ENTO-365 **Title: MANAGEMENT OF BEIFICIL INSECTS**

Introduction Beneficial insects provide regulating ecosystem services to agriculture such as Pollination and the natural regulation of plant pests. It aims to enhance insect-derived ecosystem services from a conservation perspective (i.e. enhancing beneficial insects in agricultural landscapes that provide ecosystem services to crops. Human cultures and civilizations have been maintained in countless ways through these beneficial insects, they regulate the pest population of many harmful pest species, produce natural products, and they also dispose the waste and recycle the organic nutrients. It should be consider in Thought that how much we depend on them for our survival and what kind of life would be without insects. Requirements for Enhancing Beneficial Insects The generalized intensification of agriculture and the use of broad-spectrum pesticides decrease the diversity of natural enemy populations and increase the likelihood of pest out breaks. Indeed, pesticide use has been shown to be associated with a large decrease in natural pest control services. Thus, enhancement of agro ecosystem appears to be one of the best ways in which we can decrease the use of chemical pesticides for pest and disease control. And it will increase the sustainability of crop production

1 . Role of Beneficial Insects As Pollinators: Insect pollinators are flower visiting Insects that forage on flowering plants to obtain plant-provided food (nectar, pollen). Flower-visiting insects have the potential to transfer male gametes (contained in pollen) to the female gametes while foraging, resulting in pollination. Insect-mediated pollination is an essential step in reproduction for the majority of the world'sflowering plants, including numerous cultivated plant species i.e. Sunflower, Cucurbitaceous vegetables, Alfalfa, Coriander, Cardmom, Gingelly, Apple etc. Many crops depend on pollination for seed production and fruit set to achieve good yield. Globally, an estimated 35% of crop production is a result of insect pollination. The Apis meliffera L. (European honey bee) is responsible for the pollination servicesin majority of crops. Non-Apis bees also are important pollinators of crops, especially for crops in which honey bees are inefficient pollinators (e.g. alfalfa, squash). A few non-Apis species are managed for crop pollination. Examples of managed non-Apis species include bumble bees, Bombus impatiens Cresson (Hymenoptera: Apidae) managed for cranberry (Vaccinium spp.) and greenhouse tomato (Solanum lycopersicum L.) pollination. Although bees are considered the most effective insect-pollinator of most plant species, other insects have been recognized for their contributions to pollination. Flower visiting flies (Diptera) have been documented as proficient pollinators of several crops including carrot (Dacus carota L.), mustard (Brassica spp.), leek, (Allium ampeloprasum L.), and almond (Prunis dulcis). Weevil Elaeidobius kamerunicus (Coleoptera: Curculionidae) plays great role in pollination of Oil palm. Fig wasps are responsible for the pollination in both Smyra and Capri Fig Plantation

2 . Natural Enemies: Insect predators and parasitoids that attack and feed on other insects, particularly on insect pests of plants are considered natural enemies. Through this type of feeding, natural enemies contribute to a type of pest regulation referred to as natural biological control. Natural enemies responsible nearby 33% of the natural pest control in cultivated

systems. Predaceous natural enemies belong to several insect orders and are generally characterized as free-living, mobile, larger than their insect prey, and are able consume several preys throughout their life cycle. But the parasitoids mainly belong to two orders Hymenoptera and Diptera, and their host ranges are considered to be more specialized than that of predator. Free-living adult parasitoids seek out a host, and depending on the parasitoid species, parasitize different life stages of their host (i.e. egg, larva, and pupa, adult). Parasitoids can lay an egg (solitary) or several eggs (gregarious) on or within their host and the immature parasitoid(s) feed on their host to complete development, kill their host, and emerge as free-living adult. In agricultural landscapes, natural enemies have the potential to prevent crop pests from reaching economically damaging levels (table-1). Predators and parasitoids can suppress or delay pest population growth by contributing to pest mortality that is most vulnerable to herbivores. When diverse populations of natural enemies are present, pest control became more effective due to differing phenology. Beyond natural biological control, natural enemies can be manipulated as part of integrated pest management programs through the importation and establishment of exotic natural enemy species (classical biological control), direct manipulation of populations (augmentative biological control), and, more pertinent to this research, through manipulation of their environment (conservation biological control)

