ENTO – 365: Management of Beneficial Insects (1+1 = 2)
Compiled by: Dr. R.M. Wadaskar,
Entomology Section, CoA, Nagpur

TEACHING SCHEDULE

THEORY

Lecture	Topic	Weightage (%)
1	Importance of beneficial insects in Agriculture, Honeybee, Silkworm, Lac insects, Bioagents as natural enemies, Various Institutes related to beneficial insects	20
2	**Apiculture**: Introduction and history of Beekeeping, Bee keeping, morphology and anatomy, bee biology, Pollinating plants and their cycle, bee conservation	
3	Commercial methods of bee rearing, equipments used, seasonal management of bees	
4	Bee hives and their description, Bee pasturage, bee foraging, behaviour and communication	
5	Enemies- Insect pests and diseases of honey bee and their management	
6	**Sericulture**: Related terminologies, History and development of silkworms in India, types of silkworm, voltinism and biology of silkworm	25
7	Mulberry cultivation, crop varieties, method of harvesting and preservation of mulberry leaves	
8	Rearing house and rearing appliances of mulberry silkworm, methods of disinfection and hygiene	
9	Silkworm rearing, mounting, harvesting and marketing of cocoons	
10	Pest and diseases of silkworm and their management	
11	**Lac culture**: Species of lac insect, morphology, biology, behaviour, host plants	10
12	Lac production and its uses, Types of lac- seed lac, button lac, shellac, and lac-products	

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Lecture	Topic	Weightage (%)
13	**Biocontrol agents** (Natural Enemies): Introduction of bioagents, Ideal characteristics of bioagents, Successful examples of biological control	25
14	General classification: Important insect orders bearing predators, and parasitoids used in pest control. Identification of major parasitoids and predators commonly used in biological control of crop pests.	
15	Major parasitoids: *Trichogramma sp., Chelonus blackburni, Cotesia (Apanteles) sp., Bracon sp., Epiricania melanoleuca*, *Goniozus nephantidis, Campoletis chloridae,* Major predators: *Chrysoperla* sp., Australian lady bird beetle-*Cryptolaemus* montrouzieri, Weed killers: *Zygogramma bicolorata*, *Neochetina* spp.	15
16	Mass multiplication and field release techniques of some important parasitoids: *T. chilonis, Chelonus blackburni, Cotesia / Bracon, Goniozus nephantidis, Epiricania melanoleuca*	
17	Mass multiplication and field release techniques of important predators: *Chrysoperla* sp., Australian lady bird beetle, Weed predators/killers: *Zygogramma bicolorata*, *Neochetina* sp.	
18	Important species of pollinator and scavengers with their importance	5
	Total	**100**

VARIOUS INSTITUTES RELATED TO BENEFICIAL INSECTS

1. The **Commonwealth Institute of Biological Control (CIBC)**, Indian Station was established in 1957 at Hebbal, Bangalore. The advent of CIBC marked the beginning of organized and systematic biological control research in India. During this period, our knowledge of natural enemies of crop pests and weeds increased manifold. CIBC Indian station was closed during 1987.

2. **All India Coordinated Research Project on Biological Control of Crop Pests and Weeds (AICRP-BC&W)**, which was launched in 1977 under the aegis of the Indian Council of Agricultural Research was shifted to the same campus in 1988. The centre was named as Biological Control Centre and the entire programme functioned under the administrative/financial control of the National Centre for Integrated Pest Management (NCIPM).
3. **National Centre for Integrated Pest Management (NCIPM)**, New Delhi established in 1988 is associated with achieving the goals of IPM by promoting environmentally sound IPM technologies. Centre strives for effective co-operation with All organisations in India for implementation of its programmes.
4. In the eighth five-year plan, the project was elevated to an independent **Project Directorate of Biological Control (PDBC)**, with its headquarters in Bangalore during 1993. PDBC was the nodal agency in the country that organizes biological control research at the national level with 16 centres spread across the country. The Directorate at Bangalore carried out basic research on the biosystematics of important groups of insect bioagents. The reference collection maintained at PDBC

5. During XIth plan, PDBC was upgraded as **National Bureau of Agriculturally Important Insects (NBAII)** located in Hebbal, Bangalore to act as a nodal agency for collection, characterization, documentation, conservation, exchange and utilization of agriculturally important insect resources (including mites and spiders) for sustainable agriculture.

