Wax Moths

Many species of moth infect honey combs, but two are the most common: the greater wax moth, *Galleria mellonella*, and the lesser wax moth, *Achroia grisella*. The greater wax moth, the most destructive one, is found all over the world and causes severe damage, especially to weak colonies. The lesser wax moth usually appears also in the weak colonies and is more common in tropical countries. Both species of wax moth are more dangerous in tropical and sub-tropical countries since a warm climate is favourable to their development. Both the greater and the lesser wax moth are found in Bangladesh.

The greater wax moth female usually enters the hive in the evening or at night and lays eggs (up to 600) in clusters from 50 to 150 directly on the combs or in cracks between the wooden parts of the hive. After the eggs hatch, the larvae feed on the wax combs, cocoons which line the brood cells, pollen and even honey. The darker combs are preferred due to accumulation of cocoons and are more often infested and destroyed than light combs. The larvae of the wax moth are very harmful to combs in storage, especially in warm, dark and poorly ventilated accommodation. However, the wax is the most dangerous during the monsoon period, when their attacks are heaviest, with the result that a large number of colonies desert their hives. Strong colonies of bees can defend themselves against moths. However the moths often enter into colonies that have become weak during the dearth period.

Control methods of both wax moths in the apiary are limited to the retention of only strong colonies, periodical cleaning of hives, especially bottom boards, and removal of combs not covered by bees. To protect empty combs the following chemicals are used: paradichlorobenzene, dibromoetylene, sulphur and naphthalene, as well as carbon dioxide. The empty combs are stacked in supers and fumigated in the similar manner as described for the disinfection against nosema disease.

It should be emphasized that all these chemicals are very dangerous to people, and therefore it is necessary to handle them with great care. After fumigation it is very important to ventilate combs before reintroducing them to hives.

9.4.2 Wasps and Hornets

Wasps and hornets are very destructive to bees in many parts of the world, but they cause the heaviest damage to bee colonies in some Asian countries. Wasp activity is usually seasonal and highest when their colonies are large and require a lot of food. then losses of bees are heavy. Usually wasps hunt for slow-flying bees which are approaching their hives. Weak colonies are often invaded by wasps which kill adult bees and destroy brood and honey reserves.

The most common control method is the destruction of the entire wasp and hornet nests by burning or closing the nest entrance with a ball of cotton soaked in insecticide. Some beekeepers use cagetraps made of wire screen with a piece of meat which allows wasps to pass into the cage, but prevents their return. Since wasps are carnivorous, they search for meat, are trapped in the cage and later destroyed. Placing meat impregnated with insecticides, such as malathion, on hive covers and branches of nearby trees is also a very effective method of wasp control. In some countries wasps attack on a few hives is controlled by replacing the alighting board by few small holes, 2 to 3 cm above the bottom board of the hive. It should be emphasized that control of wasps is particularly important in queen mating yards. At the beginning of the breeding season it is advisable to catch wasp and hornet queens. Fortunately, the apiculturist did not see wasps attacking bees in Bangladesh.

9.4.3 Ants

Ants are the most common of all groups of insects and they are in many tropical and sub-tropical countries a very serious pest of bees. In Bangladesh, especially in the Sundarbans Reserved Forest, ants are very destructive for the bees. Sufficient protection from ants can be ensured by keeping the bees under bee shed and covering the poles of the bee shed with grease. In apiaries without bee shed, the beekeeper may give protection to the hive by placing the legs of hive stands in ant wells (tins containing old diesel oil). Furthermore, keeping bee colonies in clean apiaries free of weeds, rotten wood and planting tomatoes as an ant repellent near the hives, keep ants away from such places.

In some extreme cases it is necessary to destroy ants nests in the apiaries with Chlorolane or Diazinon.

9.4.4 Bee-eater birds

In the majority of Asian countries bee-eater birds are causing some problem to beekeepers but at the same time they are also keeping pest insect populations in check. Especially destructive to the bees, is the Meropidae family of bee-eaters which includes 24 species spread all over the world. In Bangladesh the most destructive are the following species:

Merops orientals	- green bee-eater
Merops lischenauliti	- chestnut - headed bee-eater and
Merops Philippinus	- Blue-tailed bee-eater.