3 . Weed Killers: So many insects feed upon unwanted weeds just the same manner they do with the cultivated crops. In many cases the occurrence of these insects has contributed much towards eradication of the weeds. Soil Builders: Insects which live in soil make tunnels, creating channels for smaller organisms, water, air, and roots to travel through. Insects improves soil aeration, and earthworm activity can enhance soil nutrient cycle, the soil physical properties, such as soil structure and tilth and activity of other beneficial soil organisms. Small Dung beetles makes tunnel walls with dung and also make dung balls that helps in maintaining the quality of the soil. Excreta of insets also enrich the soil. Examples- Beetles, Ants, Cut-worms, Larvae of flies, Crickets, Termites, Wasps etc Scavengers: Insects which feed on dead and decaying matter of plants and animals are called as scavengers. Insects (scavengers and decomposers) help in the biochemical cycling of the nutrients. Examples: Bark beetle, water scavenger beetle, Termites, Ants etc

4 Some Beneficial Insects and Their Pictures: i. Honey bee, ii. Silk worm larvae, iii. Lac insect, iv. Assassin bug, v. Hover fly, vi. Aphidius calamani, vii. Syrphid fly, viii. Zygogramma bicolorata, ix. Termites, x. Dragon fly, xi. Praying mantis, xii. Trichogramma sp., xiii. Damselfly, xiv. Coccinella sp., xv. Chrysoperla carnea.

Some Products from Beneficial Insects Production if Honey and Bee Wax: From thousands of year Apis meliffera L. (Honey bees) are important for gaining Honey and bee wax. And honey was the only sweetener, viscous fluid, produced by honeybees. It is collected from nectar from nectories at base flowers. Also collected from nectar secreted by plant parts other than flowers known as extra floral nectories. It is also collected from fruit juice, cane juice etc. In present, the developing markets are available for the other two products (Bee pollen and royal jelly) from

honey. The bee pollen collect by pollen trap from ingoing pollen foragers. It is rich protein source. Bee pollen is a "complete" and good supplement in diet. It is available in health food stores. The royal jelly is secreted by gland of nurse bees when the glands are fully active. It is very nutritious food and is fed to the young workers larvae and queen larvae and adult. Royal jelly is milky and light pale in color. And it is also a good ingredient of some expensive skin care products, which helps in reducing wrinkles and works as anti aging. Production of Silk: A unique natural fiber silk cloth, which usually derives from silkworm, Bombyx mori. This "domestic" silk is famous for its finishing and light colors. The silk can also harvest from the many other species e. i. Antherea spp., that found in the India, Japan and China's forests. The silk provided by willed spp e.i. Eri, Muga, Tussah and Yamamai are heavier and dark in color hence they are less valued than that of Bombyx mori. Silk can be dyed, spun, in to thread and woven in to fabric. Cloth of Silk is warm in winters, cool in summers, light in weight, and resistant to wrinkling. Production of shellac: laccifer lacca, is a scale insect that secret a hard encrustation over the body as a protective covering. It is of brown color usually and these insects grow on acacia trees in India and Burma. Scale insects present on twigs are heated to extract the resins and then purify. One gram of Lac is extracted from Up to 200 insects. In present the synthetic material such as Polyurethane and vinyl has been taken place of Lac, even after Lac is still in use as dyes, inks, polishes, sealing waxes, and as stiffening agents in the fabrication of felt hats. It is animal originated and commercial resin. Production of Cochineal: Cochineal pigments use in Painting: A scale insect Dacylopius coccus found in Mexico and Central America on prickly pear cacti. Cochineal pigment is extracted from these scale insects. For the first time it was used by Aztec Indians as medicines, body paints and as textile dye. The cochineal pigment was important for the intensity and permanency of colors. It was very costly because of its scarcity, so it was used in only the finest fabrics. Now a day's aniline dyes have taken place of Cochineal in textile industries which is very economic. But the cochineal pigment is still giving the colors in foods, beverages, cosmetics (lipsticks) and art product.

