Apiculture

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Lecture 1

INTRODUCTION TO APICULTURE: IMPORTANCE AND HISTORY

Insects are dominant animals on this earth. Usually insects are considered harmful to man but hardly 1 per cent of insect species fall in the pest category. Benefits of insects in maintaining economy outweigh the injury inflicted. Honey bees are one of the few insects directly beneficial to man.

- In the animal kingdom honey bees belong to: Phylum-Arthropoda, Class- Insecta, Order-Hymenoptera, Superfamily-Apoidea and Family-Apidae.
- Honey is highly valued food produced by honey bees and it is also used as medicine. In addition to honey, other products like bees wax, pollen, royal jelly and bee venom are also produced by honey bees.
- More than the producers of these hive products; bees play an important role in pollination of plants while collecting their food from flowers in the form of nectar and pollen.
- Pollination is involved in a chain of complex events significant to our economy. Pollination by insects including honey bees is important for ecological balance.
- Visitation by honey bees between distant varieties or cultivars promotes hybridization and help sparse populations to survive. Their mutual dependency has resulted into great degree of co-evolution.
- The science of rearing honey bees or beekeeping is known as apiculture.

We can learn a lot from these little wonderful creatures. Honey bees are admired for

- Their industriousness
- Unity
- Self sacrifice
- Tolerance
- Division of labour
- Even the most feared bee stings help in healing muscular pains, rheumatism, arthritis and reduction in cholesterol level.

Beekeeping can be practiced as

- An ideal hobby
- Part-time business.
- Full-time business.

History of beekeeping

- Primitive man used to rob bee colonies found in the cavities of hollow trees or on rocks and in traditional mud houses (Fig. 1.1) and this is still being followed by some tribes
- There was no development in beekeeping until 16th century.
- Proper beekeeping started only when man started giving protection to colonies found in the nature

- Idea to keep bees in log hives has been reported to come from the fallen trees which were nested by the cavity nesting bees.
- Development of modern beekeeping has its origin between 1500 and 1851 when many attempts were made to domesticate bees in different types of hives but were not successful because bees attached their combs together as well as to the walls of hive and combs required had to be cut for honey.
- The discovery of the principle of bee space in 1851 by L. L. Langstroth in USA resulted in first truly movable frame hive. This bee space was 9.5 mm for *Apismellifera*.
- This discovery was followed by subsequent innovations like comb foundation mill, honey extractor, smoker, etc., which helped in the development of modern beekeeping we see today.

Beekeeping in India

- In India first attempt to keep bees in movable frame hives was made in 1882 in Bengal and then in 1883-84 in Punjab.
- In south India, Rev. Newton during 1911-1917 trained several beekeepers and devised a hive for indigenous bee *Apiscerana* based on principle of bee space (which was named after his name as "Newton hive").
- Beekeeping was also started in the Travancore state (now Cochin) in 1917 and in Mysore in 1925.
- In Himachal Pradesh modern beekeeping with indigenous honey bee *A. cerana* started in 1934 at Kullu and in 1936 at Kangra.
- The exotic bee *A. mellifera* was successfully introduced for the first time in India in 1962 at NagrotaBagwan (then in Punjab state and now in Himachal Pradesh), because this bee has potentials to produce more honey.
- At present both the hive bee species are being used in modern beekeeping and lot of honey is also being collected from the wild bees viz. *A. dorsata* and *A. florea*.
- India is producing approximately 70000 metric tons of honey annually from all the four species of honey bees.

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Lecture 2

DIFFERENT SPECIES OF HONEY BEES

There are four well known species of true honey bees (belonging to genus *Apis*) in the world:
i. Rock bee, *Apisdorsata* F. (Fig. 2.1)
ii. Little bee, *A. florea* F. (Fig. 2.2)
iii. Asian bee, *A. cerana* F. (Fig. 2.3)
iv. European bee, *A. mellifera* L. (Fig. 2.4)

Figure 2.1 *Apis dorsata* (single comb on tree branch)

Figure 2.2 *Apis florea* (single comb in bushes)

Figure 2.3 *Apis cerana* (L, in log hive; M, movable frame hive; W, wall hive- note the parallel combs)

Figure 2.4 *Apis mellifera* (in movable frame hive)

Characteristics of four well known species of honey bees:

	Apisdorsata	*Apisflorea*	*Apiscerana*	*Apismellifera*
Nesting	Open nesting. Builds single large comb (ca $1m^2$) attached to branches of trees or rocks etc.	Open nesting. Builds single small comb (ca size of palm of hand) fixed to branches of bushes.	Cavity nesting. Builds many parallel combs in cavities of tree trunks, hollows of rocks, poles and other covered places	Cavity nesting and similar in habits to *Apiscerana* and builds parallel combs.
Distribution in India	Found in plains as well as hills up to 1600 metres above sea level. Highly migratory.	Found in plains up to 300 metres above sea level. Highly migratory.	Found throughout India having 3 subspecies	Exotic bee to India. Introduced successfully in 1962. It has many subspecies (more than 23)throughout world
Size	Biggest honey bee (16-18mm)	Smallest *Apis* bee (9-10mm)	Medium size (14-15mm)	Medium size (14-16mm)
Swarming/ Absconding	Strong tendency	Strong tendency	Strong tendency	Only in African sub species
Temperament	Furious	Mild	Furious	Gentle except African sub species
Average honey yield per colony/year	40 kg (wild bees; cannot be domesticated)	500 g (wild bees; cannot be domesticated)	5 kg (Hive bees; can be domesticated)	15 kg Hive bees; can be domesticated)
Method of honey extraction	By squeezing (unhygienic)	By squeezing (unhygienic)	By centrifugal honey extractor from the hived bees (hygienic).	By centrifugal honey extractor from the hived bees (hygienic).
Number of cells/10cm comb (worker cells)	18-19	32-36	21-25	17-19

SPECIES AND SUBSPECIES OF HIVE BEES

It is important to know difference between a species and subspecies. Species are reproductively isolated from each other and these cannot interbreed where as subspecies are geographically isolated and can interbreed

Among the two domestic bee species, each has many subspecies in different parts of the world e.g. *Apiscerana* has three subspecies in India:
A. ceranacerana in Himachal Pradesh and Jammu and Kashmir (North India)
A. ceranaindica in Kerala, Tamilnadu and Karnataka. (South India)
A. ceranahimalaya in Nagaland, Manipur, Mizoram, Assam and Meghalaya. (Eastern parts of India)
In addition to above three subspecies, *A. cerana japonica* has been identified from Japan.

***A. mellifera* has many subspecies which can be placed under three groups:**
1. Eastern subspecies
2. European subspecies
3. African subspecies

Eastern subspecies:
i. *Apismelliferaremipes* (in Iran)
ii. *A. melliferasyriaca* (in Syria, Israel and Lebanon)
These subspecies are not suitable for modern beekeeping

European subspecies:
i. *A. melliferamellifera* (Dark Dutch or German bee)
ii. *A. melliferacarnica* (Carniolan bee; in Southern Austria)
iii. *A. melliferaligustica* (Italian bee; Italy)
iv. *A. melliferacaucasica* (Caucasican bee; USSR)

African subspecies:
Some of the important subspecies are:
i. *A. melliferaintermissa* (Tellian bee; Morocco and Lybia)
ii. *A. melliferalamarckii* (Egyptian bee; restricted to the Nile Valley)
iii. *A. melliferacapensis* (Cape bee; the only bee which can rear queen from eggs laid by workers)
iv. *A. melliferaadansonii* (African bee; also known as killer bee)
In India, all the four bee species are found. *A. mellifera* is an exotic bee which was introduced in India for the first time successfully in 1962 at NagrotaBagwan, Himachal Pradesh. Honey yield from this species from stationary beekeeping varies from 10-15 kg/colony but through migration yield increases to 45-60 kg/colony. One beekeeper in Himachal has extracted as much as 110kg honey from a single colony of *A. mellifera* which is indicative of its potentials.

Other species found in different parts of the world: In addition to the four *Apis* honey bee species, more species have been reported from some parts of the world.
i. *Apislaboriosa* (from Bhutan, Yunnan and Nepal)
ii. *A. breviligula* (from Philippines)
iii.*A. binghami* (from Sulawesi)
Above three species resemble *A. dorsata* and are wild
iv. *A. andreniformis* (from China) It resembles *A. florea*.
v. *A. koschevnikovi* (from Malaysia)

vi. *A. nuluensis* (from Malaysia, Indonesia)
vii. *A. nigrocincta* (from Indonesia).
These three species (v - vii) resemble *A. cerana*.

Stingless honey bees:
In addition to honey bees of genus *Apis*, stingless honey bees also provide honey which are:
i) *Melipona* sp.
ii) *Trigona* sp.
These bees are also domesticated, but produce little amount of honey.

Pollen bees: All the honey bee species are good pollinators besides being honey producers. In addition to these, there are more than 20000 species of other bees which help in pollination. It should be clear that all bees are not honey bees. Batra (1992) has even separated non Apis bees in a separate group of 'pollen bees' that includes all bees except honey bees which help in pollination.

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Lecture 3

GENERAL MORPHOLOGY

In honey bees, body parts are modified as per their food habits and social life. Like any insect, body of honey bee can be distinguished in to three parts (Fig. 3.1):
a. Head
b. Thorax
c. Abdomen

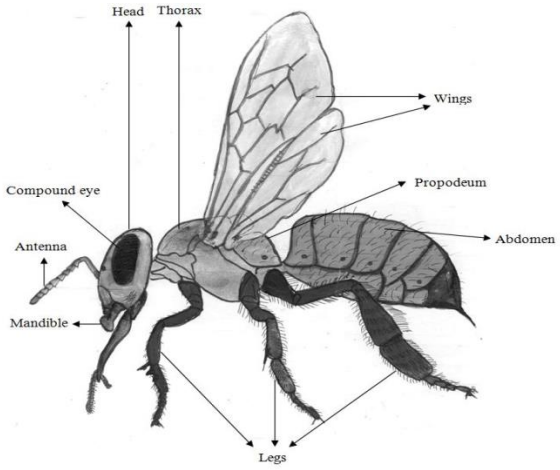
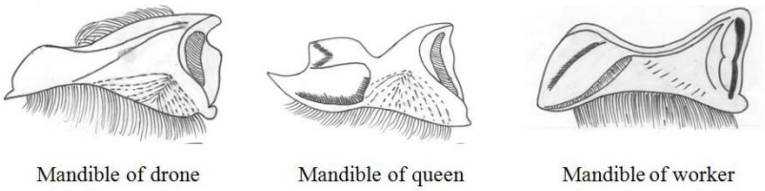


Figure 3.1 General morphology of a worker honey bee

HEAD

- Head Bears a pair of geniculate antennae
- Two compound eyes on lateral side of head. Bees can distinguish different colours but are red blind and can perceive ultraviolet rays
- Head bears 3 ocelli (simple eyes) on top portion which perceive degree of light
- Two mandibles are attached to ventro-lateral part of head capsule. Mandibles differ in shape in three castes (Fig. 3.2). Workers use mandibles for grasping and scrapping pollen from anthers, feeding of pollen and in manipulation of wax scales during comb building
- Mouth parts of worker bees are modified for sucking and lapping (Fig. 3.3). Tongue or proboscis (formed by medium labium and two lateral maxillae) is used for ingesting liquids. Labium has long median glossa and spoon shaped lobe (flabellum) at the end
- Inside the head there are long coiled strings of small lobes known as hypopharyngeal glands which secrete glandular food known as royal jelly that is fed to queen and young larvae.



Mandible of drone Mandible of queen Mandible of worker

Figure 3.2 Mandibles of different castes of honey bees

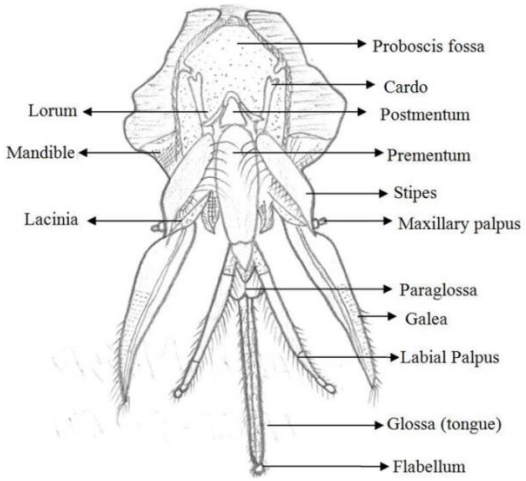


Figure 3.3 Mouth parts of a worker honey bee

THORAX

- It consists of three segments: prothorax ,mesotmhorax and metathorax, each bears a pair of legs. Meso and metathorax, each bears a pair of wings (Fig. 3.5). Legs and wings are locomotory organs. In addition to locomotion legs in honey bees are also modified to perform following functions:
- Prothoracic legs serve as antenna cleaner. Basal part of basitarsus has a notch (Fig. 3.4) and a small lobe projects from distal end of tibia (tibial spur). It is found in all the three castes.
- On mesothoracic legs, bushy tarsi serve as brushes for cleaning of thorax. Long spine at end of middle tibia (Fig. 3.4) is used for loosening pellets of pollen from pollen basket of hind leg and also for cleaning wings and spiracles. Wax scales are also removed from wax pockets of abdomen by these legs.
- Hind or metathoracic legs differ from other legs in being larger in size and with broad flattened form of tibia and basitarsus. In worker bees, smooth somewhat concave outer surface of hind tibia is fringed with long curved hairs and forms pollen basket or corbicula (Fig. 3.4)
- Two pairs of wings arise from sides of meso and metathorax. Fore wings are stronger than hind wings. Series of upturned hooks (hamuli) are present on front margin of each hind wing. Decurved fold on rear margin of fore wing works as coupling apparatus for holding hamuli and this result in unity of action of the wings in flight.