6. In the twelfth five year plan the Bureau is now re-named as **National Bureau of Agricultural Insect Resources (NBAIR)** located in Hebbal, Bangalore and the bureau's Mandate is

- To act as a nodal agency for collection, characterization, documentation, conservation, exchange, research and utilization of agriculturally important insect resources (including mites, spiders and related arthropods) for sustainable agriculture.
- Capacity building, dissemination of technologies and forging linkages with stakeholders.
- On-farm validation of biocontrol strategies, forging linkages with commodity-based crop research institutes, AICRP/AINP and capacity building.

7. **Khadi & Village Industries Commission, Mumbai (KVIC)** with the inspiration of Rastrapita Mahatma Gandhi took the task of development of the beekeeping Industry with a view to uplift the financial status of people living in extremely interior rural areas by introducing and popularizing modern beekeeping.
8. KVIC in 1957 established **Central Bee Research & Training Institute** at Pune on 1 st Nov' 1962.
9. KVIC established a separate department namely **Directorate of Beekeeping** in Mumbai and **Central Bee Research & training Institute** at Pune and started beekeeping in modern and scientific way throughout the country
10. In view of the tremendous scope for increasing productivity due to cross pollination and increase in income through Apiculture, it was proposed to revive Beekeeping activity in the country, exponentially by pooling the resources of the Department of Agriculture and Cooperation with other organization, including private sector. Accordingly, the **National Bee Board,** New Delhi **(NBB)** was reconstituted in June, 2006. The main objective of the National Bee Board (NBB) is overall development of Beekeeping by promoting Scientific Beekeeping in India to increase the productivity of crops through pollination and increase the Honey production for increasing the income of the Beekeepers/ Farmers.

11. **Central Sericultural Research & Training Institute (CSRTI)**, Mysore, the pioneer research institution in the field of tropical sericulture, was established at Chennapattna in 1961 (During the course of development the Institute was shifted to Mysore in the year 1963).
12. **CSRTI** works under the administrative control of **Central Silk Board**, Bangalore (Ministry of Textiles, Government of India) for the overall development of silk industry in the country. Central Silk Board (CSB) is a statutory body established in 1948 by an Act of Parliament.
13. Lac merchants organized themselves into the Indian Lac Association for Research, On the suggestions of Lindsay- Harlow Committee constituted by the then Imperial Govt. of India under the aegis of which, the foundation stone of **Indian Lac Research Institute (ILRI)** was laid at Ranchi on September 20,1924.
14. Subsequently, the **Indian Lac Cess Committee (ILCC)** was constituted, which took over the reins of the ILRI on August 1, 1931. The ICAR took over the administrative control of the ILRI from April 1, 1966. This is one of the oldest Institutes within ICAR. The institutes mandate is to look after important issues related to all natural resins & gums of Indian origin. Accordingly ILRI has been renamed as **Indian Institute of Natural Resins and Gums (IINRG)**. The Institute is known by this name since Sept.20, 2007.

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IMPORTANCE OF HONEYBEE IN AGRICULTURE

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.

The science of rearing honey bees or beekeeping is known as **apiculture**.

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.

Even the most feared bee stings help in healing muscular pains, rheumatism, arthritis and reduction in cholesterol level.

Honey bees are admired for	**Beekeeping can be practiced as**
Their industriousness	An ideal hobby
Unity	Part-time business.
Self sacrifice	Full-time business.
Tolerance	
Division of labour	

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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 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 *Apis mellifera*.