Table-1 Natural enemies and their use

Predator/ Parasitod	Group	Beneficial insect or Invertebrate	Pest attacked	Impact on pest
Predators	Beetles (Coleopter)	Ladybirds (Family Coccinellidae), Red and Blue beetles (Dicranolaius bellulus), Green carab beetles (Calosoma schayeri), Green soldier beetles (Chauliognathus pulchellus)	Aphids, mites, thrips, mealybugs, moth eggs including Heliothis spp. and larvae.	Able to handle a wide range of prey and are immediately effective. Some species (e.g. ladybirds) both the adult and larvae are predatory.
Predators	Bugs (Hemiptera)	Assassin bugs (Family Reduviidae), Bigeyed bugs (Geocoris lubra), brown smudge bugs (Deraeocoris signatus), Damsel bugs (Nabis kingbergii), glossy shield bug (Cermatulus nasalis), Pirate bug (Orius spp.), Apple dimple bug (Campylomma liebknectic), Spined predatory shield bug (Oechalia), Broken backed	Aphids, Diamondback moth, eggs of and larvae of Heliothis spp., cutworms (Spodoptera litura), false loopers	Pierces pest using mouthparts and then sucks out interior. Depending on the species of predatory bug, adults, larvae or eggs may be attacked

		bug (Taylorilygus pallidulus)		
Predators	Predatory Larvae	Hoverfly larvae (Family Syrphidae),	Aphids	Larvae spear aphids with jaws and suckout internal juices. Adult hoverfly are not predacious.
Predators	Mites (Acarina)	Predatory mites from different Familiese.g. Anystidae, Bdellidae, Erythraeida, Parasitidae and Cunaxidae	Blue Oat mite, Lucerne flea, Redlegged earth mite	)., Predacious on other mite species and Lucerne fleas (Sminthurus viridis)
Predators	Lacewings	Green (Mallada signatus) and brown Lacewings (Micromus tasmaniae)	Aphids, moth larvae and eggs, whitefly, thrips, mites and mealybugs.	Larvae insert jaws into softbodies insects and eggs and suck out contents. Larvae of both Brown and green lacewings are predatory. Adult brown lacewings feed on heliothis eggs and mites.
Predators	Spiders	Variety of species including wolfspiders, nightstalking spiders, orbweavers, tangle web spiders, flower spiders, jumping spiders and lynx spiders.	Predators or a range of insect pests	Pest species are consumed
Parasitoids	Aphid Parasitoids	Trioxys Complanatus, Aphidius ervi, Lysiphlebus testaceipes, Aphidius colemani	Aphids	Wasp inserts egg into aphid. The developing larvae eventually killing the aphid "mummy" as the adult wasp emerges.
Parasitoids	Caterpillar Parasitoids	Hymenoptera: Numerous parasitic wasps including Banded caterpillar parasite (Ichneumon promissorius), Two-toned caterpillar parasite (Heteropelma scaposum) (Family Ichneumonidae), Microplitis demolitor, Cotesia spp. (Family Braconidae)	Heliothis and other moth larvae	Female lays eggs in host pupae as the parisitoid larvae develop in the host it causes the death of the pupa.
Parasitoids	Caterpillar Parasitoids	Sorghum midge parasites (Eupelmus australiensis, Aprostocetus diplosidis, Tetrastichus spp.)	Sorghum midge	Wasp lays eggs in midge larvae and emerges at pupal stage.
Parasitoids	Caterpillar Parasitoids	Tachinid flies	Heliothis, looper, armyworm, grasshopper and other larvae	Female lays eggs in host pupae as the parisitoid larvae develop in the host it causes the death of the pupa.
Parasitoids	Helicoverpa Egg parasitoids	Hymenoptera: Trichogramma (Family Trichogrammatidae) and Telenomus (Family Scelionidae) egg parasitoids	Helicoverpa and other Lepidoptera	Tiny wasps that parasitise Lepidopteran
Parasitoids	Whitefly Parasitoids	Eretmocerus spp. and Encarsia spp. including Encarsia Formosa	Whitefly	Small parasitoid wasps that attack whitefly nymphs
Parasitoids	GVB egg Parasitoids	Trissolcus basalis	. Green vegetable bug	Small black wasp that parasitises GVB; doesn't distinguish

				between eggs of pests and beneficials and will also parasitise eggs of predatory shield bugs.