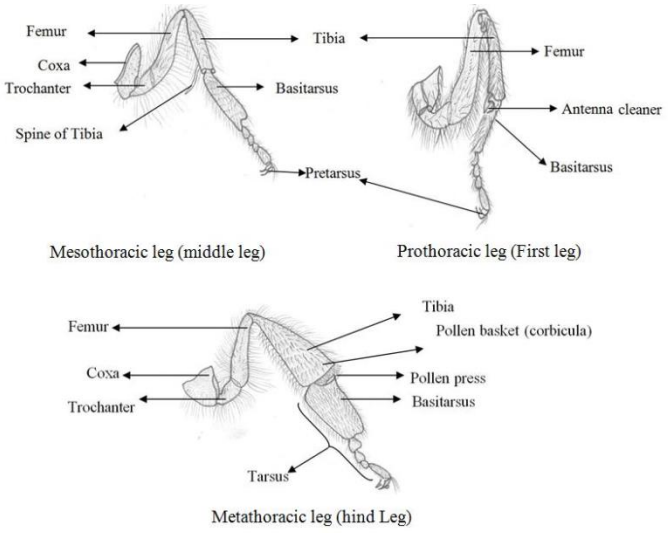


Figure 3.4 The legs of a worker honey bee

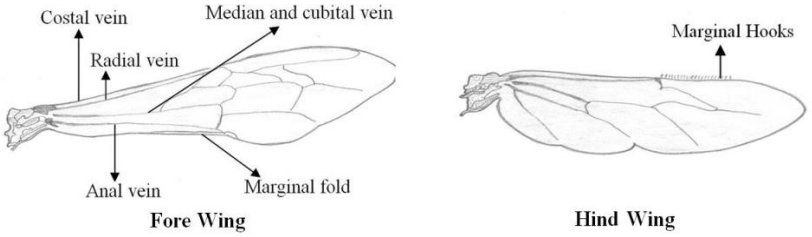


Figure 3.5 The wings of a worker honey bee

ABDOMEN AND ANATOMICAL FEATURES

Abdomen

- First abdominal segment is united with the metathorax and forms anatomically a part of thorax known as propodeum
- Bee larva has 10 abdominal segments but in adult workers abdomen appears 6 segmented; segments 8-10 are reduced in size and first segment (propodeum) is transferred to thorax during pupal stage
- Abdomen bears sting, wax glands (on sternites 4 to 7) and scent glands (on last two terga) and genitalia in addition to other viscera
- In workers egg laying apparatus (ovipositor) is modified into sting
- Queen uses ovipositor for egg laying and for stinging rival queen.

Important anatomical features:

- Digestive system is unique in having oesophagus with expanded honey stomach which stores the collected nectar (Fig. 3.6)
- From honey stomach food goes to ventriculus through X shaped opening known as proventriculus, regulating passage of food to ventriculus. It removes pollen from

nectar and nectar is retained in honey sac and pollen passes to ventriculus. Nectar is regurgitated in the comb cells for conversion into honey

- Reproductive organs are fully developed in queen and drone but greatly reduced in worker.
- Sperms are stored in the queen in a sac like structure known as spermatheca. The stored sperms are utilized by queen throughout her life time as she does not go for mating once starts egg laying.

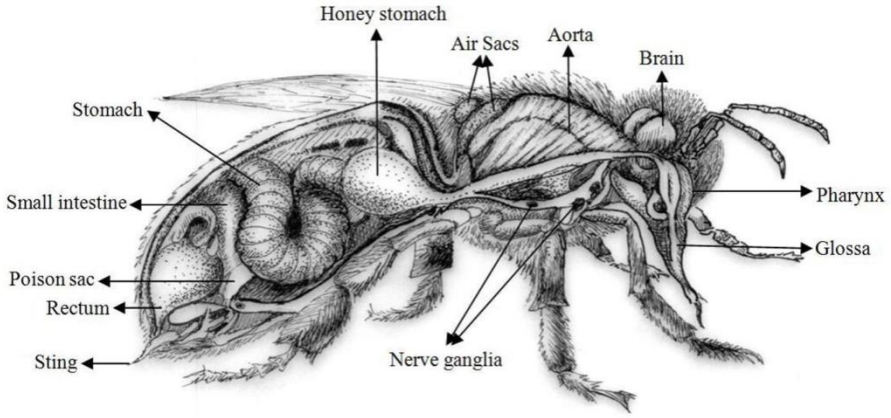


Figure 3.6 Anatomy of a worker bee
(Adapted from Grolier's Multimedia Encyclopedia)

LECTURE 4

COLONY ORGANIZATION AND DIVISION OF LABOUR

Honey bees are social insects and live in colonies. A normal colony, during active season is composed of 3 kinds of individuals: one queen, thousands of workers (10000 to 30000 or even more) and few hundreds of drones, which vary in size (Fig. 4.1). In addition, each colony has different developmental stages viz eggs, larvae and pupae which are collectively known as brood.

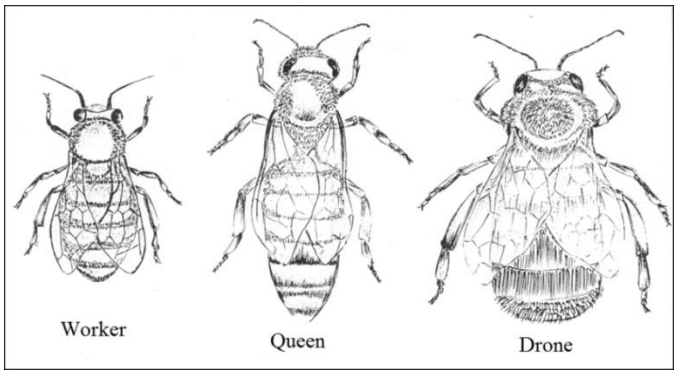


Figure 4.1 Different castes of honey bee

Queen:

- Only one queen is found in a colony except under supersedure or swarming instinct
- She is the mother of the whole colony producing workers and drones and is the only perfectly developed female member of the colony
- Her function is to lay eggs. She does not have motherly instinct or ability to feed the brood. She is fed lavishly by a large number of nurse bees with highly nutritious food known as royal jelly
- A good queen can lay 1500-2000 eggs per day
- A laying queen is the longest bee in the colony. It has larger thorax than worker and her abdomen gets greatly distended during egg laying
- The queen lays both fertilized and unfertilized eggs. Fertilized eggs produce workers (also queens) and unfertilized eggs produce drones (Figure 4.2)
- A good mated queen may work satisfactorily for 2 or more years, although queens can live eight years or longer. However, in commercial beekeeping, queen is replaced every year to keep high brood rearing in a colony.
- Queen releases queen substance (pheromone) which helps in the colony organization. It acts as worker attractant and inhibits ovary development in worker bees as well as raising new queen. Absence of queen pheromone is detected after about 30 minutes of queen loss and colony may start raising new queen. The pheromones in queen substance stimulate brood rearing, comb building, hoarding and foraging in a colony and thus play important role in normal working of a colony.

- The virgin queen mates with a number of drones (5-7) within 5-10 days of emergence in the air (not inside the hive) and spermatozoa are stored in spermatheca. Stored sperms are utilized to fertilize eggs throughout her life till exhausted.

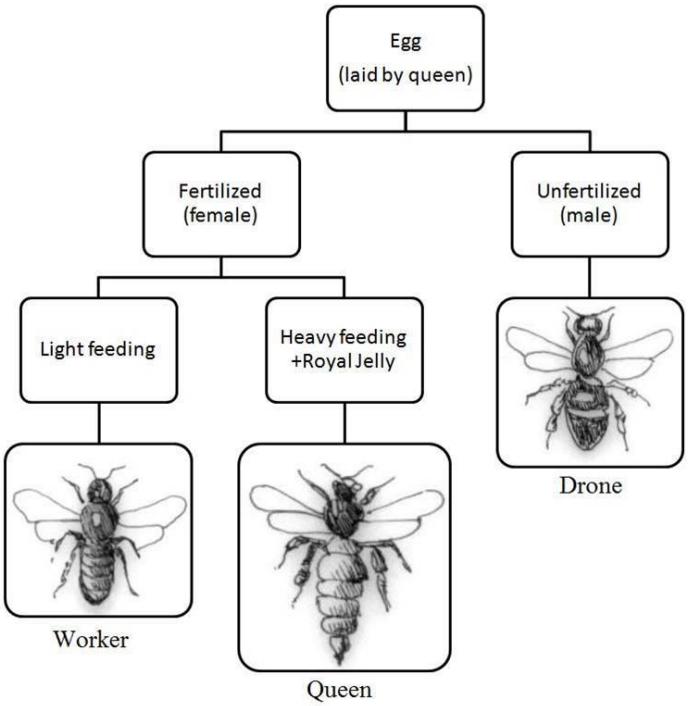


Figure 4.2 Development of different castes of honey bees based on quality and quantity of food and whether fertilized or unfertilized (After Winston)

Worker:-

- Workers are imperfect females. They are unable to mate though may start egg laying if a colony remains queen less for long period
- The workers perform all the useful work in the colony
- **Duties of workers include:** Cleaning of the hive, feeding of larvae, raising queen cells when required, ventilate hive, guard the hive entrances, secrete bees wax, construct the combs, collect the nectar and convert it into honey (Fig. 4.3), collection of pollen, water and propolis, produce a predigested food of royal jelly for feeding queens and young larvae and scouting for a new nest site during swarming. The workers also feed the drones but when not needed, they are thrown out of hive.

- **The duties are related to the age of the worker:**

Age of Worker Bee	Duties performed
a) Till 3rd day of emergence	Maintain wax cells in sanitary state, cleaning their walls and floors after the emergence of young bees.
b) From 4th-6th day of emergence	Feed older larvae with mixture of honey and pollen and making flights around the hive for getting layout of the hive, (play flights or orientation flights)?
c) From 7th-11th day of emergence	Hypopharyngeal glands (food glands) get developed and start secreting royal jelly and feed younger larvae.
d) From 12th to 18th day	The bees develop wax glands and work on building of comb, construction of cells etc., Receive the nectar, pollen, water, propolis etc., from field gatherers and deposit in the comb cells and help in keeping the brood warm.
e) From 18th to 20thday	Perform guard duty
f) From 20th day onwards	The worker bees take the duty of field i.e. exploring or foraging for nectar and pollen; collecting water and propolis.

Worker bees release alarm pheromone on stinging from lining of sting chamber and it assists in defense of the colony by alerting other colony members of the threat.

- A worker has an average life of only 40-50 days during honey flow season (active period) and her life may extend up to 6 months during off season
- Laying workers: Under queenless conditions for a long duration, ovaries of some of the workers start developing and they can lay even eggs but since these are unfertilized, give rise to only drones. The eggs laid by the laying workers have haphazard pattern and many eggs are laid in each cell of the comb. The colonies with laying workers ultimately perish. *A. melliferacapensis* is the exception where even from the eggs of laying workers queen and workers are raised by the bees.

Drone:

- Drones neither perform any duty inside the hive nor do they collect food from flowers. Each drone is fed by 3 to 4 worker bees. A colony rears and tolerates the drones only during breeding season when new queens are being produced and are later driven out of the colony to die of starvation. The sole function of a drone is to mate once which costs him his life. Maximum life of drone honey bee in summer is 59 days

LIFE CYCLE

Queen deposits egg at the base of cell and fastens with mucilaginous secretion. After 3 days egg hatches and workers provide pearly white food in which "C" shaped larva floats. Cell is sealed when larva is fully grown. In the sealed cell it turns into pupa from which adult emerges. Larva sheds skin five times during development. The sealed cells containing worker and drone brood and honey can be differentiated on the basis of appearance (Figs 4.3 to 4.6).

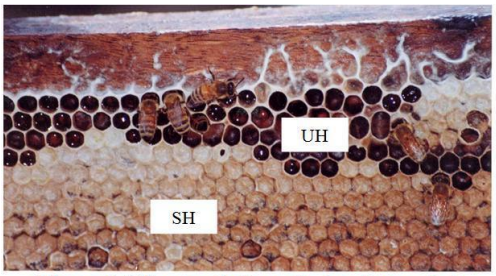


Figure 4.3 Top part of comb showing sealed (SH) and unsealed honey (UH)

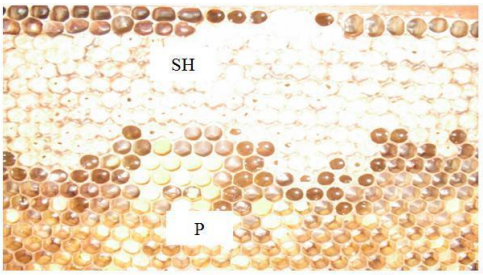


Figure 4.4 Comb with freshly sealed honey (SH) and pollen (P)

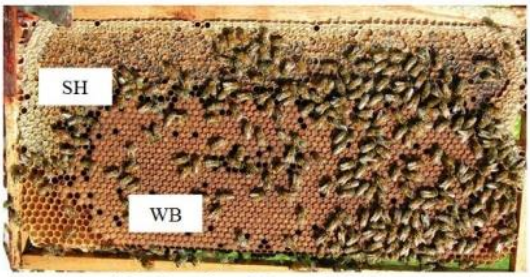


Figure 4.5 Comb with sealed honey (SH) and sealed worker brood (WB)

Figure 4.6 Comb with sealed drone brood (DB): raised cells

Development: The developmental stages of honey bees are: egg, larva, pupa and the adult.

Duration of life stages of different castes of honey bee varies which is given in the table and presented through Fig 4.7 below:

Caste	Egg period (days)		Larval Stage(days)		Pupal Stage (days)		Total (days)	
	A. cerana	*A. mellifera*	*A. cerana*	*A. mellifera*	*A. cerana*	*A. mellifera*	*A. cerana*	*A. mellifera*
Queen	3	3	5	5	7-8	8	15-16	16
Worker	3	3	4-5	5	11-12	12-13	18-20	21
Drone	3	3	7	7	14	14	24	24

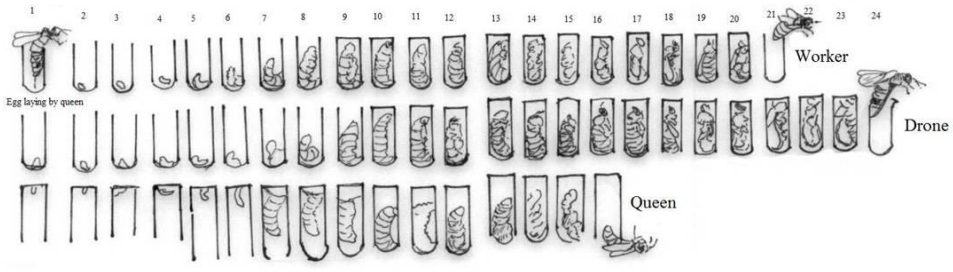


Figure 4.7 Development period (in days) and development stages of different castes of honey bee *Apismellifera* (After Winston)

In a comb, workers rear brood in the central part where temperature can easily be maintained and honey is stored in the upper and peripheral part (Fig. 4.5). Pollen is stored around brood area so that it is easily available for rearing brood (Fig. 4.4). Drone brood area can be differentiated from worker brood as the sealed brood cells in the former case are raised (Fig. 4.6).