This discovery was followed by subsequent innovations like comb foundation mill, honey extractor, smoker, etc., which helped in the development of modern beekeeping.

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 *Apis cerana* 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 Nagrota Bagwan (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.
- Dr. A.S. Atwal is referred as Father of Modern Bee keeping in India.

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GENERAL MORPHOLOGY

As per their food habits and social life of honey bees, body parts are modified in to three parts:

a. Head

b. Thorax

c. Abdomen

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.

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. 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.

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. 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 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 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.

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

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.

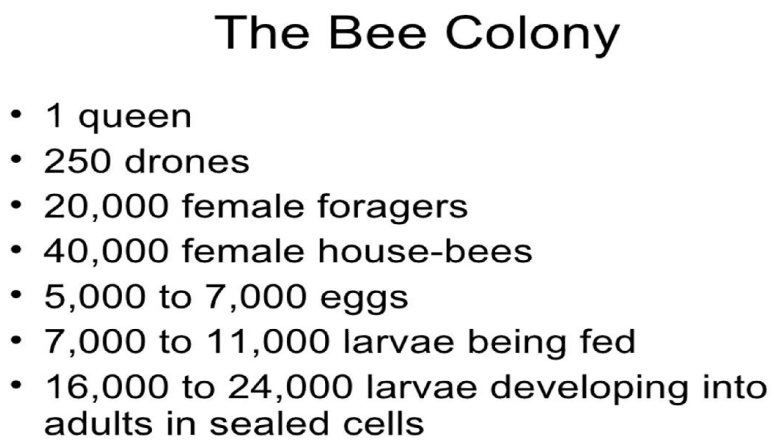
From honey stomach food goes to ventriculus through X shaped opening known as proventriculus, regulating passage of food to ventriculus. It removes pollen from nectar and nectar is retained in honey sac and pollen passes to ventriculus. Nectar is regurgitated in the comb cells for conversion into honey.

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.

Development of honey bees

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.



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HONEY BEE CASTES

Every honey bee colony comprises of a single queen, a few hundred drones and several thousand worker castes of honey bees. Queen is a fertile, functional female, worker is a sterile female and the drone is a male insect.

Duties of a queen:

1. The only individual which lays eggs in a colony .(Mother of all bees).
2. Lays upto 2000/day in *Apis mellifera*.
3. Five to Ten days after emergence, queen mates with drones in one or more nuptial flights.
4. When her spermatheca is filled with sperms, she will start laying eggs and will not mate any more.
5. Queen lives for 3 years.
6. The secretion from mandibular gland of the queen is called queen's substance. The queen substance if present in sufficient quantity performs following functions.

a) Prevent swarming and absconding of colonies.

b) Prevent development of ovary in workers.

c) Colony cohesion is maintained.

8. The queen can lay either fertilized or sterile eggs depending on the requirement.

Duties of a drone:

1. Their important duty is to fertilize the queen.
2. They also help in maintenance of hive temperature.
3. They cannot collect nectar/pollen and they do not possess a sting.

Duties of a worker:

1. Their adult life span of around 6 weeks can be divided into

a) First three weeks- house hold duty.

b) Rest of the life- out door duty.

House hold duty

a. Build comb with wax secretion from wax glands.

b. Feed the young larvae with royal jelly secreted from hypopharyngeal gland.

c. Feed older larvae with bee-bread (pollen + honey)

d. Feeding and attending queen.

e. Feeding drones.

f. Cleaning, ventilating and cooling the hive.

g. Guarding the hive.