Table2.: Weed Killers

Weed	**Scientific name**	**Biotic agent / insects**
Prickly pear	*Opuntia dilleni*	*Dactylopius opuntiee*
Congress grass or Carrot weed	*Parthenium hysterophorus*	*Zygogramma bicolorata*
Lantana weed	*Lantana camara*	*Ophiomyia lantanae*
Siam weed	*Choromoloena odorata*	*Pariuchaetes pseudoinsulata*
Water fern	*Salvinia molesta*	*Cryptobagus singularis*

Table-3 Some insects and their products as medicine

Insects / insect products	**Uses**
Maggots	Wounds Healing
Honey	Wounds Healing, skin disease, infection
Bee Royal-jelly	Post Menopausal symptoms
Been and Ant venom	Joints pain
Bee Propolis	Infection
Canthiridine	Skin Diseases

Production of Tannic Acid: Tannic acid first produced by an abnormal pant growth found on oak trees in Asia known as Allepo gall. Tiny wasps (Family Cynipidae) secrete some chemical and in response of it the tree produces gall tissues. Tannic acid is a chemical compound used in the dying, in leather industries, for tanning and in the manufacture of some inks. It can also be extracted economically from Quebracho tree, hence there is no commercial market for oak gall is present today.

INTRODUCTION TO APICULTURE: IMPORTANCE AND HISTORY

Insects are dominant animals on this earth. Usually insects are considered harmful toman but hardly 1 per cent of insect species fall in the pest category. Benefits of insects inmaintaining economy outweigh the injury inflicted. Honey bees are one of the fewinsects 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 venomare also produced by honey bees.More than the producers of these hive products; bees play an important role inpollination of plants while collecting their food from flowers in the form of nectar andpollen.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 hybridizationand help sparse populations to survive. Their mutual dependency has resulted intogreat 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 industriousness,Unity,Self sacrifice,Tolerance,Division of labour ,Even the most feared bee stings help in healing muscular pains, rheumatism, arthritisand 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 onrocks and in traditional mud houses and this is still being followed by sometribes. There was no development in beekeeping until 16th century. Proper beekeeping started only when man started giving protection to colonies foundin the nature. Idea to keep bees in log hives has been reported to come from the fallen trees whichwere 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 notsuccessful because bees attached their combs together as well as to the walls of hiveand combs required had to be cut for honey.

- The discovery of the principle of bee space in 1851 by L. L. Langstroth in USAresulted 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 beekeepingwe see today.

Beekeeping in India

- In India first attempt to keep bees in movable frame hives was made in 1882 inBengal and then in 1883-84 in Punjab.

• In south India, Rev. Newton during 1911-1917 trained several beekeepers and deviseda hive for indigenous bee *Apiscerana* based on principle of bee space (which wasnamed after his name as "Newton hive").

• Beekeeping was also started in the Travancore state (now Cochin) in 1917 and inMysore in 1925.

• In Himachal Pradesh modern beekeeping with indigenous honey bee *A. cerana* startedin 1934 at Kullu and in 1936 at Kangra.

• The exotic bee *A. mellifera* was successfully introduced for the first time in India in1962 at NagrotaBagwan (then in Punjab state and now in Himachal Pradesh), becausethis bee has potentials to produce more honey.

• At present both the hive bee species are being used in modern beekeeping and lot ofhoney 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 thefour species of honey bees.