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LECTURE 5

SOCIAL BEHAVIOUR OF HONEY BEES

INTRODUCTION

Among different insect orders, only 8 have been recognized by insect taxonomists which have some communal life. Out of these 8 orders only two orders viz. Isoptera and Hymenoptera have well developed social organization. Even in Hymenoptera, only two families namely Halictidae and Apidae of superfamily Apoidea contain fully social species. Most of other bees live solitary life.

Social behaviour
Honey bees are among the fully social insects having overlap of many generations in the same nest. The colony is a well organized social group having division of labour in terms of laying of eggs, nursing, comb building, guarding, food collection and its storage. They have well developed communication system through different types of dances as well as trophallaxis.

Biological communication can be defined as an action on the part of one organism that alters the probability pattern of behavior in another organism in an adaptive fashion. Adaptive means that the signaling or the response or both which have been genetically programmed to some extent by natural selection.

Trophallaxis is food transmission (exchange of food) which is common between workers and also from workers to queen and drones. It is a sort of communication regarding availability of food and water and also a medium for transfer of pheromone.

In honey bees, recruit communication is very important mode of communication which is defined as a communication that brings nest mates to some point in space where work is required. Dances of honey bees are important recruit communication.

DANCES OF HONEY BEES

It was Father Spitzner in 1788 who for the first time described bee dances as method of communication among inmates of the hive about volume of honey flow and place of source of nectar. These observations remained unnoticed till Frisch (1920) published his observations. Karl von Frisch got noble prize in 1973 (under physiology & medicine, who shared it with two other animal behaviourists) on the basis of his work published in 1946.

Types of dances: In honey bees there is a well developed recruitment system to increase

foraging efficiency. Some of the foraging force (5-35%) acts as scout bees/searcher bees. These bees may travel many kilometers. Average foraging radius of a colony is only few hundred metres in agricultural areas and about 2km in forested areas. Scouts communicate distance, direction and quality of flowers through different types of dances which in turn results in recruitment of other workers to forage on the best available sources.

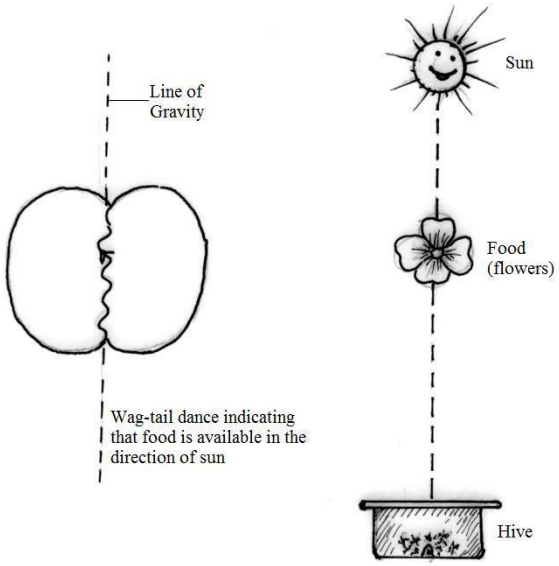
The scout bees perform two types of dances
i) Round dance
ii) Wag-tail dance

ROUND DANCE

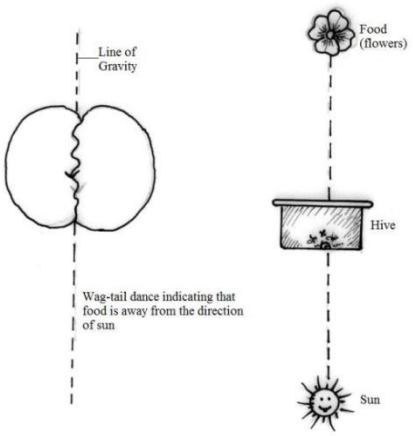
This type of dance is performed if food source is nearby (within100 metres in case of *A. mellifera* and 10 metres in *A. cerana*). The performing bee takes quick short steps and runs around in narrow circles on the comb; once to right and then left and then repeating for several seconds (Fig. 5.1). The dance excites the bees and they touch the performer with their antennae and then leave the hive in search of source of food. In this dance there is no indication of direction of food and the foragers search within 100 metres in all direction using floral odour clinging to hairy body of scout bee as cue as well as from the sips of nectar which they receive from the dancing bee.

WAG-TAIL DANCE

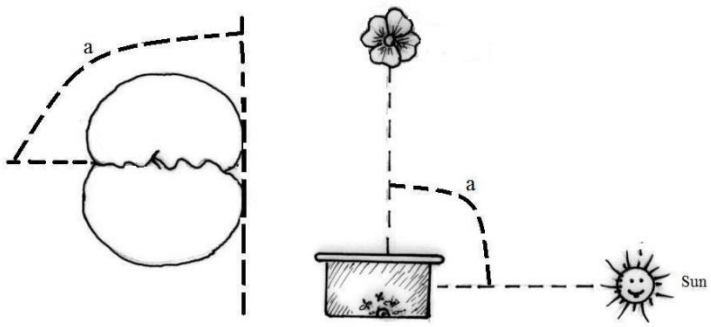
This dance is performed when the distance of food source is more than 100 metres from the hive. In this dance the bee starts dancing on the comb making a half circle to one side and then takes a sharp turn and runs in a straight line to starting point. Thereafter takes another half circle on the opposite direction to complete one full circle (Figure 5.2). Again the bee runs in a straight line to the starting point. In the straight run the dancing bee makes wiggling motion with her body that is why this dance is known as wag-tail dance. Location of food is indicated by direction of straight run in relation to line of gravity. If the food is in line with the sun, bee wag-tails upwards (Figure 5.3a) and if away from the sun, it performs downwards (Figure 5.3b). If the food source is to the left of the sun the bees dance at an angle counterclockwise to the line of gravity (Figure 5.3c) whereas, if it is to the right of the sun the bees dance to the right of the line of gravity (Figure 5.3d).



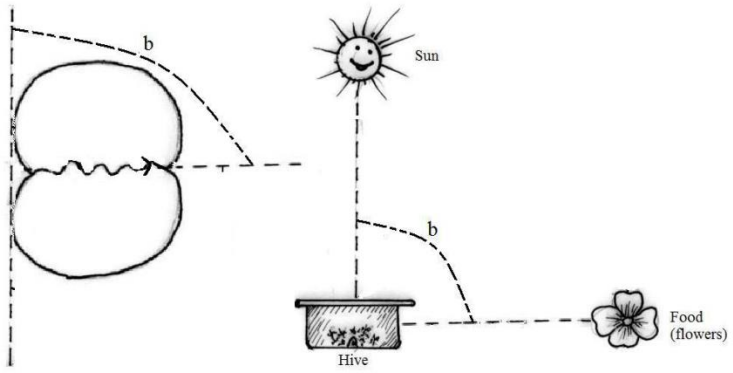
5.3a Direction indication in wag-tail dance when food is in the direction of sun



5.3b Dance when food is away from direction of sun



5.3c If food is to the left of the sun, bee dances at an angle counterclockwise to the line of gravity



5.3d If food is to the right of the sun, bee dances to the right of the line of gravity

Figure 5.3 Wag-tail dance in relation to direction of sun

The distance is indicated by the number of straight runs per 15 seconds as given below:

Distance of food from hive (metres)	Number of straight runs/15 sec.
100	9-10
600	7
1000	4
6000	2

As a social unit a bee colony maintains its hive temperature between 32-35^{o}C in the brood area. Queen substance 9-oxo-2-decenoic acid (9-ODA) from the queen bee, alarm pheromone and alarm odour from worker bees play important role in the welfare of the colony and help in the social organization.

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Lecture 6

BEE KEEPING EQUIPMENT

BEE HIVE

L.L. Langstroth discovered the principle of bee space in 1851 in the U.S.A. This space permits free passage for worker bees and is too small to build a comb by bees or too large for depositing bee glue i.e. propolis. We can say that bee space is optimum distance between two surfaces in a bee hive essential for normal movement and functioning of bees. This principle was a big discovery for modern beekeeping. The modern hive has been designed on the bases of principle of bee space in which frames can be easily moved. The bee space measures 9.52 mm for *A. mellifera* and this was modified for *A. cerana* to be between 7 and 9 mm. Different parts of a movable frame bee hive are shown in Fig. 6.1.

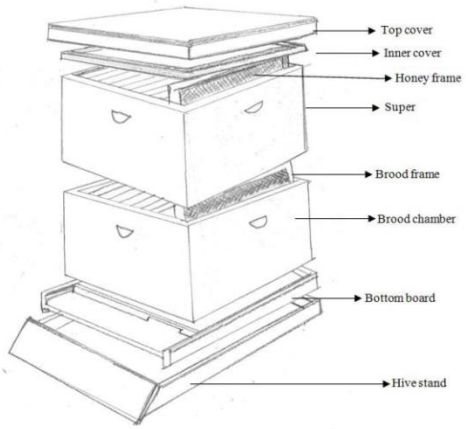

Figure 6.1 Parts of a movable frame hive

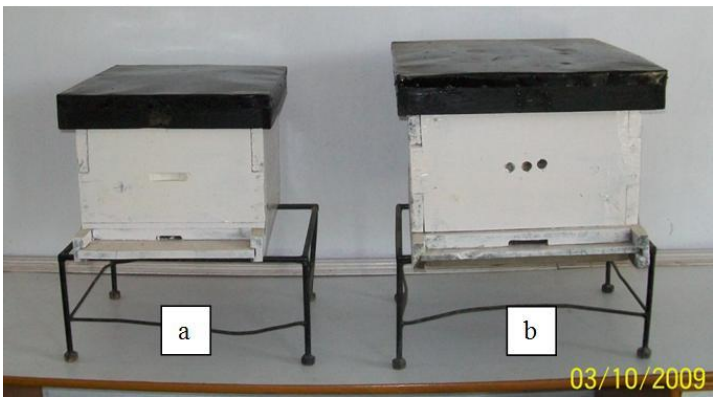

Figure 6.2. a) BIS type (B) hive for *Apiscerana*. b) BIS type (C) hive for *Apismellifera*

Stand: To support bottom board.

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

Brood chamber: Chamber used for rearing of brood. Frames are placed in this chamber on which bees raise combs. The dimensions and number of frames vary with the type of hive. A wooden dummy board is used to limit the size of brood chamber and is placed at the end of brood frames.

Frame: Each frame consists of a top bar, two side and a bottom bar. Inner aspect of the top bar has a groove for fixing comb foundation sheet. Side bar has 4 holes for wiring the frame. The frame holds a comb.

Dimensions of hive: In general for *A. mellifera*we use Langstroth hive (named after L.L. Langstroth) and for *A. cerana*, BIS (Bureau of Indian Standard) hive A and B type. In 1995, BIS introduced C-type hive based on Langstroth hive, for *A. melifera*. Well seasoned wood of "Kail, "Toon", teak or rubber can be used for making good quality bee hives. Wood having strong smell is not used. Dimensions of different types of bee hives being used in India are given below:

Super: Dimensions may be same as that of brood chamber or half of it (depending on type of bee hive). This is the chamber where bees store surplus honey.

Inner cover: A board which acts as a partition between brood/super chamber and the roof .

Top cover: A type of lid acting as roof placed over inner cover.

OTHER EQUIPMENT

Nucleus hive: Small bee hive for keeping 4-6 frames. These are used for mating of queens and division of colonies (Fig. 6.3).

Observation hive: Small hive with glass sides so as to observe movements and behaviour of bees (Fig. 6.4).

Figure 6.3 Nucleus hive

Figure 6.4 Observation hive

Comb foundation mill: Used to print natural cell size of desired comb foundation sheet for *A. mellifera* and *A. cerana* (Fig. 6.5).

Bee veil: Used for preventing bee stings on face and neck (Fig. 6.6).

Figure 6.5 Comb Foundation Mill

Figure 6.6 Bee Veil

Smoker: Used to calm down the bees while opening the hive (Fig. 6.7a).

Uncapping knife: Large sized knife used to uncap the frames before honey extraction (Fig. 6.7b).

Hive tool: An iron strip used for opening of hive and its cleaning (Fig. 6.7c).

Queen cell protector: A spring like structure for protecting queen cells (Fig. 6.7d).

Queen cage: Used to introduce a queen to new colony and also to transport the queen. (Fig. 6.7e).

Bee brush: To brush the bees from frames (Fig. 6.7f).

Figure 6.7 a) Smoker, b) Uncapping Knife, c) Hive Tool, d) Queen Cell Protector, e) Queen Cage, f) Bee Brush

Feeders: Different types of feeders are used for feeding sugar syrup to the bee colonies. (Fig. 6.8). These can be (i) slow feeder (friction top pail feeders) in which holes are made in the lid and the feeder is placed inverted inside the hive (ii) fast feeder (division board feeder) which is of the size of

a regular frame and the trough contains a wooden float inside the cavity.

Swarm basket: Basket to catch bee swarm (Fig 6.9).

Figure 6.8 Feeders

Figure 6.9 Swarm Basket

Queen excluder: Perforated zinc sheets or round wires (Fig. 6.10) assembled in such a way that workers can pass through them and queen cannot (perforation size is 4.20mm for *A. mellifera* whereas worker thorax size varies from 3.33 to 3.50mm). It is used during honey flow season to restrict queen to brood chamber and thereby preventing egg laying in the super. It is also used in maintaining multiple queen system in a colony.

Figure 6.10 Queen excluder

Honey extractor: It is a machine to centrifuge out the honey from uncapped frames (Fig. 6.11).15. Wax melter: Double walled chamber for melting of bees wax for making comb foundation sheets (Fig. 6.12).

Figure 6.11 Honey Extractors

Wax melter: Double walled chamber for melting of bees wax for making comb foundation sheets (Fig. 6.12).

Pollen trap: For trapping corbicular pollen of returning bee foragers: (Fig. 6.13). For *A. mellifera* pollen trapping screen has holes of 4.7 to 5mm. and for *A. cerana* 3.5 to 3.7mm.

Figure 6.13 Pollen Trap

Bee escape: To provide one way passage to bees (Fig. 6.14)

Figure 6.14 Two types of bee escapes (Different veiws)

Figure 6.12 Wax Melter

LECTURE 7

HANDLING OF A HONEY BEE COLONY AND MAINTENANCE OF APIARY RECORD

SELECTION OF APIARY SITE AND BEE SPECIES

The key to success of beekeeping lies mainly in three things:
A. Good apiary site.
B. Good bee.
C. Proper management.

What is an apiary?
Apiary is the place where the bee colonies are kept (Fig. 7.1).