The first two species are common in the Sundarbans and the third is spread all over the country. In the south-eastern part of the country there is quite common blue-beard bee eater *Nyctyomis athertoni*. Depletion of the strength of some bee colonies due to bee-eaters can reduce the production of honey. It should be noted that in some cases from 20 to 100 bees were counted in the midgut of individual bee-eaters. In some countries bee-eater birds are controlled by shooting e.g. Azerbaijan *Merops apiaster*.

10. SOME IMPORTANT TERMS OF APICULTURE

ABDOMEN	-	the third part of the body of the bee
APIARY	-	the place where bee colonies are kept
APICULTURE	-	the art of raising honeybees
Apis cerana	-	a social bee producing honey also called Eastern honeybee
Apis dorsata	-	a social bee producing honey with a wild and ferocious nature, also called Giant honeybee
Apis florea	-	a social bee producing honey, having similar habits to *Apis dorsata*, but it is not ferocious, also called the Dwarf honeybee
Apis mellifera	-	a social bee producing honey, also called the European or Western honeybee
ARTIFICIAL CELL CUP	-	a queen cell made for queen rearing which is as deep as it is wide
BEE BRUSH	-	a device to remove bees from their comb
BEE ESCAPE	-	a device which allows bees to pass through, but prevents their return
BEE GLOVES	-	gloves worn to protect the hands from stings
BEE HIVE	-	a box in which to keep a colony of bees
BEE PASTURE	-	plants and trees from which bees collect pollen and nectar
BEE PLANTS	-	plants which yield pollen and nectar available to bees
BEE SPACE	-	an open space in which bees build no comb or deposit propolis = 1 cm
BEE VEIL	-	a net to protect the head from bees
BEE WAX	-	the wax secreted by bees to build their combs

BOTTOM BOARD	-	the floor of a bee hive
BROOD	-	young developing bees in the egg, larval or pupal stage before emerging from their cells
BROOD COMB	-	the comb containing the brood
CAP	-	the cover which closes cells containing the brood or honey
CAPPED BROOD	-	combs of brood in which bees have closed the top of the cells containing larvae with a thin layer of wax
CAPPED HONEY	-	combs of honey closed with a layer of wax
CELL	-	one of the hexagonal compartments of a honey comb
CLEANSING FLIGHT	-	the flight of hive bees for defecation
COLONY	-	a community of bees with a queen, some thousands of workers and, during part of the year, a number of drones
COMB FOUNDATION	-	thin sheets of embossed bees wax to form a base on which bees will construct a complete comb
CROSS POLLINATION	-	the transfer of pollen from the anther of one plant to stigma of another plant of the same species
DIVIDING	-	separation of a colony to produce two colonies
DRAWN COMBS	-	completed brood or honey combs
DRIFTING OF BEES	-	flight of bees to the wrong hive in the apiary
DRONE	-	male bee
DRONE LAYER	-	a queen short of semen necessary to fertilize eggs
DYSENTERY	-	fecal matter discharged by bees within the hive
EMERGING	-	young bees in the act of chewing their way out of their cells
ENTRANCE	-	an opening in the hive permitting the passage of bees

EXTRACTOR	-	a machine to remove honey from the comb by centrifugal force
FERMENTATION	-	a chemical breakdown of honey with high moisture content by sugar tolerant yeasts
FERTILIZED QUEEN	-	a queen that has mated with drones and has semen in her spermatheca
FIELD BEES	-	worker bees who begin work outside the hive to collect nectar, pollen, water and propolis
FOULBROOD	-	a contagious bee disease affecting the brood
FRAME	-	four pieces of wood joined at the end to form a rectangle to hold a honey comb
GRAFTING	-	the process of transferring worker larvae from their comb into queen cups
GRAFTING TOOL	-	a spoon used to transfer larvae
HIVE	-	man-made home for bees
HIVE TOOL	-	a metal tool with a scraping surface at one end and a flat blade at the other, used to open hives
HONEY	-	a sweet product made by bees from the nectar of flowers or honeydew
HONEY COMB	-	the mass of hexagonal wax cells built by bees where they rear brood and store honey and pollen
HONEYDEW	-	a sweet liquid excreted by aphids and scale insects
HONEY HOUSE	-	a building used for honey extraction
ITALIAN BEES	-	the most common race of bees for honey production
LANGSTROTH HIVE	-	a hive with movable frames invented by Langstroth
LARVA	-	a developing bee in the worm stage
LAYING WORKER	-	a worker who lays eggs
MATING FLIGHT	-	the flight effected by a virgin queen during which she mates