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

i. Rock bee, *Apis dorsata* F. ii. Little bee, *A. florea* F.iii. Asian bee, *A. cerana* F. iv. European bee, *A. mellifera* L.

Characteristics of four well known species of honey bees:

It is important to know difference between a species and subspecies. Species arereproductively isolated from each other and these cannot interbreed where as subspecies aregeographically 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 subspecies2. European subspecies3. 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. mellifera intermissa* (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 byworkers)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. Honeyyield from this species from stationary beekeeping varies from 10-15 kg/colony but throughmigration yield increases to 45-60 kg/colony. One beekeeper in Himachal has extracted asmuch as 110kg honey from a single colony of *A. mellifera* which is indicative of itspotentials.

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.

GENERAL MORPHOLOGY

In honey bees, body parts are modified as per their food habits and social life. Like anyinsect, body of honey bee can be distinguished in to three parts (Fig. 3.1):a. Headb. Thoraxc. Abdomen

HEAD

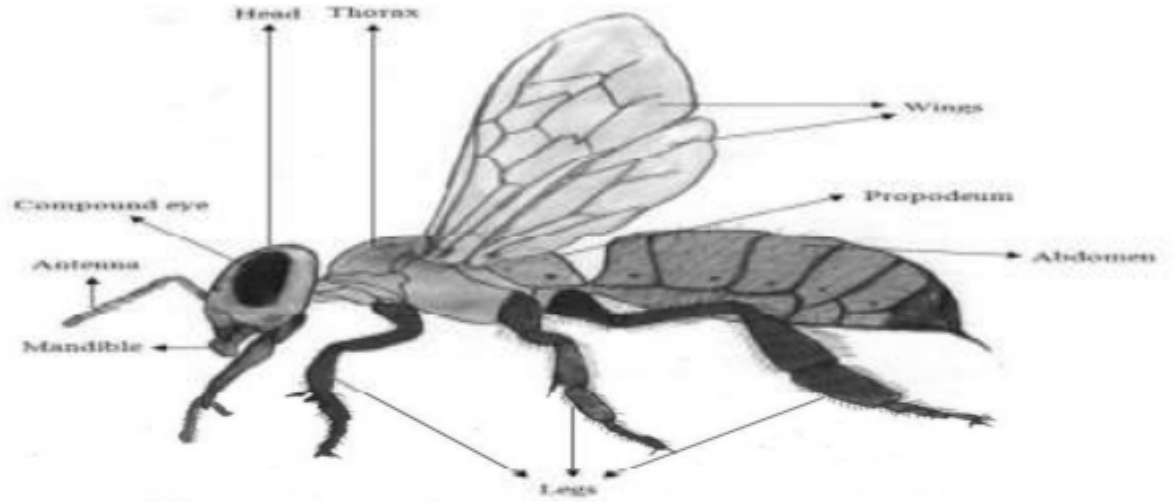


Figure 3.1 General morphology of a worker honey bee

Head Bears a pair of geniculate antennae, Two compound eyes on lateral side of head. Bees can distinguish different colours butare 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 inshape in three castes (Fig. 3.2). Workers use mandibles for grasping and scrappingpollen from anthers, feeding of pollen and in manipulation of wax scales during combbuilding.• Mouth parts of worker bees are modified for sucking and lapping (Fig. 3.3). Tongueor proboscis (formed by medium labium and two lateral maxillae) is used foringesting 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 hypopharyngealglands which secrete glandular food known as royal jelly that is fed to queen andyoung larvae.

THORAX

• It consists of three segments: prothorax ,mesotmhorax and metathorax, each bears apair of legs. Meso and metathorax, each bears a pair of wings (Fig. 3.5). Legs andwings are locomotory organs. In addition to locomotion legs in honey bees are alsomodified 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 thethree castes.• On mesothoracic legs, bushy tarsi serve as brushes for cleaning of thorax. Long spineat end of middle tibia (Fig. 3.4) is used for loosening pellets of pollen from pollenbasket of hind leg

and also for cleaning wings and spiracles. Wax scales are alsoremoved from wax pockets of abdomen by these legs.