Selection of good apiary site:

- The apiary site should be rich in bee flora which may provide forage for most parts of the year and in addition there should be good density of honey flow sources near the apiary site. For collecting 20 kg of honey, one colony needs 100 blooming trees or 2-4 acres of blooming crop
- The apiary site should be easily accessible by road
- There should be availability of fresh running water near the apiary
- The apiary site should have natural or artificial wind breaks to protect the bees from strong/chilly winds
- The site should receive morning and afternoon sunshine. During summer provision of shade (either using artificial structures or using shade of the trees) should be made (Fig. 7.1).

Figure 7.1 Bee colonies in an apiary kept under trees which provide shade during summer

Selection of good bee:

Beekeeping can be taken up with either of the two domesticated honey bee species (*Apiscerana* and *A. mellifera* Figs. 7.2 & 7.3). However, in cold areas e.g. high hills, *A. cerana* being cold hardy performs better than *A. mellifera*. Moreover this bee is more frugal and does well even in areas, which are not very rich in bee flora. Farmers who are incapable of making more investment in bee keeping with *A. mellifera*can use *A. cerana*, since it needs less investment.

Figure 7.2 *Apis cerana*

Figure 7.3 *Apis mellifera*

EXAMINATION OF A BEE COLONY

Success of beekeeping also depends upon proper understanding of bee behaviour and manipulating the colonies accordingly. For manipulation of colonies in modern hives, as per needs of the bees, examination is frequently required.

Handling of bee colonies:

- For management of honey bees in modern beekeeping, examination of colonies forms one of the important aspects. But whenever we talk about examination of bee colonies, there is general fear of stinging by bees. It is to be made clear here that if we are aware of bee behaviour, stinging can be prevented. Bees sting only for their own protection and after stinging they die. If all the precautions are taken before examination of colonies we can avoid stinging by bees.

Figure 7.4 Handling of a bee colony.

Aim of examination of bee colonies: A bee colony is examined to check its working and to determine its requirements at a particular time, since these vary during different parts of the annual cycle of a bee colony. When a bee colony is opened, make the following observations:

- Whether a bee colony has sufficient food or it needs artificial feeding. Each colony, depending upon its strength, should invariably have at least 2-5kg of stores all the time
- Whether the queen is present or not? If present whether laying satisfactory. If absent colony needs a new queen.
- Whether there are sufficient combs for egg laying by the queen and to store nectar or not. If not provide more frames.
- Whether there are any of the enemies or diseases in the colony. If yes, manage them accordingly.

Honey bees do not like much of interference since it affects their normal working. Therefore, the colonies should be disturbed as little as possible. It is suggested that during built-up period of the colony it is examined once a week whereas during off-seasons only once or twice a month.

Requirements for examination of bee colonies:
Hive tool, bee veil, apiary record register, measuring scale or grid, smoker

Precautions:

- Before handling bee colonies it is better to wear a bee veil (Fig. 7.4).
- Do not wear black or dark clothing as bees are furious to black colour.
- Any kind of perfume or strong smelling hair oils or metals like ring, watch etc which would induce bees to sting, should be removed before handling the bees.
- Do not be shaky while handling bees. Take care and avoid quick and jerking movements.
- If a bee stings (Fig. 7.5), do not get nervous. Gently pull out the sting with the sharp edge of hive tool or finger nail from the base (Fig. 7.6) and not from the top without squeezing the venom out of it. Rub some grass on the stung area to mask the smell of alarm pheromone which otherwise induces other workers to sting in that area.
- Do not crush any bee while taking out or putting the frames back in a colony.
- Be careful about queen and avoid crushing it.

- Hive should not be opened on a windy, chilly day or the period when bees are not working outside the hive

Figure 7.5 Bee stinging on the arm

Figure 7.6 Removal of sting by scrapping

MAINTENANCE OF APIARY RECORDS

Observations: Keep the record of every colony and enter your observations whenever the colony is examined. These observations can be made in the given proforma.

PERIODICAL COLONY INSPECTION RECORD

Colony Number:

Date of Inspection	Total number of frames	Number of frames covered by bees (Bee strength)	Brood area (sq.cm.) L x B	Pollen area (sq.cm) L x B	Honey/ nectar stores (g)*	Presence of queen and its working	Remarks (date & amount of sugar feeding, drone rearing, honey extraction, temper etc.)

***Estimation based on assumption that each fully sealed Langstroth type frame of honey contains 2kg and BIS Type A&B about 750g of honey**

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LECTURE 8

COLLECTION AND PRESERVATION OF BEE PASTURE

INTRODUCTION TO BEE FLORA

Honey bees collect nectar and pollen from a variety of plants which are known as bee flora or bee forage or bee pasture or nectar and pollen plants. Nectar is source of honey, meeting the carbohydrate requirements of honey bees, where as pollen is source of protein. Bee pasture can be designated as build up, honey flow and dearth period flora depending on period of availability with respect to development of bee colonies. The flora of an area is characteristic of its agro climatic conditions and as such varies from place to place. This flora is also a food base for large number of pollinators. Out of 3,52,000 species of flowering plants in the world nearly 3,08,000 species (87.5 per cent) are pollinated by animals (including insects, birds, bats, etc.). Bees pollinate a large majority of these plants. Pollination is an ecosystem service provided by the bees that is almost always taken for granted. In simple terms bees make more fruits and seeds for us by collecting nectar and pollen then the quantity of honey they make. Hence, it is essential to understand various types of bee flora and their blooming phenology in a given area to conserve bee colonies.

List of important bee flora:

Sr. No.	**Common name**	**Botanical name**	**Family**
1.	Stone and pome fruits	*Prunus&Pyrus spp.*	Rosaceae
2	Bramble	*Rubusellipticus*	Rosaceae
3	Barberry	*Berberislycium*	Berberidaceae
4	Honey suckle	*Loniceraangustifolia*	Caprifoliaceae
5.	Yellow clover	*Medicagodenticulata*	Leguminosae
6.	White clover	*Trifoliumrepens*	Leguminosae
7.	Egyptian clover	*Trifoliumalexandrinum*	Leguminosae
8.	Hirad	*Terminaliachebula*	Combretaceae
9.	Jamun	*Syzygiumcumini*	Myrtaceae
10.	Eucalyptus	*Eucalyptus* sp.	Myrtaceae
11.	Bottle brush	*Callistemon lanceolatus*	Myrtaceae

12.	False acacia	*Robiniapseudoacacia*	Leguminosae
13.	Gulmohar	*Jacaranda mimosaefolia*	Bignoniaceae
14.	Bird's foot treefoil	*Lotus corniculatus*	Leguminosae
15.	Daru	*Punicagranatum*	Punicaceae
16.	Toon	*Toonaciliata*	Meliaceae
17.	Sunflower	*Helianthus annuus*	Compositae
18.	Shisham	*Dalbergiasissoo*	Leguminosae
19.	Wild rose	*Rosa moschata*	Rosaceae
20.	Ber	*Zizyphusjujuba*	Rhamanaceae
21	Ohi	*Albiziachinensis*	Mimosaceae
22	Khair	*Acacia catechu*	Mimosaceae
23	Bhang	*Cannabis sativa*	Cannabaceae
24	Maize	*Zea mays*	Graminae
25	Shain	*Plectranthusrugosus*	Labiatae
26	Cruciferous oil seeds	*Brassica spp*	Cruciferae
27	Wild cherry	*Prunuspuddum*	Rosaceae
28	Rubber	*Heveabrasiliensis*	Euphorbiaceae
29	Soapnut	*Sapindusspp*	Sapindaceae

QUALITIES OF A GOOD BEE FLORA

For commercial beekeeping, large crop acreage with good floral qualities is required. A beekeeper must have the details about the availability and suitability of bee flora. Following are the qualities of good bee flora:

- Long flowering period
- High density of flowers per unit of the plants
- Good quality of nectar with high concentration of sugars
- Easy accessibility of the nectaries to the honey bees and ease in collection of nectar
- Availability of flora in the close vicinity of the apiary

IMPORTANT HONEY FLOW SOURCES IN INDIA

Flora secreting abundance of nectar and having large plantations is known as honey flow source. But to avail honey flow colonies should have peaked their population by this time. Some of important honey flow sources are: eucalyptus, brassica (sarson&toria), toon, soapnut, citrus, litchi, berseem, rubber, cotton, plectranthus, jamun, buckwheat, sunflower, shisham, acacia etc (see Fig. 8.1 to 8.6).

Figure 8.1 Bushes of *Plectranthus* in bloom (Autumn honey flow flora)

Figure8.2 *Toona ciliate*, a summer honey flow source

Figure 8.3 *Acacia catechu*, monsoon honey flow or dearth period flora

Figure 8.4 *Brassica* sp, a winter honey flow crop

Figure 8.5 Sunflower, a summer honey flow crop

Figure 8.6 *Eucalyptus*, summer honey flow tree source

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LECTURE 9

SEASONAL MANAGEMENT OF HONEY BEE COLONIES (SPRING MANAGEMENT)

PRINCIPLES OF BEE MANAGEMENT

All the management practices needed for increased honey production revolve around the following basic principles of bee management:
i) Ensuring built-up of foraging force of bees at right time for collection of surplus nectar.
ii) Providing space for storage and ripening of nectar into honey by the bees.
iii) Removing honey from hive at right time and extracting it.
iv) Preparing the colonies to withstand any period of dearth and menace of bee enemies.

Generally, beekeeping activities start with the onset of spring in cold areas. Therefore, it is appropriate to know the management practices, starting from spring. However, in some parts of the country there are different seasons and the management varies as per season.

SPRING MANAGEMENT

The advent of spring, particularly in northern parts of the country, marks the beginning of warm weather and blooming of several tree species and cultivated crops. Following management practices are performed:

- Remove the protective covering of lightly packed hives in the early spring. But in the heavily packed colonies, the packing is removed only when daily maximum temperature has reached 16°C.
- Examine the colonies on a sunny day. Check the food store and general condition of the colony. The examination should be for short duration to avoid brood chilling and robbing
- It is a good practice to equalize the strength of normal colonies in an apiary by giving brood frames to the needy colonies
- The colonies which do not have brood, are likely to be queen less or if queen has failed and has become drone layer, there will be predominance of drone brood. Such colonies if are weak (less than 5 frames), be united

with other needy normal colonies. If these are strong, then provide a mated queen and if not available, give a frame of brood with eggs and young larvae for rearing new queen

- Give stimulatory feeding of sugar syrup (dilute syrup; 30 per cent) to the bee colonies on the onset of spring which is indicated by the start of blooming of spring flowers. Take all the steps to guard against the robbing by bees. Bees will put their whole force during this period for brood rearing
- Provide raised combs or frames with comb foundation sheets if raised combs are not available so that there is no shortage of space for brood rearing. But be careful not to over expand the brood in the uncertain weather conditions of early spring, which may result in chilling of brood. Once the colony is strong enough to cover the brood, there is no risk of this problem
- Examine the colonies at least once a week on a sunny day and when conditions permit, clean the debris from the bottom boards. Provide empty frames as per needs of the colonies. Ensure that each colony always has at least 5 kg of food stores
- During spring old bees die which are normally replaced by young bees. If mortality of old bees exceeds the rate of emergence of young bees, the colonies show sign of dwindling which is known as spring dwindling. Such colonies should be provided with adequate stores of pollen and honey and be given 1-2 sealed brood frames from the strong colonies.

If all above mentioned practices are followed, the colonies will be well built up by the time of honey flow when maximum strength is needed. However, increase in strength also induces swarming.

In warmer areas of the country, all these practices can be carried out during early summer.

SWARMING AND CONTROL

What is swarming? This is a natural instinct for increase in the number of colonies. Division of colony takes place in which worker bees (30 to 70 per cent), fill their honey stomachs with the food and leave the colony along with old queen and this divide, called as swarm, settles down temporarily generally in the nearby area of the colony on the bushes, hedges, tree branches etc.

Period of swarming: It occurs when queen has reached her peak of brood rearing activity under the stimulus of incoming pollen and nectar, mainly in late spring or early summer, but can also occur during summer or fall, depending upon floral conditions of the area. This generally occurs during the period before honey flow.

What causes swarming? Swarming occurs due to:

- Overcrowding and lack of ventilation.
- Presence of old queen
- Sudden honey flow
- Lack of space for egg laying and honey storage.

Problems due to swarming:

- Loss of working force due to division of the colony
- The morale of colony is not favourable for honey collection. The bees direct their efforts towards building queen cells and searching for new home sites
- Colonies show great variations in respect of swarming. Some colonies do not swarm even after becoming quite populous yet many swarm without any apparent reason indicating genetic variations to the instinct of swarming. *A. cerana* is more prone to swarming than *A. mellifera*.

Indication of swarming:

- The colonies start raising large number of queen cells usually along the lower edges of combs . However, few emergency queen cells are also raised in the event of queen failure i.e. supersedure.
- Many bees do not go to field creating additional crowding, resulting in clustering of bees outside the hive.

Time of swarming: Time to issue swarms by the colonies is from 10AM to 2PM on sunny days. If weather is not favourable, swarms may be issued even earlier in the morning or late in the evening.

Catching and hiving a swarm:

- A settled swarm can easily be caught using swarm catching basket . This basket is placed above the bee cluster and the cluster is gently pushed upwards so that the bees start ascending into the basket. Once the queen has entered, the whole swarm will follow the queen
- The swarm in this basket can be taken to the apiary for hiving
- To make the swarm settle properly, a hive is prepared by giving one frame each of capped brood, pollen and honey and provided with extra frames as per strength of the swarm.
- The swarm from the swarm catching basket is then shaken on the top bars of such a prepared hive and immediately covered with burlap cloth, inner cover and top cover

- Sugar syrup is also fed to such a newly settled swarm (1 part sugar dissolved in 1 part of water).

How to prevent and control swarming? Depending on the internal and external factors, one colony may issue one to several swarms resulting in loss of population of the parent colony. To prevent swarming do as given below:

- Avoid overcrowding by adding empty combs for egg laying. Sealed brood can be shifted to second hive body
- Remove the queen cells at regular interval as soon as these are made. Delay in queen cell removal is not much effective
- Provide shade and ventilation to the colonies
- Swarming can be prevented by removing old queen (which otherwise provides the supersedure impulse) followed by introduction of a young laying queen. Requeening the colonies annually is also a good practice
- Another well known method of swarm control is " Demaree plan of swarm control" which is described below:
    - Examine the brood of the colony and remove all the queen cells
    - Remove the brood chamber from the bottom board. Place another hive body containing one comb of unsealed brood, eggs and the queen on this bottom board. Fill the remaining hive with empty combs.
    - Place queen excluder on this hive body and keep the removed brood chamber along with remaining brood and bees over it
    - Again inspect the top hive body after 10 days and remove all queen cells that may have been built in this interval. In 21 days, all of the brood will have emerged in the upper body and it will be used for honey storage. In this way swarming can be checked.
- Swarming instinct of the colonies can also be overcome by temporarily dividing the colony and then re-uniting them just before honey flow.