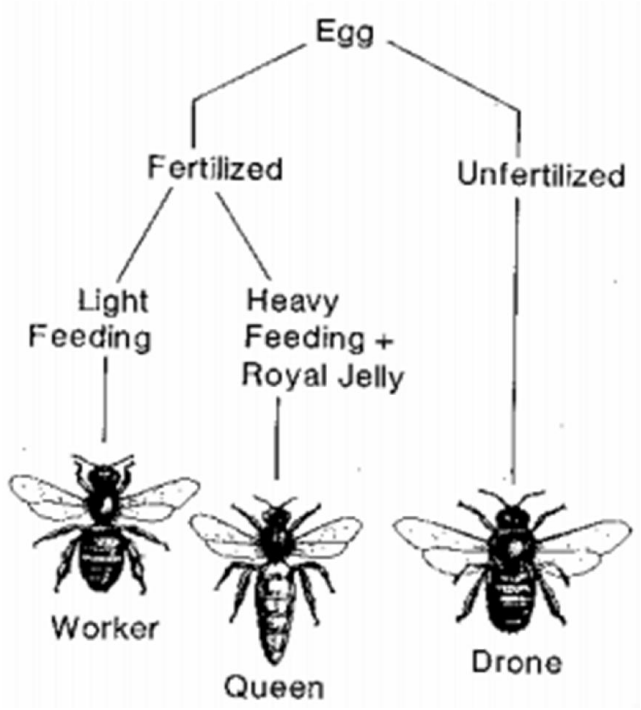
h. Evaporating nectar and storing honey.

Outdoor duties:

1. Collecting nectar, pollen, propolis and water.

2. Ripening honey in honey stomach.

SEX DIFFERENTIATION IN BEES:



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BEE PASTURAGE

Honey bees gather nectar and pollen from plants as their food.

Nectar: it is a sweet secretion from the floral buds and extra floral nectories of blossoms is the raw materials for honey.

Pollen: It is a highly proteinaceous food for the bees.

The plants that yield these two substances are collectively termed as 'bee pasturage', bee forage or 'nectar and pollen plants'. The days when a good number of plants have nectar to be foraged by bees is called a **'Honey flow period'.** If the nectar yield is abundant from a good number of plants of a particular species it is called a **"Major honey flow period**". When the amount of nectar to be collected is small the period is called a **Minor honey flow**. The days when there is no honey flow is called **"dearth period"**.

Bee pasturage/Florage: Plants that yield pollen/nectar to bees are called bee pasturage/florage.

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.

Plants which are good source of nectar:

1. Tamarind
2. Neem
3. Soapnut tree
4. Eucalyptus
5. Pungam
6. Moringa
7. Prosopis juliflora
8. Glyricidia maculata
9. Tribulus terrestris

Plants which are good source of pollen:

1. Sorghum
2. Maize
3. Millets like Bajra, Ragi
4. Roses
5. Pome granate
6. Sweet potato
7. Tobacco
8. Coconut
9. Castor
10. Date palm

Plants which are good source of Pollen and Nectar:

1. Banana
2. Citrus
3. Apple
4. Berries
5. Pear
6. Plum
7. Peach
8. Guava
9. Sunflower
10. Safflower
11. Mango

BEE BEHAVIOUR:

a) Swarming:

Swarming is a natural method of colony multiplication in which a part of the colony migrates to a new site to make a new colony. Swarming occurs when a colony builts up a considerable strength or when the queen's substance secreted by queen falls below a certain level. Swarming is a potent instinct in bees for dispersal and perpetuation of the species.

Steps involving in swarming

1. Strong colonies develop the instinct of swarming.
2. Development of drone brood and emergence of large number of drones is first sing of swarming.
3. New queen cells are built at the bottom of comb.
4. When the queen cells are sealed after pupation the old queen along with 1/3 rd or half colony strength moves out of the hive.
5. They first settle in a nearby bush and hang in a perdant cluster.
6. The scout bees go in search of appropriate place for colonization and later the entire colony moves to the suitable site.
7. The first swarm which comes of the parent colony with the old queen is called primary swarm.
8. The new queen which emerges kills all other stages of queen present inside the queen cell.
9. Sometimes the new queen is not allowed to destroy stages of other queens.
10. In this case the new queen leaves the hive along with a group of workers. This is called after swarm or cast.