MIGRATORY BEEKEEPING - the moving of bee colonies from one place to another in order to take advantage of the honey flow in other locations

MITE - a parasite infesting adult bees and their brood

MOVABLE FRAME - a frame of comb which can be easily removed from the hive

NATURAL SWARM - a swarm of bees leaving a parent hive naturally to form a new colony

NECTAR - a sweet liquid secreted by nectaries located in flowers and on the leaves of plants

NOSEMA DISEASE - a disease of adult bees caused by a protozoan parasite

NUCLEUS - a small hive of bee, nuclei are used to mate queens

NURSE BEES - young workers bees which feed the larvae and the queen

PACKAGE BEES - the adult bees with or without the queen in a wooden box which has two screened ends to ensure ventilation during transportation

PHEROMONE - a substance secreted by insects which, when sensed or ingested by other individuals, makes them respond by a definite behaviour

POLLEN - grains formed in the anthers of flowering plants within which male elements are produced

POLLEN BASKET - a structure on the bee's hind legs adapted to carry pollen, gathered from flowers, to the hive

POLLEN TRAP - a device to collect pollen by removing it from incoming field bees

POLLINATION - the transfer of pollen from an anther to the stigma of a flower

PROBOSCIS - the bee's tongue

PROPOLIS - a kind of glue or resin collected by bees and used to polish the cells and close up cracks in the hive

PUPA	-	the third stage of a developing bee, when it is inactive and sealed in its cell
QUEEN	-	a fully developed female bee
QUEEN LESS	-	having no queen
QUEENRIGHT	-	having a laying queen
QUEEN CAGE	-	a small box made of wire and wood in which queens are shipped and introduced into new colonies
QUEEN CANDY	-	a candy made of powdered sugar and honey or inverted sugar syrup until it forms a stiff dough, it is used as feed in the queen cage
QUEEN CELL	-	a cell in which a queen is reared
QUEEN EXCLUDER	-	a grid with openings large enough to let worker bees pass, but too small for the queen and drones
QUEEN INTRODUCTION	-	giving a strange queen to a queenless colony
QUEEN REARING	-	queen production
QUEEN SUBSTANCE	-	a secretion from mandibular glands in the head of a queen which attendant worker bees lick and pass on to the rest of the colony, queen substance has stabilizing effects on the colony's social order
REFRACTOMETER	-	a precision instrument to determine the water content of honey
RENDERING WAX	-	the process of melting combs and cappings to separate the wax from its impurities
REQUEENING	-	introduction of a queen in a queenless colony
RIPE HONEY	-	honey which contains less than 18% of water or capped honey
ROBBING	-	the process of stealing honey by the bees from hives of other colonies
ROYAL JELLY	-	a milky substance secreted from the geal glands of nurse bees used to feed worker larvae up to three days and queen larvae during the entire period of larval life

SACBROOD - a disease of the brood caused by a virus

SEALED BROOD - brood which has been capped by bees with wax=capped brood

SELF-POLLINATION - the process of transferring pollen from the male to female parts of the same plant

SEMEN - the male reproductive cells which fertilize the eggs

SMOKER - a device to create smoke which, when puffed over the bees, tends to subdue them

SPERMATHECA - a small sack attached to the oviduct of the queen to store the semen received from drones during mating

SUPER - a box used for extension of the hive

SWARM - the aggregate of worker bees, drones and queen that leave the parent colony to establish a new colony during swarming

SWARMING - formation of a new colony or an offspring of a parent colony

TESTED QUEEN - a queen whose progeny shows that she has desirable characteristics, such queens are used for the production of larvae in queen rearing

UNCAPPING KNIFE - a knife used to remove the cappings from combs before extraction

UNRIPE HONEY - honey which contains too much water

UNSEALED BROOD - brood not yet sealed by the bees

VIRGIN QUEEN - unmated queen

WAX GLANDS - the glands of a bee worker which secret a bee's wax

WAX MOTH - a moth whose larvae damage honey combs

WORKER BEE - a female bee whose reproductive organs are undeveloped

WORKER COMB - comb with cells in which workers are reared and honey or pollen is stored

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