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LECTURE 10

SEASONAL MANAGEMENT OF HONEY BEE COLONIES (SUMMER, MONSOON AND AUTUMN MANAGEMENT)

SUMMER MANAGEMENT

Under summer management, information on indication of honey flow, method of supering, honey extraction and management for dearth period has been provided.

What is honey flow? : It is the period when honey bees gather and store surplus honey in the hive after attaining peak population in the colony. Honey flow is indicated by:

- Whitening of honey cells of the comb due to deposition of fresh wax
- Appearance of large quantities of burr and brace combs (freshly prepared pieces of combs)
- Increase in weight of the colonies due to incoming nectar (a colony kept on a stage balance in an apiary indicates the sudden increase in weight; such a colony is also known as balance colony)

During this period colonies should be quite populous but without swarming instinct and should gather maximum honey instead of only concentrating on brood rearing. Colony morale should be high for honey collection.

Supering:

- With the first indication of honey flow, provide supers to the colonies. But before putting supers, examine the colonies for disease; check whether queen is present or not and whether laying satisfactorily because after the honey flow starts, the bee keeper becomes too busy in putting and taking off the supers
- Place queen excluder between brood chamber and super so as to prevent laying in the super by the queen
- Keep swarming under check by avoiding congestion in the brood chamber. Provide empty combs at all the times until end of honey flow. The space can be provided by removing sealed brood to super chamber

- Supers should contain drawn combs. If these are not available, provide frames with comb foundation sheets. In that case, also place at least one or two drawn combs with the comb foundation sheets to attract bees for raising the combs on foundations
- Supers can be of half or full depth. But full depth supers are more practical since frames can be exchanged among different chambers
- When first super is full and there is a need to put the second one, it should be added between brood chamber and first super
- If there is shortage of drawn combs and raising of new combs is likely to lower honey production (since bees consume about 7kg of honey to secrete one kg of beeswax), the fully sealed and two third sealed honey frames can be taken out for honey extraction and empty combs can be returned for re-use
- A strong colony can collect 4.5 to 10 kg of unripe honey in a single day during good honey flow. Therefore, keep the supers ready for meeting colony demand. It is better to supply at least one super ahead of needs of the colony.

HONEY EXTRACTION

For honey extraction only sealed honey frames are removed. Do not extract uncapped honey since it is unripe and due to higher moisture contents it is liable to ferment.

Time to remove supers: Early in the morning before bees start storing unripe honey in the combs. If combs are well sealed, these can be removed at any time of the day.
All the management practices of honey bee colonies are ultimately directed to get better quality hive products. It is, therefore, important that apiary honey is extracted properly so as to retain its quality. The process of extraction should be hygienic and prevent any extraneous material in honey.

Requirements:

- Smoker, bee veil, hive tool, bee brush, empty super bodies, uncapping knife, boiling water, drip trays, honey extractor, honey storage container, muslin cloth

Procedure of honey extraction:

- To remove sealed honey combs, give few puffs of smoke to the colony and brush off bees from the honey combs using soft bee brush (Fig. 10.1) or bunch of soft green grass
- Place the honey combs in bee tight hive bodies and shift to honey extraction room
- Never rob the colonies of their entire honey stores. Depending on strength, keep with each colony at least 5-10 kg of honey in case of Apismellifera and 2-3kg with A. cerana for summer and monsoon dearth periods

- Honey extraction room should be bee tight. After bringing the honey frames for extraction, these can be uncapped (Fig. 10.2) either with a steam heated double walled uncapping knife or with ordinary uncapping knife by heating in boiling water
- Keep these uncapped frames in hive bodies with drip trays below, till extraction
- Put the uncapped frames in honey extractor and work at about 150 revolutions per minute for 1 to 2 minutes. Then reverse the sides of the frames and repeat the extraction process (Fig. 10.3 and 10.4)
- Stock the emptied frames in hive bodies and return these to the colonies for cleaning. Shorten the hive entrance to avoid robbing
- Since freshly extracted honey is warm and easy to strain, arrangements for straining using muslin cloth and packing should be promptly made so as to prevent subsequent heating
- Clean the appliances and the place where honey is extracted
- Beeswax collected during uncapping of honey frames should be allowed to drain off its honey. Then purify this beeswax by putting in a muslin bag and boiling in a water bath. On, cooling pure beeswax will float over the surface of water and all impurities will remain in the muslin bag.

Figure 10.1 Brushing bees from honey frame

Figure 10.2 Uncapping sealed honey

Figure 10.3 Unsealed frame being put in the extractor

Figure 10.4 Honey extractor in motion

Precautions during honey extraction

- Remove only completely sealed or two third sealed combs of honey for extraction. Never extract unripe honey
- Keep sufficient food stores with the colonies as per strength and prevailing dearth period. Do not rob the colonies of their whole stores.

OTHER MANAGEMENT DURING SUMMER

Other management during summer: Honey flow in most of the areas is generally followed by summer dearth period. Summer is generally marked by hot winds and ambient temperature often exceeds 40°C. During this period bees throw out drones and colony population also dwindles due to the death of old bees who have worked hard during honey flow season. Attack of bee enemies increases and robbing activity of bees is also more. If colonies are not managed properly, they may even abscond. This tendency is more in *A. cerana* and little in *A. mellifera*. Manage the colonies as described below:

- Provide the bee colonies with shade by shifting to shady areas or placing them under open straw huts
- Provide proper ventilation by slightly raising the brood chamber or the super such that bees do not pass through this ventilation. Otherwise robbing may be induced
- Close all cracks and crevices in the hive so as to prevent entry of the enemies and robbers.
- Ensure that colonies do not remain brood less for longer duration. Provide sufficient food stores if the colonies have been stripped heavily of their honey stores during honey extraction
- Do not examine the colonies very frequently
- Restrict the number of frames as per colony strength. Remove extra frames and store these safely for later use
- In areas where summer temperature rises above 40°C, gunny bags or straw packs moistened twice a day with water should be spread over the top covers of the colonies
- Provide a source of fresh water as honeybees maintain their hive temperature during summer by collecting water from outside source, spilling it inside hive and evaporating it by fanning. This can easily be arranged in an apiary by hanging an earthen pitcher filled with water having a hole at its bottom, provided with a wick and allowing drops of water to fall on sloping stones or log of wood.

MONSOON AND AUTUMN MANAGEMENT

Monsoon management: In the tropical and sub- tropical regions of the country, June to September represents the monsoon or wet season. Bees face several problems of pests, predators, excessive humidity and starvation. Sometimes due to continuous rains, bees are confined to their hives for a long period. Honey bees become lethargic and may develop dysentery. The colonies need following management to keep them strong:

- Weak colonies which have become queenless, should be united with queen right colonies, since during this period due to absence of drones new virgin queen can not mate
- Avoid broodlessness in colonies; if pollen stores and fresh pollen is not available, feed the colonies either pollen substitute or pollen supplement
- If colonies have poor food stores (below 5kg) provide sugar in the form of candy or dry sugar instead of sugar syrup
- Keep in check the attack of enemies like wax moth, ants, mites and wasps.
- The hives are kept on stands sloping towards entrance in order to drain out water and prevent its accumulation inside the hive.

Autumn/fall management: Management practices during this period depend on the climatic and floral conditions where bees are kept. In some parts of Himachal Pradesh, there is a second honey flow season in autumn. The colonies in such places are managed as described earlier for availing honey flow. Near the end of honey flow, reduce the hive space to the needs of colony for winter. Restrict the food storage space to the lower hive body so that bees are forced to store their winter stores there instead of super.

During this period many colonies make preparation for superseding old queens and raise few queen cells and this is natural replacement of failing queen in a colony. The new queen on emergence kills the old queen.

For successful overwintering, which is the non-productive season, following management should be done.

- Ensure that the colony has vigorous and productive queen. An ideal queen is one whose egg laying rate is high and continues to lay well till late fall and thus provides population of predominantly young bees in sufficient number for wintering
- Colonies below average population or having scattered or less brood than the average colonies indicate failure of queens. Replace queens of such colonies by early fall so that these colonies produce desirable number of young bees
- Colonies for wintering should be free from disease
- Reduce the comb space by removing extra frames to such a level which can be covered by the bees well
- Under moderate climatic conditions, colonies of bees on 3-5 frames can winter successfully, if the colonies have proper food stores. Unite the weak colonies with colonies of average bee strength
- If colonies have less honey stores, feed them with heavy sugar which is prepared by dissolving 2 parts of sugar in one part of boiling water and to avoid crystallization add 1 table spoon full of tartaric acid to each of 50kg of sugar. Fill this syrup in combs and exchange for empty combs in the hive.

Precaution: Sugar should be fed while outside temperature is sufficient for bees to take syrup and store in combs after reducing its moisture. To avoid robbing, feeding should be done only in the evening.

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LECTURE 11

SEASONAL MANAGEMENT OF HONEY BEE COLONIES (WINTER MANAGEMENT AND MIGRATORY BEE KEEPING)

WINTER MANAGEMENT

After preparing the colonies in fall for wintering, protection should be provided to the colonies from winter by:

- Reducing the hive entrance
- Plugging all cracks and crevices in the hive
- Protecting the colonies from direct chilly winds.

Storage and protection of combs: Protect the spare combs from attack of wax moth by fumigating in hive stacks frequently till spring when these drawn combs will be needed by the colonies again.

Wintering: In upper Himalayan region, bees experience severe winter from November to March and colonies are lost due to poor wintering. Loss of colonies in winter can be avoided if following four fundamental principles in beekeeping management are kept in mind:
i. Every colony must have a young vigorous prolific queen of superior genetic stock and young worker bees.
ii. Every colony must be properly protected from extreme climatic conditions through reduced entrance and proper packing.
iii. Every colony must have adequate reserves of honey and pollen.
iv. Every colony must be maintained in "disease free" condition.

Honey bees use honey as source of energy for generating heat and to maintain hive temperature of 32-35oC near brood area. For wintering, if insulation to hive is provided, it will help in reduction of store consumption and saving energy of bees. The type of insulation depends upon the climatic zones.

Winter packing of hive:

- Only good colonies with young bees in large number and enough food stores should be packed
- For packing colonies straw, sawdust, wood shavings, bean stalks or dry leaves, chopped rice or wheat straw can be used
- Packing material should be dry since moisture will make it poor insulator
- Packing can be given in the brood chamber beyond dummy board (Fig. 11.1 to 11.3), as well as between inner and top cover.

Fig. 11.1 Position beyond dummy board where winter packing is to be given

Figure 11.2 Winter packing being given in the form dry grass packed in newspaper

Figure 11.3 Winter packing packed in newspaper before closing the hive

Strong colonies with young bees and good food stores, with proper packing need no care during winter and are opened only in spring.

MIGRATORY BEE KEEPING

Flora and honey flow season vary from region to region. Several vegetation regions of the country exhibit short or long gaps in the flowering. Thus there are one or more floral dearth periods of short or long duration. Migratory beekeeping is practiced to overcome these deficiencies in bee forage availability and find out the places where flows can be availed by bees at different periods of the year. This helps not only to prevent colony losses, but even to increase colony number and getting additional honey production.

Preparing colonies for migration:

- Provide proper ventilation by using entrance screens and even top screen in place of inner cover during hot weather
- Close all cracks or openings in the hive
- Nail all the movable parts of the hive properly or tie with migratory belts
- Before packing the colony, remove frames of honey which are more than half sealed since honey combs cannot bear much jolts. However, the colonies should have sufficient food during the journey
- Close the entrance in the evening when all bees have returned. Colonies should be moved during night
- For deciding migrating site, the beekeeper should have a detailed knowledge of honey flow sources and density of bee colonies in the surrounding area. Avoid areas which already have lot of bee colonies
- Migration can involve shifting of one truck load of bees up to 200km or even more. If journey cannot be undertaken in one night during hot periods then the truck should be parked in the shade during day, entrances opened and providing water. Journey can be started in the evening after closing hive entrance
- On arrival at the destination, colonies are unloaded and placed at the desired site. Then the entrance screens are removed
- Check the colonies after 1 or 2 days for any damage to combs and working of queens.

Migration cycle: If a beekeeper of hilly area in northern India wants to exploit his colonies to the maximum extent, he may follow the following cycle:

- Migrate colonies to the plains of Punjab and Haryana during first week of November for availing toria, sarson, eucalyptus, berseem and sunflower till first week of June
- In case, a beekeeper is interested to avail litchi flow, he may migrate his colonies during end March till 3rd week of April to Dehradun in Uttrakhand after availing the Brassica, (sarson) flow and bringing back to the plains of Punjab and Haryana by end April to avail flows from berseem and sunflower
- In the first week of June, the colonies can be migrated to foot hills of Himachal to avail nectar of khair
- To avail Plectranthus flow, the colonies can be migrated by end August to the floral rich pockets of district Shimla, Chamba and Kinnaur in Himachal Pradesh. However, the honey flow from this source is erratic and depends on the good monsoon rains needed for growth of this wild bush
- After Plectranthus flow the preparations can again be made for winter migration.

In South India, beekeepers generally migrate their bee colonies to sunflower, safflowers, cotton, sesamum and other crops. However, in the hilly areas, flowering of coffee in March-April and that of cardamom between June-August is exploited. In some regions extensive flowering of Schifflera spp. during May, helps in building strength of bee colonies between coffee and cardamom flowering.

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LECTURE 12

MISCELLANEOUS MANAGEMENT

DIVIDING, UNITING AND SHIFTING OF BEE COLONIES

During different seasons as described earlier, different manipulations are done. These manipulations have been described separately under miscellaneous management since these may or may not be season specific.

Colony multiplication/dividing of colonies:

- Catching of swarms is an old method to increase the number of colonies but this method should not be encouraged since the colonies raised from swarms will have the swarming instincts. Moreover, this is a time consuming method
- Spring is the best season for increasing number of colonies by dividing the colonies which are not as strong as others and sparing these colonies from honey production. Such colonies can be divided into nuclei with two to three frames of bees and each nucleus is given a queen cell or new queen. These nuclei should be fed with 50% sugar syrup
- Another method to increase the colonies is before the honey flow when colonies are having peak population. Remove 2-3 combs of brood and bees from strong colonies to make nuclei. This will not affect the strength of the strong colonies and these can avail honey flow well due to strong condition. This also reduces the chance of swarming. The nuclei are given new queen or queen cells.