Supersedure:

When a old queen is unable to lay sufficient eggs, she will be replaced or superseded by supersedure queen. Or when she runs out of spermathezoa in her supermatheca, and lays many unfertilized eggs from which only drones emerge. In this case, one or 2 queen cells are constructed in the middle of the comb and

not at the bottom. At a given time both new and old queens are seen simultaneously. Later the old queen disappears.

Emergency queen:

In the event of death of the queen the eggs (less than 2½ days old) in worker cells are selected and the cell extended like a queen cell. It is fed with abundant royal jelly and covered into queen. In this case many queen cells are built in the middle of the comb. The first queen which comes out of the emergency queen cells kills other stages of queen inside the cells and then go for mating. After mating they laying fertile eggs.

Laying workers:

In the event of loss of a queen and in the event of absence of worker eggs less than 2½ days old the chance of producing new queen is lost. In this case, the worker status laying eggs. Since the worker cannot mate, they lay unfertilized eggs. From these eggs only drones emerge. Moreover, a worker lays more than one egg per cell and there is competition among the larva, suited drones are produced.

Colony odour:

Every colony has a specific odour. This is brought about by scent fanning of secretion of **Vasanov** gland present in last abdominal segment of worker bees recognize colony odour and return to same hives.

Hive temperature maintenance:

It is brought about by fanning of wings in hot weather to reduce temperature. In cold weather they sit on the brood and prevent heat loss.

Division of labour:

Each and every caste of bees have their own role to play as described earlier. Queen controls colony with her queen's substance. The workers perform duty of guarding the hive by sitting at hive entrance and preventing and stinging intrudes.

Royal fidelity or Blossom faithfulness:

Bees restrict themselves to a single source of pollen and hectar until it is available. Only if the pollen and nectar from a plant species is exhausted they more to the next plant species.

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COMMUNICATION

Honey bees are among the fully social insects in a well organized colony 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 pattern of behavior in another organism

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

Father Spitzner in 1788 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, 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 Apiculture 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 forest 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. 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. 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 and if away from the sun, it performs downwards. If the food source is to the left of the sun the bees dance at an angle counterclockwise to the line of gravity whereas, if it is to the right of the sun the bees dance to the right of the line of gravity.

The distance of food source is indicated by the number of straight runs per 15 seconds:

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

ENEMIES OF HONEY BEES AND THEIR CONTROL

PESTS ASSOCIATED WITH BEES:

Honey bee colonies are attacked by a large number of enemies.

1. **Predatory wasps: Vespa sp.**

Nature of damage: Predation by *Vespa spp*. on commercial apiaries is generally a seasonal problem. most serious wasp invasions take place during the monsoon season, particularly from late June to August. Initially, a 'hunting phase' is observed, during which a few hornets capture and kill slow-flying bees one at a time, usually near the entrance of a weak colony's hive. Later, a 'slaughtering phase' sets in: some 20 to 30 hornets attack a weak colony en masse, to maul the bees and dropping the dead and dying bees to the ground. Finally, when this phase has continued long enough for the colony under attack to have lost most of its defender workers, the hornets invade the hive itself, the honey and brood nest and the wasps carry away any surplus brood to their nest. The weak colonies may even perish due to its attack.

Prevention and control: Bait-trapping can be employed by trapping them at the hive entrance and using protective screens. Kill the fecunded females visiting the apiary during spring by flapping. Locating hornet nests and destroying. 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.