Uniting of bee colonies: The colonies to be united should be brought close to each other by moving 1 metre each day so as to avoid drifting of bees. When they are near to each other (within one metre), the colonies can be easily united using newspaper method in which few small holes are punctured in the paper and placed over the brood chamber of the colony. Place the brood chamber of other colony (without bottom board) over the first colony which is now separated by punctured newspaper. The bees will gradually mingle together by gnawing the paper.

Precaution: Keep the better queen and remove poor queen before uniting.

When the necessity arises?

- During fall, uniting weak colonies which cannot overwinter well.
- Just prior to honey flow, uniting weak colonies to make one strong colony.
- During spring when equalizing the strength of colonies by providing frames from strong to average colonies.
- Queen less colony is to be united with queen right colony when no spare mated queen is available or queen cannot mate due to non availability of drones or bad weather.

Shifting of bee colonies:

- If colonies are to be moved within the apiary to a short distance, these should be moved 1 metre every day in the evening to the desired site
- If colonies are to be moved to a few hundred metres in the apiary, then these should first be taken to a distance of about 5km beyond the flight range. Keep the colonies for 2-3 days, and then bring back to the apiary and place at the desired site. However, before moving the colonies, all movable parts are nailed and colonies are closed in the late evening after the bee activity has ceased.

ROBBING AND ABSCONDING

Robbing and its prevention: Robbing is stealing of food store by bees from other colonies.

What causes robbing?
- Exposure of colonies for long duration during examination
- Exposed sugar syrup or its spillage near apiary
- Careless feeding of weak colonies
- Robbing is more during lean period when there is little nectar in the field.

How can we identify robber bees?
- Robber bees become smooth, shiny and dark coloured due to repeated attack of guard bees
- Robbing bees generally do not alight at the hive entrance boldly and face the guard bees with fear. They try to sneak in the hive through cracks and crevices.

Prevention of robbing: For an attentive beekeeper robbing is not a problem. Following precautions are needed:
- Never leave combs of honey exposed and examine the colonies quickly during dearth period
- During feeding avoid spillage of sugar syrup near apiary
- Take special care of weak colonies while feeding, since these are prone to robbing. Try to make weak colonies strong by uniting weaker ones. Feed such colonies in the evening.
- Do not keep honey combs exposed after honey extraction. These combs are given back to the colonies only in the evening when foraging activity has stopped.

Control of robbing: If inspite of taking precautions the robbing is prevalent, manage colonies in the following manner:
- Reduce the entrance of the colony and close all other cracks and crevices
- Place wet grass in front of entrance of colony being robbed
- Sprinkling of repellents like carbolic acid or kerosene at hive entrance will also discourage robbing
- The colonies being robbed badly may be shifted to new site in the apiary after reducing entrance and throwing green grass at the hive entrance.

Absconding: It is desertion in which the whole colony leaves the hive. *A. cerana* is more prone to absconding than *A. mellifera*.

Causes:
- Shortage of food reserves
- Attack of bee enemies
- Too much disturbance and handling.

Prevention:
- Keep colonies strong and ensure that each colony has at least 5kg of food stores
- Avoid broodlessness in the colonies. If a colony is broodless, provide 1-2 frames of young healthy brood.
- Check the colonies for diseases and attack of bee enemies. Manage colonies accordingly.

SUPPLEMENTARY FEEDING

Supplementary feeding of bees: Bees require supplementary feeding when the food stores are poor. Supplementing the food stores of bee colonies with sugar syrup and pollen substitute/pollen supplement is known as supplementary feeding.

When do the bees need feeding?
- When the colonies do not have sufficient stores in fall for wintering
- Stimulatory feeding during spring as a stimulus to rear more brood
- When new colonies or new queens are being prepared
- During drought and even before honey flow when colonies are very strong and they may have exhausted their food stores.

What is the best food? : Honey is the best food for bees. To substitute honey stores, sugar in different forms (as syrup, dry or candy) can be fed to the needy colonies.

Feeding methods:
Honey bees collect surplus food in the form of nectar and pollen when bee forage is available in plenty. Nectar is converted in to honey and stored for future use when there is dearth of flora. Similarly pollen is processed to form bee bread for later use to meet protein requirement of the colony. But with commercial interests in mind different hive products are harvested from bee colonies which need to be supplemented for their survival. Colonies are fed sugar in different forms to supplement honey and pollen substitute or supplement in place of pollen. Therefore, it is important to know method of preparation of different types of feeds given to bee colonies and methods of feeding.

Figure 12.1 Feeder kept over top bars of brood frames by providing space for bees using 2-3 pebbles.

Figure 12.2 Feeder covered with empty super.

Requirements

• Table sugar
• Glucose
• Water
• Tartaric acid
• Fat free soy flour
• Wheat flour
• Brewers' yeast
• Butter paper
• Different types of feeders (friction pail, division board feeder)

Procedure: Sugar is fed to bees by preparing syrup of different concentration depending on the season. Sugar is fed even in dry form or in the form of candy.

Preparation of sugar syrup:
• For general feeding, prepare syrup of 1 part of sugar and 1 part water (by volume), say one cup sugar and one cup water
• For preparing stimulatory feeding make dilute syrup by mixing 1 part sugar with 2 parts water
• Feeding during autumn/winter should be with concentrated sugar syrup. To prepare heavy sugar feeding, dissolve 2 parts of sugar in 1 part of boiling water and add 1 tablespoon full of tartaric acid to 50kg of sugar, so as to prevent crystallization of sugar from the syrup on cooling.

Feeding method:
• Feed the sugar syrup prepared using friction pail feeders and division board feeders
• Friction pail feeder can be any container of 2 to 3 litre capacity (may be wide mouthed bottle or can) with 4 to 5 small holes made by nail in the lid. Place (after filling with syrup and putting the lid tight) on the side of brood chamber with lid inverted on the bottom board if space is available. Otherwise place on top bars and put an empty super to cover it (Fig. 12.1 and 12.2). Place 2-3 small pebbles below the lid so that bees have sufficient space to feed on drops of syrup which comes out when bees are feeding through the holes
• Division board feeder is of the shape of frame having sufficient capacity for 2-3 litre syrup. Fill it with syrup. A wooden float in the feeder provides surface for bees landing and take up syrup by sitting on it. This feeder is placed on the extreme side of the hive where space is available
• The syrup can also be fed by filling in empty combs. Giving these to the needy colonies
• Some beekeepers use community feeder in the bee yard by placing syrup in open in a large capacity tank and bees take syrup from it. But this should be discouraged as it may initiate robbing and weak colonies are victim of this type of feeding.

Dry sugar feeding: Dry sugar can also be fed to the colonies. Sugar can be provided on the inner cover with its hole open.

Preparation of sugar candy:
• Dissolve 7.5kg cane sugar (table sugar) and 1.5kg glucose in four cups of water by stirring and boiling mixture until temperature of syrup rises to 116^{o}C
• Let the syrup cool to 82^{o}C and then beat until thick

• Pour the candy in to mould lined with wax paper and let it cool
• Candy is ready to be fed to the colonies.

Feeding method: Place cake of sugar candy on small strips of wood above cluster of bees and place an empty super hive over the hive body.

Precautions:
• Feeding of colonies requires special attention of the beekeeper. Take all the steps to prevent robbing. Avoid spillage near the bee colonies and feed the colonies in the evening
• Type of feeding given to bees depends on season and give the recommended type of feeding e.g. heavy sugar feeding in autumn and winter when the colonies do not have sufficient stores for wintering. Dilute stimulatory feeding during spring as a stimulus to rear more brood. Dry sugar is to be fed during monsoon and sugar candy in winter when food stores fall (avoid feeding sugar syrup during winter to prevent initiation of brood rearing).

Pollen substitute and pollen supplement:
In addition to honey, bees also need pollen to meet their protein requirements and rearing of brood. If pollen stores are not sufficient and fresh pollen is not available, colonies can be given pollen substitute/pollen supplement.

Pollen substitute: This is a food to supplement pollen stores to which no pollen is added.
• Mix defatted soy flour (DSF) and wheat flour in equal parts by weight (say 150 g each)
• To three parts of this mixture add one part (100g) of deactivated yeast (killed at 60ºC for half an hour)
• Mix with equal amount of heavy sugar (400ml) prepared by mixing 2 parts of sugar in 1 part of hot water
• Keep the kneaded pollen substitute overnight for proper penetration of sugar in the mixture
• To make the feed more attractive to bees, add 20 ml “dark rum” to 400 g of substitute before feeding
• Fill 400g of this substitute in the frame and give one frame each to needy colony using frame feeding method (Fig. 12.4)
• Also try feeding this substitute by wrapping it in butter paper and placing on top bars after making few punctures in the butter paper (Fig. 12.3).

Figure 12.3 Pollen substitute patty wrapped in butter paper and top bar feeding method

Figure 12.4 Frame feeding method of pollen substitute

Pollen supplement: Pollen supplement in addition to other components also contains pollen. It is readily accepted by bees.

Preparation of pollen supplement: To prepare pollen supplement mix 1 part of pollen in 3 parts of fat free soy flour and 2 parts of sugar syrup (prepared by dissolving 2 parts of sugar in 1 part of hot water). This is fed to the bees in a similar manner as described for pollen substitute.

Precaution: Pollen substitute or supplement should be fed only during dearth period when pollen is not available or during spring when colony demand for pollen is more for brood rearing as compared to available pollen.

QUEEN MANAGEMENT

Qualities of a good queen:

- Good young mated queen (Fig. 12.5), has a gently tapering large abdomen full along the sides as compared to failing old queen (Fig. 12.6). Unmated queen is small in size (Fig. 12.7)
- Evenly coloured and large thorax
- Good egg laying capacity; lays single egg in the exact centre of the cell bottom which are slanted in the same direction (Fig. 12.8). In failing queen, there is uncontrolled egg laying and resultant brood is patchy (Fig. 12.9). Laying workers on the other hand lay many eggs in each cell (Fig. 12.10)
- Eggs are laid symmetrically, starting above the centre of combs and spreading out in all directions
- Combs are well occupied with concentric circle of brood of identical age.

Fig. 12.5 Good queen

Fig. 12.6 Old failing queen

Fig. 12.7 Unmated queen

Queen can also be judged from the behaviour of its progeny:
- Good honey producer.
- Less swarming instinct of the colony.
- Workers gentle in temperament.

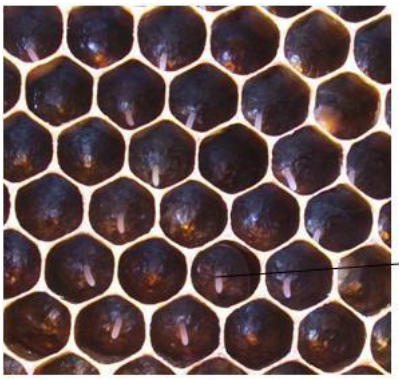

Figure 12.8 Eggs laid by a good queen

Figure 12.9: Failing queen and patchy brood pattern: Observe uncontrolled laying

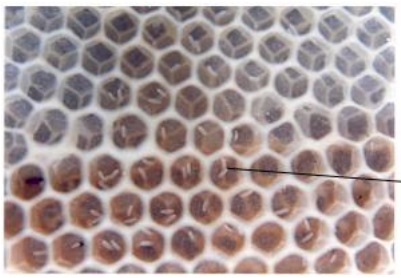

Figure 12.10 Multiple egg laying by laying workers

When to replace the queen? Replace the poor queen whenever it is found (not on yearly basis), if reserve queens are available. Otherwise replace poor queen either during early spring or during fall.

Re-queening/Queen introduction:
- To introduce a queen in a queen less colony, it is caged along with 5-10 attendant workers in a queen cage and is suspended in between the frames. The queen is released after one day.
- Young queens can easily be introduced during a nectar flow in spring or late in fall when egg laying is minimum.
- It is advised that a beekeeper should have some queens in the nucleus hives as reserve queens for replacing as and when need arises (at least 10 queens per 100 bee colonies).

LECTURE 13

MANIPULATIONS FOR HONEY PRODUCTION

DIFFERENT MANIPULATIONS

An understanding of all the seasonal and miscellaneous management practices described under different chapters is required for manipulation of bee colonies for honey production. However, additional information is required for the commercial beekeepers to fully exploit the bee colonies for increased honey production.

1.Use of queen excluder
2.Use of good combs
3.Preventing bee losses
4. Selective breeding
5.Bee forage management
6. Adoption of scientific migratory beekeeping

1.Use of queen excluder:
To get quality honey, it is recommended to use queen excluder (Fig. 13.1 and 13.2) to get super combs without brood. If queen excluder is not used, the queen moves to the super chamber to lay eggs. Honey should be extracted only from the supers and stores in brood chamber should be left for the colony.

Figure 13.1 Queen excluder placed over brood chamber

Figure 13.2 Super placed on queen excluder

2. Use of good combs:
It is important to secure good combs for use in the bee colonies to increase their efficiency and quality of produce. Honey stored in old and dark combs becomes darker. Combs older than 3-4 years should be discarded. Best time to raise combs is during honey flow when the bees construct comb fully from top to bottom bar. Poor combs should be removed as and

when found. In older combs even queens are reluctant to lay eggs. There are reports which indicate that continuous use of combs for brood rearing results in reduction of cell size which in turn affects the bee size.

3. Preventing bee losses:
Large number of bees dies due to indiscriminate use of pesticides on the crops. Poisoning of bees occurs due to following reasons:
• Most bee poisoning occurs when insecticides are applied to crops during the blooming period.
• By drifting of toxic pesticides onto adjoining crops or weeds that are in bloom.
• Contamination of flowering cover crops when orchards are sprayed.
• Insecticidal dusts adhere to foraging bees and ultimately become packed with the pollen onto the hind legs. Insecticides Penncap-M and Sevin are especially dangerous because they may be stored with pollen and kill newly emerged workers the following season.
• Bees drinking or touching contaminated water on foliage or flowers.
• Bees collecting contaminated pollen or nectar.

Symptoms of bee poisoning
• Large number of dead bees in front of hive:
o 100 bees /day normal death rate
o 200-400 /day low death rate
o 500-1000/day medium death rate
o over 1000/day high death rate
• Bees also die in between field & hive
• Bees become paralytic; loose power of orientation
• Abdomen distended, tongue extended
• Bees become irritated and sting heavily
• Regurgitation of gut contents
• Brood chilling due to reduced bee population
• Queen may stop egg laying or lay in irregular pattern
• Longevity of adult bees reduced due to sub-lethal doses

Prevention of bee losses
o Do not spray on blooming crops
o If necessary, spray only during early morning or late evening
o Use proper dosage and safe pesticides
o Avoid combination of pesticides
o Use safe formulations; fine sprays less toxic than coarse; wettable powder more hazardous than emulsifiable or water soluble concentrates
o If colonies are kept in the field for pollination, cover them with burlap cloth
o Ensure that there is no blooming cover crops in the crop to be sprayed
o Local bee keepers should be warned before application of pesticides
o Feed colonies with sugar and pollen/pollen substitute
o If poisoned pollen stored by bees, bees & brood may die even after pesticide application: remove combs with stored poisoned pollen & soak in water for few hours; wash by shaking
o Provide brood and bees to weak colonies

4. Use of selectively bred stock:
Selection of breeder colonies
Breeder colony represents the mother of queens to be raised. The welfare of a colony depends

on inherited and physical qualities of its queen because queen transmits to the colony all the characteristics pertaining to disease resistance, longevity, industry, temper, swarming tendency and even excellence in raising combs. Breeder colonies can be selected for:
o Increased honey production
o Fast spring build up
o Disease resistance
o Frugal and strong overwintering qualities
o Heat tolerance
o Good handling qualities or gentleness (With least sting attitude)

Different subspecies or the already existing bee stocks, form the gene pool for the bee breeder. From the existing stock desirable bees can be bred. Import of new germplasm is in no way substitute to selection programme. Further import of fresh germplasm may be of questionable benefit as it may have undesirable traits or may combine with existing stock to produce undesirable hybrids.

5. Bee forage management:
Bee forage management involves large scale plantations of forage for bees. But it is not economical to a beekeeper to plant forage exclusively for bees. However, plantation of bee forage having other multiple uses too can be undertaken under different programmes. Plantations made on waste lands and as roadside plantations as well as community forestry are some of the examples. Reports of flourishing apiculture after taking up roadside plantations, under social forestry and community plantations in different countries like China, India, Nepal etc. point out to the success of increasing bee forage.

The bee forage which is selected for large scale plantations should have some desired qualities like:
• Long blooming period
• High density
• Good nectar quality having high sugar concentration etc.

In addition to these qualities, if the desired forage is to be planted as food source for dearth period in an area, then it should bloom during that period only. However, if the selected area in general is poor in terms of bee flora, the floral plants to be planted should bloom for most of the period for which different plants having different period of bloom can be selected.

6. Adoption of scientific migratory beekeeping:

To overcome limits of carrying capacity of different areas, beekeepers migrate their colonies to different potential areas. Thus migratory beekeeping is taken by beekeepers to exploit different honey flow sources or even for providing bee colonies for pollination on rental basis to the orchardists. In India, the commercial beekeeping is at present based on exploiting only honey flow sources and to a limited extent for pollination of apple (restricted to Himachal Pradesh). Colonies are rented out for pollination @ Rs 600-700 per colony for flowering duration of the crop.

Benefits of migratory beekeeping
• The income of beekeepers that migrate their colonies increases more than three times than those who practice stationary beekeeping.
• Due to migratory beekeeping natural resources in the form of nectar and pollen are utilized

which otherwise are going waste.
• Migratory beekeeping provides free ecosystem service in terms of pollination of variety of wild and cultivated plant species of the area.
• Beekeepers taking up stationary beekeeping have to bear lot of cost in feeding and packing of bee colonies which is also saved in migratory beekeeping.

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LECTURE 14

ECONOMICS OF BEE KEEPING

After going through different aspects of beekeeping including seasonal management, it is important to work out the economics of this enterprise if one goes for commercial bee keeping. It requires information of expenditure and income from a unit of an apiary. For commercial bee keeping it is recommended that one should start with minimum of 100 bee colonies. Details of expenditure and income are given below:

Expenditure for 100 *Apismellifera* bee colonies

NON RECURRING

	Number	Rate/unit	Total amount (Rs)
Bee hives	**100**	**Rs 2200/hive**	**2, 20,000.00**
Bee colonies	100	Rs 350/frame x 4	1, 40,000.00
Honey extractor	1	Rs 2500/-	2,500.00
Smoker, bee veil, Hive tool etc	1 set	Rs 500/-	500.00
Miscellaneous (honey cans, mating nuclei etc)	-	Rs 7000/-	7,000.00
Total			**3,70,000.00 (A)**

RECURRING (per year)
a) For stationary beekeeping

Labour (full time)	1	Rs 3900/month	46,800.00
Comb foundation sheets	1000	Rs 20/sheet	20,000.00
Sugar for feeding	500 kg	Rs36/kg	18,000.00
Chemicals for pest control	-	Rs 20/colony	2,000.00
Miscellaneous	-	-	2,000.00
Total			**88,800.00 (B)**

b) For migratory beekeeping

Transportation	**No. of trips**	**cost per trip**	**Total**
Truck	4	Rs 2500/trip	10,000.00
Total cost (a + b)			**98,800.00 (C)**

DETAILS OF EXPENSES

a) Stationary beekeeping:

Interest on non-recurring cost @15%	55,500.00
Recurring cost (B)	88,800.00
Interest on recurring for 6 months @15%	6,660.00
Depreciation on permanent articles except bees @ 10%	23,000.00
Total	**1,73,960.00 (D)**

b) Migratory beekeeping:

Commodity	**No/average**	**Quantity**	**Rate**	**Amount**
Honey	35kg/colony	3500 kg	Rs80/kg	2,80,000.00
Sale of divided colonies	40 % colonies	40 colonies	Rs1400/colony	56,000.00
Beeswax	2% of honey produced	70 kg	Rs200/kg	14,000.00
Commercial queen production(two breeding seasons)	from 10% colonies	200 queens	Rs400/queen	80,000.00
Total				**4,30,000.00(G)**

NET INCOME
Stationary beekeeping (F-D) 214000-173960= Rs 40,040.00
Migratory beekeeping (G-E) 430000-184710=Rs 2, 45,290.00
ADDITIONAL BENEFITS
Increase in crop yield
Boost for employment in bee equipment related industry

ECONOMICS IF LOAN TAKEN FROM BANK FOR PURCHASE OF NON-RECURRING ITEMS (migratory bee keeping)

Years after start of bee keeping

	I	**II**	**III**	**IV**	**V**	**VI**
a. Income	430000	430000	430000	430000	430000	430000
b. Annual reducing interest on non recurring (expenditure @ 15% after payment of bank installment)	55500 (on 370000 as in A)	43500 (on 370000-80000)	31500 (on 370000-160000)	19500 (on 370000-240000)	7500 (on 370000-320000)	nil
c. Bank installment (on principal amount as per A)	80000	80000	80000	80000	50000	nil
d. Recurring cost & interest on recurring & depreciation	129210	129210	129210	129210	129210	129210
Net income a-(b+c+d)	**165290**	**177290**	**189290**	**201290**	**243290**	**300790**

LECTURE 15

QUEEN REARING

INTRODUCTION TO QUEEN REARING

In a normal bee colony, there is only one queen and raising of new queens is inhibited by pheromones secreted by the queen. Mated queen inhibits queen raising by workers only if it is able to move freely over brood area by distributing a pheromone from its tarsi on the combs by foot pads

• This pheromone in combination with secretions from mandibular glands inhibits raising of queen cells. When used alone, neither of these secretions inhibits construction of queen cups
• Natural periods for colony to rear queens attributed to inadequate queen movement over brood area
• Crowding of workers restricts queen movement.

Under natural conditions bee colonies raise queen cells during:

• Swarming period
• If queen becomes inefficient (due to old age, injury or disease)
• If a colony becomes queen less.

Production of queen
Queen rearing can be taken up during the periods when the queens are raised naturally. For quality queen production there should be abundance of drones for mating and plenty of floral sources for bees to collect nectar and pollen.

• Spare queen cells produced during swarming season can be used but the colonies raised from these queens may have more swarming instinct, hence generally discouraged.
• Few queen cells can be raised by removing the queen from a strong colony making it queen less
• For large number of queen cells: Doolittle (1889) method of queen rearing is used which involves transfer of young larvae from worker cells to artificial queen cups by grafting

MASS QUEEN REARING

How to proceed for mass queen rearing:
Queen transmits to the colony all the important characters like longevity, disease resistance, temperament, swarming tendency etc. Hence, selection of a breeder colony (colony providing brood for grafting and raising quality queens) is made on the basis of progeny potential of such queens like increased honey production and other characters. For selecting breeder colony, best performing colony in the apiary is marked and brood from this colony is used for raising quality queens.

Pre-requisites to produce good queens
• Presence of well fed larvae (24 h old or younger)
• Strong cell builder colonies to provide surplus royal jelly and proper care for queen cells
• Large number of mature drones of desired stock near queen mating yard
• Stimulation of cell builder colony by constant feeding during development period
• Nucleus of adequate strength to keep ripe cell (matured queen cells) warm and proper care of emerging queen.
Requirements: Queen cell forming rod, grafting needle, beeswax, oven, bee colonies, queen cell protector, queen cell holding frames and queen storage frames, sugar, candy, feeders.

Controlled queen rearing
• Preparation of queen cups: Cell forming rod of 7.5 cm length, tapering from 9.4 mm diameter at 12.5 mm from the tip to a diameter of 6.25 to 7.8 mm at tip
• Prepare queen cups using molten beeswax, having diameter of 9 to 10 mm and 11 to 12 mm in length for mass queen rearing of *A. mellifera* . The cup size will be different for *A. cerana* queen rearing
• Cell builder colony: colony managed to rear queen cells. Select a strong colony with young bees having access to stored or fresh pollen. Feed continuously using friction- pail feeders.
• Strength of cell builder colony should be more than 20000 worker bees (one frame full of bees has about 1600 number of bees)
• The colony should have nine combs containing sealed brood, honey and plenty of pollen with 2 combs of young brood in the centre, next to where queen cups are to be placed
• Breeder queens: it represents the selected stock of mother queens from which new queens are to be reared.
Basic grafting
• Grafting is best done inside a building under bright light preferably at temperature of 30°C and 60-70 per cent relative humidity. Items required are:
– bars of cell cups (Fig. 15.1a)
– a grafting needle (Fig. 15.1b)
– frame containing (frame marked after egg laying by queen) 12-24 h old brood
– royal jelly in case of wet grafting
• In dry grafting there is no need of priming the cells with royal jelly
• In wet grafting, a drop of royal jelly (1:1 diluted with water) is placed in queen cup before grafting

Figure 15.1 (a to c) Grafting of larvae in queen cups

Figure 15.2 Accepted queen cells after 24hours of grafting

• Young larvae from the selected breeder stock (from best performing colony in an apiary) are picked up with a grafting needle from (Fig. 15.1a-c) the brood comb.
• The grafting needle is moved down from the side of the comb cell and as it reaches under the "c" larva, it is moved up with the larva on its tip.
• This larva from the grafting needle is then dislodged at the bottom of queen cup attached on the bars without changing its position (15.1c).
• In this way 15 to 30 queen cups can be grafted with larvae and once grafting is complete, the frame with grafted cells is immediately moved to cell builder colony.

Figure 15.3 Sealed queen cells

Figure 15.4 Protected sealed queen cells

Figure 15.5 Queens in mating nuclei kept for mating

Management of cell builder colonies

• Cell builder colony needs proper management and same colony can be used to rear queen cells during entire season
• Cell builder colony is made queen less by removing its queen. Grafted cells are accepted (Fig. 15.2) within few hours after making it queen less ; better acceptance if dequeened in morning and first lot of cells given in afternoon or next day
• This colony being queen less needs sealed brood or nurse bees to maintain sufficient population. For this purpose two frames of brood (1 with uncapped cells) are sufficient which should replace 2 brood less combs
• Frame containing grafted queen cups is placed in the centre of cell builder colony and workers start raising queen cells once accepted by them (Fig. 15.2)
• Destroy any queen cell reared on other brood combs, since these queen cells are not from selected stock.
• On 10th day after grafting: shift finished queen cells (Fig. 15.3) to individual queen mating

nucleus or use queen cell protectors (Fig. 15.4) to prevent cell destruction by any of the emerging queens
• Mating nuclei can be baby nuclei (Fig. 15.5) or large 2-3 frame full depth nuclei. However, generally baby nuclei are preferred by breeders as these are easy to feed, easier to stock and easier to find mated queen.

Mating of queens
• Mating nuclei are placed in mating yard having ample mature drones from selected colonies (better performing colonies)
• Young queen mates after 5 to 10 days of emergence during mating flights in the open air with a number of drones in drone congregation areas (areas having hundreds of drones)
• Queen starts laying after 7-10 days of mating and is ready for further use.

Transportation/Mailing of queens
After successful mating of the queens, these can be transported in mailing queen cages
• Standard wooden mailing cages are used for mailing
• One end of each queen cage is provisioned with candy. The mated queen is placed in this cage with 3-4 attendant worker bees
• Queens can be transported to long distances in these mailing cages
• In many advance countries, queens are even mailed as parcels in queen mailing cages through department of posts.

Preparation of honey-sugar candy: 0.568 litre (800 g) honey & 1.82 kg sugar (1:2.27 w/w mixtures). Prepared by warming honey to 65.6^{o}C, adding powdered sugar with continuous stirring and then kneading the mass produced. This candy can be fed to the bees when queen is transported in mailing cage or introduced in to a new colony.

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LECTURE 16

FAMILIARIZATION WITH ENEMIES OF HONEY BEES AND THEIR CONTROL

PREDATORY WASPS

Honey bee colonies are attacked by a large number of enemies. For efficient management, the colonies require appropriate protection from these enemies. It is important to understand nature and extent of damage caused by the bee enemies and how to prevent and control them? Some of the important enemies requiring regular attention of a beekeeper are described below.

1. Predatory wasps:

***Vespa velutina* (*V. auraria*) Nests on tree tops/buildings**
***Vespa magnifica* Under-ground nest.**
***Vespa tropica* (*V. cincta*) Underground nest.**
***Vespa basalis* Nest on tree top/buildings.**

Figure 16.1 *Vespa auraria* at hive entrance to attack bees. Note clustering of bees at entrance as a protective measure

Figure 16.2 *Vespa magnifica* Note large number of slaughtered bees at hive entrance

Figure 16.3 Severe attack of *Vespa basalis* at the hive entrance of *A. cerana*.

Nature of damage:

- The wasps catch the bees at hive entrance and kill them (Fig. 16.1)
- Most serious damage in hills is caused by *V. magnifica* which cuts down bees in large number while sitting or flying at/near hive entrance (Fig. 16.2)

- Sometimes even *V. basalis* has been found causing severe damage to the colonies (Fig. 16.3)
- The weak colonies may even perish due to its attack.