2. **Wax moth (*Galleria mellonella*)**

Nature of damage:

The greater wax moth, is a major pest of *A. cerana*, often causing colonies to abscond. It is often reported to cause damage both to honey bee colonies and to bee products. The attack is more prevalent during monsoon. The adult female enters the hive at night, through the entrance or cracks in the walls, deposits her eggs directly onto the combs or in narrow crevices. The newly-hatched *Galleria* larvae feed on honey and pollen, and then burrow into pollen storage cells, later extending their tunnels to the midrib of the comb leaving behind a mass of webs and debris leading to the complete destruction of unattended combs. Empty combs, rendered wax,

comb foundation and bee collected pollen, if not properly stored and left unattended, almost always suffer considerable damage from wax-moth infestation. 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.

3. **Ectoparasitic Mites:** *Varroa destructor* and *Tropilaelapsclareae* are causing severe damage to *A. mellifera* colonies.

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.

The damage caused to colonies by Tropilaelaps infestation is similar to that brought about by varroa and the injuries inflicted on individual bees and bee brood are essentially the same.

ii) **Varroa mite:**

This mite develops and reproduces in the sealed brood cells of honey bees. Varroa causes injuries to honey bees by direct feeding. The adult female pierces the bees' soft intersegmental membrane with their pointed chelicera and sucks the bees haemolymph ('blood'). The adult bee, however, is only damaged if the infestation is severe. Varroasisis a brood disease. 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

- Now it is well known that the mite earlier referred to as *Varroa jacobsoni* 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.
- Mite can be seen on adult bee's body 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.
- Natural mite drop in 24 hours is also taken as assessment tool for mite infestation but for this purpose screened bottom boards 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. Formic acid can also be used.

ii. *Varroa destructor*: Among the commonly-used mite-control agents are organic acids, ethereal oils, synthetic pyrethroids and amitraz. 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.

4. **Bee louse:** *Braulacoeca* are 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. **Bee eater Bird:** *Merops orientalis* and king crow, *Dicrurus* sp. eat bees while they are flying. To control the menace, scare them away.
6. **Ants:** Red ants (*Oecophylla smaragdina*), and the black ant (*Monomorium indicum*) are among the most common predators of honey bees and will attack the hives taking virtually everything viz., dead or alive adult bees, the brood and honey. In addition to this destruction, they can also be a nuisance to beekeepers. Destroy ants' nests in the vicinity of the apiaries by burning. Attack of ants can be controlled by making the hive ant proof by putting the legs of hive stand in pots containing water.
7. **Mammals:** Bears and pine martines are the mammals which attack the bees for honey and bees.
8. **Amphibians**:

   Predation by Lizzards, toads, frogs on adult bees.

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.

LARVAL DISEASES

1. **American Foul Brood**

The most destructive microbial disease affecting bee brood. The disease is contagious and the disease will spread within the colony and can quickly spread to other colonies in the apiary.

Causative Organism: a spore-forming bacterium *Paenibacillus* larvae (bacteria)

Time of death: Late larval or early pupal stage, adult bees are safe from infection.

Cappings: Sunken and punctured. As the disease spreads within the colony, a scattered, irregular pattern of sealed and unsealed brood cells can be easily distinguished from the normal, compact pattern of healthy brood cells.

Colour of dead brood: Off white to light cream to brown; coffee brown to dark brown or almost black

Position of dead brood: Lying flat on cell base

Consistency of dead brood: Sticky to ropy

Odour of dead brood: Glue pot, putrid faint

Type of brood affected: Worker, rarely drone or queen

Control: Terramycin @ 0.250 – 0.400g in 5lt sugar syrup feeding. For American foulbrood infection hive materials belonging to the colony, are disinfected or destroyed by burning.

2. **European Foul Brood**

European foulbrood disease is not confined to Europe alone; the disease is found in all continents where *Apis mellifera* colonies are kept. It is generally considered less virulent than American foulbrood.

Causative Organism: *Melissococcus pluton (bacteria)* It is a Gram-positive bacterium and does not form spores.

Time of death: Coiled larvae in unsealed cell (usually young unsealed larvae sometime older sealed larvae). Younger honey bee larvae killed by EFB than those killed by AFB. The diseased larvae die when they are four to five days old.