Prevention and control:

- Kill the fecunded females visiting the apiary during spring by flapping
- Burn the nests during night time
- In fire prone places destroy the nests by spraying them with strong insecticidal solution.
- Kill the wasps in the apiary by flapping.

WAX MOTH

Figure 16.4 Larvae of *Galleria mellonella* exposed from the galleries

Figure 16.5 Damage of comb by larvae of wax moth

Wax moth (*Galleria mellonella*)
Nature and extent of damage:
- The attack is more prevalent during monsoon
- The wax moth larvae (Fig. 16.4) tunnel through the mid ribs of the comb (Fig. 16.5) and there is presence of small mass of minute wax particles outside the tunnels

- In case of severe infestation, further brood rearing is stopped; bees stop field work and colony may abscond.

Prevention and control:
- Close cracks and crevices in the hive. Reduce hive entrance
- Remove combs not covered by bees. Keep the bottom board clean.

Control in storage: Keep spare combs in empty hive bodies in tiers and close both at bottom and top. Disinfect the stack by burning sulphur @ 180 g/ cubic metre (fumigation by sulphur fumes). After fumigation, put naphthalene flakes in moth proof stacks.

ECTOPARASITIC MITES

In India, ectoparasitic mites *Varroa destructor* and *Tropilaelapsclareae* are causing severe damage to *A. mellifera* colonies. However, no damage in *A. cerana* colonies due to these mites has been reported.

Nature of damage:
i)*Tropilaelapsclareae:* This mite feeds only on bee brood. In case of severe infestation of this mite dead brood is thrown outside the hive by workers. The bee colonies may even abscond if control measures are not adopted. The diagnostic symptoms are:
- irregular brood pattern
- perforated brood capping
- dead or malformed wingless bees at the hive's entrance
- fast running small brownish mites can also be seen on the infected brood frame.

ii) *Varroa mite*:

Figure 16.6 Uncapped pupal brood due to attack of *Varroa destructor* (Photograph by Dr B S Rana)

Figure 16.7 *Varroa destructor* on a adult bee (Photograph by Dr B S Rana)

Figure 16.8 *Varroa destructor* **on a bee pupa** (Photograph by Dr B S Rana)

- This mite develops and reproduces in the sealed brood cells of honey bees (Fig. 16.6) feeding on haemolymph of bee pupa (Fig. 16.8). Parasitized individual may die or develop into deformed, weak individual incapable of normal functioning
- This mite has caused heavy losses to *A. mellifera* colonies throughout the world as it reproduces both on drone and worker brood of this species. Although the native host of this mite is *A. cerana*, yet it is causing no serious damage to it. On *A. cerana* this mite reproduces only on drone brood and is unable to complete life cycle on worker brood due to slightly shorter developmental period
- In India, there was no serious damage in A. mellifera colonies till 2004 due to this mite though reported in 1988 on this species from Himachal. Serious infestation in A. mellifera was recorded in Gurdaspur, Amritsar and Hoshiarpur districts of Punjab in 2004 for the first time and now seriously affecting this bee all over India
- Now it is well known that the mite earlier referred to as *Varroajacobsoni* is in fact a species complex consisting of two species *V. jacobsoni* and *V. destructor*, each having several strains. Only two strains of *V. destructor* have become pest of *A. mellifera*

The symptoms of colony infestation with Varroa are:
- Spotty brood pattern (Fig. 16.6)
- Mite can be seen on adult bee's body (16.7) as mature female mite attaches to young adult bee and also feed on haemolyph till further reproduction in the brood cell
- Dead brood and malformed adult bees are seen near/around hive entrance
- Colonies become weak and wounds inflicted by mites make the bees more susceptible to bacterial and viral diseases.

Methods of Varroa mite detection:
- Open about 50 sealed brood cells and remove pupae using forceps and count number of mites in each cell and pupa
- To examine mites on adult bees, take about 100 bees from a colony in a wide mouthed bottle and sprinkle about 15 gram of finely powdered sugar and shake the container after closing its mouth. Fine sugar particles will dislodge the mites as these stick to mite foot pads and disable them to grip the bee body surface. Take a white paper sheet and release the contents over it. The adult bees will fly away whereas mites can be seen in the collected sugar powder. Count the number of mites
- Natural mite drop in 24 hours is also taken as assessment tool for mite infestation but for this purpose screened bottom boards (with 8 mesh wire screen) with sticky paper need to be inserted in the bee hives. A drop of more than 30 mites in 24 hours is considered high infestation and requires treatment of bee colony.

Control:
i. *Tropilaelapsclareae* : Sulphur dusting on top bars @ 200mg/frame
ii. *Varroa destructor*: Formic acid fumigation @ 50ml/hive in sponge pads covered with perforated polythene bags. Level of mite infestation can be kept low by putting sugar (finely powdered sugar) @ 30g/frame and then sweeping sugar down between the frame spaces using a bee brush.

OTHER BEE ENEMIES

4. Bee louse, *Braulacoeca*: Wingless fly found on thorax of bee and feeds by coming near mouth close to opening of salivary glands and take the available nourishment. It is not a serious pest.

5. Other enemies: Bird, bee eater, *Meropsorientalis* and king crow, *Dicrurus* sp. eat bees while they are flying. To control the menace, scare them away. Attack of ants can be controlled by making the hive ant proof by putting the legs of hive stand in pots containing water. Bears and pine martines are the mammals which attack the bees for honey and bees.

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LECTURE 17

FAMILIARIZATION WITH DISEASES OF HONEY BEES AND THEIR CONTROL

BEE DISEASES

Honey bees are attacked by a large number of diseases which are caused by different organisms including virus, bacteria, protozoan and mites both ectoparasitic and endoparasitic. The extent of damage varies from death of some brood or adults to complete loss of colonies. The disease spreads from one colony to other through different manipulations done in the apiary as well as through robber bees, swarms and drifting bees. Brief account of symptoms and control measures is given in the tabular form below which can also help in differentiating one disease from the other.

BEE DISEASES:

Brood diseases:

	American Foul Brood	**European Foul Brood**	**Sac Brood/Thai sac brood**
Causative Organism	*Paenibacillus larvae* (bacteria)	*Melissococcus pluton* (bacteria)	Virus (sac brood in *A. mellifera* and Thai sac brood in *A. cerana*
Time of death	Late larval or early pupal stage	Coiled larvae in unsealed cell (usually young unsealed larvae sometime older sealed larvae)	Late larval stage; (usually older sealed larvae sometimes young unsealed larvae)
Cappings	Sunken and punctured	Dead brood in uncapped stage	Capping removed or punctured often with two holes.
Colour of dead brood	Off white to light cream to brown; coffee brown to dark brown or almost black	Yellowish white to grey or dark brown, dark brown or almost black (Fig. 17.2) as compared to glittering white in case of normal brood (Fig. 17.1)	Straw coloured, starts darkening from head
Position of dead brood	Lying flat on cell base	Coiled, twisted or collapsed	Extended with head curled upright in cells (Fig. 17.3)
Consistency of dead brood	Sticky to ropy	Soft and gummy ; rarely sticky or ropy, granular	Sac like with watery content
Odour of dead brood	Glue pot, putrid faint	Slightly sour to penetratingly sour, Putrid fish	None to slightly sour; faint sour
Type of brood affected	Worker, rarely drone or queen	Worker, drone and queen	Worker only
Control	Terramycin @ 0.250 – 0.400g in 5lt sugar syrup feeding	Feed Terramycin @ 0.2g in 500ml conc. Sugar syrup	No effective cure

Figure 17.1 Healthy worker brood of *A. mellifera*
(Photograph by Dr B S Rana)

Figure 17.2 European foul brood disease in *A. mellifera*
(Photograph by Dr B S Rana)

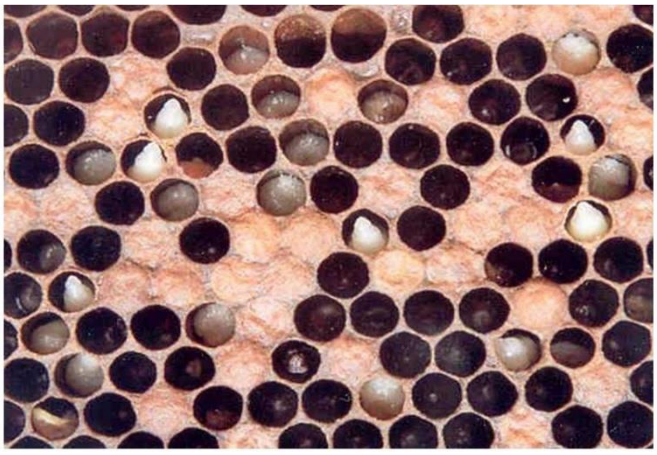

Figure 17.3 Sac brood disease in *A. mellifera* (Photograph by Dr B S Rana)

ADULT DISEASES

Adult diseases:

	Nosema disease	**Acarine disease**
Causative organism	*Nosemaapis*(protozoan)	*Acarapiswoodi* (Endoparasitic mite)
Symptoms	Infected bees collect in front of hive, sluggish, crawlers on leaf blades, distended abdomen, dysentric (Fig. 17.4)	Bees gather in front of hive as crawler bees and unable to fly; disjointed wings having typical 'k' wing condition
Control	Feed fumigillin 200 mg in sugar syrup to each colony or 0.5-3.0 mg in 100ml sugar syrup. or Two feedings at weekly intervalof Dependel-M @0.5g/litre/colony	Fumigate using folbex strips at weekly intervals or with formic acid (85%) @ 10ml/colony and replenish the quantity after every 24 h for 21 days

Figure 17.4 Symptoms of nosema disease in *A. cerana*
(Photograph by Dr B S Rana)

LECTURE 18

GLOSSARY

Apiculture	This is the science of beekeeping.
Absconding	It is desertion in which the whole colony leaves the hive.
Antenna cleaner	Basal part of basitarsus of prothoracic legs has a notch and a small lobe projects from distal end of tibia (tibial spur), used for cleaning antenna.
Apiary	Apiary is the place where the bee colonies are kept.
Bee pasture	Honey bees collect nectar and pollen from a variety of plants which are known as bee flora or bee forage or bee pasture or nectar and pollen plants.
Breeder colony	The selected stock of mother queens from which new queens are reared.
Brood	Developmental stages of honey bees before adult emergence (egg, larva and pupa)
Brood chamber	Chamber used for rearing of brood.
Build up period	Period of the year when the bees increase their population to the maximum
Cape bee	The only bee which can rear queen from eggs laid by workers (African subspecies, *Apismelliferacapensis*) .
Cavity nesting	Honey bees building many parallel combs in cavities of tree trunks, hollows of rocks, poles and other covered places
Cell builder colony	Colony managed to rear queen cells.
Comb	Made of hexagonal wax cells used to store honey and raise brood.
Corbicula	In worker bees, smooth somewhat concave outer surface of hind tibia is fringed with long curved hairs and forms pollen basket or corbicula.
Dances of honey bees	Method of communication among inmates of the hive through specific dances about volume of honey flow and place of source of nectar.
Dearth period	Period when there is scarcity of floral sources for the bees.
Division of labour	Well organized social groups and different members having specific duties in terms of nursing, comb building, guarding, food collection and its storage, egg laying etc.
Drone	Male honey bee derived from unfertilized egg.
Grafting	Removing a worker larva from its cell and grafting it in an artificial queen cup for queen rearing.
Hive bees	Honey bees which can be domesticated in hives.
Hive temperature	Maintenance of temperature in the brood nest of a colony at 32-35^{o}C
Honey flow period	The period when there is abundance of nectar secreting flora when the bee colonies have peaked their population and collect surplus honey
Honey stomach	Digestive system having oesophagus with expanded honey stomach which stores the collected nectar.

Hypopharyngeal glands	long coiled strings of small lobes known as hypopharyngeal glands present in the head , secrete glandular food known as royal jelly which is fed to queen and young larvae.
Killer bee	African subspecies which is very furious (*Apismelliferaadansonii*)
Laying workers	Worker bees which can lay eggs (In the absence of queen for a long duration, ovaries of some of the workers start developing and they lay eggs but since these are unfertilized, give rise to only drones).
Mating flight	Young queen goes out of the colony for mating with drones and these flight are the mating flights.
Migratory bee keeping	Shifting of bee colonies to flora rich belts.
Movable frame hive	Based on principle of bee space in which frames can be easily moved.
Open nesting	Honey bees building single comb attached to branches of trees or rocks or bushes in the open
Orientation flights	4 to 6 day old workers making flights around the hive for getting layout of the hive (play flights or orientation flights).
Pollen bees	All bees except honey bees which help in pollination.
Pollen substitute	Food to supplement pollen stores; does not contain pollen.
Pollen supplement	In addition to other components also contains pollen.
Principle of bee space	Optimum distance between two surfaces in a bee hive essential for normal movement and functioning of bees.
Queen	The only perfect female in a colony. She is the mother of whole colony and her function is only to lay eggs and is longest bee in a colony.
Queen substance	Pheromone, having 9-oxo-2-decenoic acid (9-ODA) from the queen bee which helps in the social organization.
Robbing	Stealing of food store by bees from other colonies.
Round dance	Dance is performed if food source is nearby.
Social insect	Insects having overlapping of many generations in the same nest, having division of labour and well developed communication system
Species and subspecies	Species are reproductively isolated from each other and these cannot interbreed where as subspecies are geographically isolated and can interbreed
Spermatheca	Sperms are stored in the reproductive system of the queen in a sac like structure known as spermatheca.
Spring dwindling	During spring old bees die which are normally replaced by young bees. If mortality of old bees exceeds the rate of emergence of young bees, the colonies show sign of dwindling which is known as spring dwindling.
Stimulatory feeding	Feeding of dilute sugar syrup to stimulate bee colonies during spring.
Sting	In worker bees, egg laying apparatus (ovipositor) is modified into sting. Queen uses ovipositor for egg laying and for stinging rival queen
Super	This is the chamber where bees store surplus honey.
Supersedure	Natural replacement of failing queen in a colony.
Supplementary feeding	Supplementing the food stores of bee colonies with sugar syrup and

	pollen substitute/pollen supplement.
Swarming	This is a natural division of colony in which some bees (may be half or more) leave the colony along with old queen.
Trophallaxis	Trophallaxisis food transmission (exchange of food) which is common between workers and also from workers to queen and drones.
Wag-tail dance	This type of dance is performed if food source is far away from the bee colony.
Wild honey bees	Honey bee species which cannot be domesticated in hives.
Winter packing	Protective covering provided to hive during winter.
Worker bee	Imperfect female which does the every work in a bee colony except laying fertilized eggs.

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