Cappings: Dead brood in uncapped Stage

Colour of dead brood: Yellowish white to grey or dark brown, dark brown or almost black as compared to glittering white in case of normal brood

Position of dead brood: Coiled, twisted or collapsed

Consistency of dead brood: Soft and gummy; rarely sticky or ropy, granular

Odour of dead brood: Slightly sour to penetratingly sour, Putrid fish

Type of brood affected: Worker, drone and queen

Control: Feed Terramycin @ 0.2g in 500ml conc. Sugar syrup. By removing the most infested brood combs.

3. Sac Brood/Thai sac brood

Causative Organism: *Virus (sac brood in A. mellifera and Thai sac brood in A. cerana*). Sacbrood disease (caused by *Morator aetotulas*) is the most common viral disease of honey bees. Sacbrood disease affects the common honey bee *Apis mellifera* and the Asian hive bee *A. cerana*. Nurse bees are the vectors of the disease. Larvae are infected via brood-food gland secretions of worker bees.

Time of death: Late larval stage; (usually older sealed larvae sometimes young unsealed larvae)

Cappings: Capping removed or punctured often with two holes

Colour of dead brood: Straw coloured, starts darkening from head

Position of dead brood: Diseased larvae fail to pupate after four days; they remain stretched out on their backs within their cells extended with head curled upright in cells. Dead larvae remaining within their cells dry out to flat scales that adhere loosely to the cell floor.

Consistency of dead brood: The larvae skin is quite tough and its contents are watery; the infected larva thus has the appearance of a small, watery sac.

Odour of dead brood: None to slightly sour; faint sour

Type of brood affected: Worker only

Control: No effective cure

4. Chalkbrood disease (Ascosphaerosis)

Causative Organism: Fungus *Ascosphaera apis*. As its name implies, it affects honey bee brood. This fungus only forms spores during sexual reproduction. Infection by spores of the fungus is usually observed in three to four days old larvae. The spores are absorbed either via food or the body surface.

Type of brood affected: Infection by spores of the fungus is usually observed in larvae that is three to four days old. The spores are absorbed either via food or the body surface.

Colour of dead brood: Initially, the dead larvae swell to the size of the cell and are covered with the whitish mycelia of the fungus.

Consistency of dead brood: The dead larvae mummify, harden, shrink and appear chalklike. The colour of the dead larvae is white initially, then grey and finally, when the fruiting bodies are formed, black.

Control: The bees remove the infested brood with their hygiene behavior. Cleaning honey bees spread the spores within the colony by this behaviour. The beekeeper can stimulate the hygiene behaviour of the bees by changing the broodrearing conditions.

ADULT DISEASES:

1. **Nosema disease:**

Causative organism: *Nosema apis* (protozoan)

Symptoms: Nosema disease is regarded as one of the most destructive diseases of adult bees, affecting workers, queens and drones alike. Seriously affected worker bees are unable to fly and may gather in front of hive crawl at the hive entrance or stand trembling on top of the frames. The abdomen of an infected worker is swollen, dysentric and shiny in appearance.

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 interval of Dependel-M @ 0.5 g/L/colony. Nosema can best be controlled by keeping colonies as strong as possible

2. **Acarine disease/ Isle of wight:**

Causative organism: Honey bee tracheal mite *Acarapis woodi* (Endoparasitic mite)

Symptoms: Mites lives and reproduce in trachea. They pierce the tracheal wall and feed on body fluid. Infects worker drone and queen. Stage of infection is adult. Bees gather in front of hive as crawler bees and unable to fly; disjointed wings having typical 'k' wing condition.

Control: Destruction of affected 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.

3. **Colony colapse Disorder:**

Causative organism: Stress, Malnutrition, Pathogen, Genetically modified Crops

Symptoms: Worker bees disappear from the hive.

Place of infection: Colony

Stage infected: Worker bees

Control: Exact cause is not known.