Figure 3.2 Mandibles of different castes of honey bees

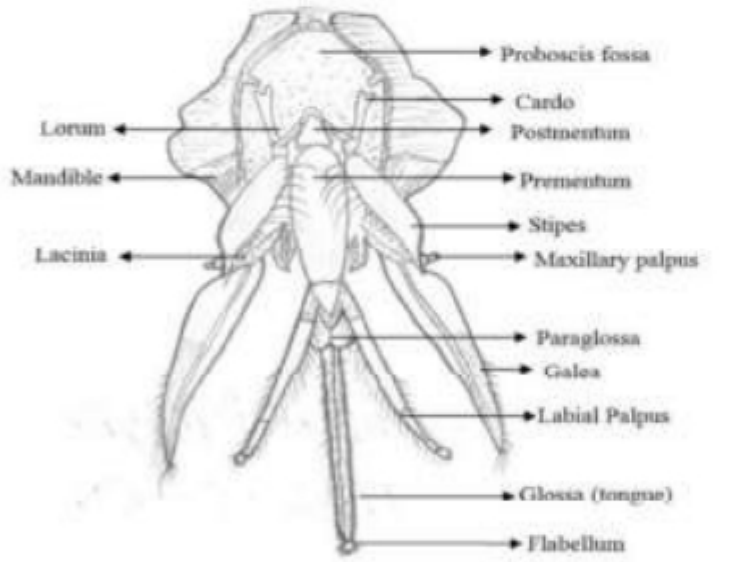


Figure 3.3 Mouth parts of a worker honey bee

• Hind or metathoracic legs differ from other legs in being larger in size and with broadflattened form of tibia and basitarsus. In worker bees, smooth somewhat concaveouter surface of hind tibia is fringed with long curved hairs and forms pollen basket orcorbicula (Fig. 3.4)• Two pairs of wings arise from sides of meso and metathorax. Fore wings are strongerthan hind wings. Series of upturned hooks (hamuli) are present on front margin ofeach hind wing. Decurved fold on rear margin of fore wing works as couplingapparatus for holding hamuli and this result in unity of action of the wings in flight.

ABDOMEN AND ANATOMICAL FEATURES

Abdomen:• First abdominal segment is united with the metathorax and forms anatomically a partof thorax known as propodeum• Bee larva has 10 abdominal segments but in adult workers abdomen appears 6segmented; segments 8-10 are reduced in size and first segment (propodeum) istransferred to thorax during pupal stage• Abdomen bears sting, wax glands (on sternites 4 to 7) and scent glands (on last twoterga) 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 stomachwhich stores the collected nectar (Fig. 3.6)• From honey stomach food goes to ventriculus through X shaped opening known asproventriculus, regulating passage of food to ventriculus. It removes pollen from nectar and nectar is retained in honey sac and pollen passes to ventriculus. Nectar isregurgitated in the comb cells for conversion into honey• Reproductive organs are fully developed in queen and drone but greatly reduced inworker.• Sperms are stored in the queen in a sac like structure known as spermatheca. Thestored sperms are utilized by queen throughout her life time as she does not go formating once starts egg laying.

STAGES OF DEVELOPMENT IN HONEY BEES

The way human beings undergo different life stages comprising of infant, child, adolescent& adult, each bee caste goes through four developmental stages viz. egg, larva, pupa andadult. But the time needed to complete each stage differs.

Let us learn The Life Cycle Stages of honey bees:

(i) Egg: Queen lays pearly white, slightly curved eggs in the cells singly and vertically withthe thin end attached to the bottom of the cell.Queen bee lays both fertilized (giving rise to females i.e. worker or queen bee) and unfertilized eggs (giving rise to males i.e. drone bees).The egg stage lasts for 3 days. At the start, the egg stands vertically on the base of the cell, then slants, and finally lies flat on the base before hatching.

(ii) Larva: Small, shiny white larvae hatch from the egg after 3 days.Initially the larvae are loop shaped lying on the bottom of the cell but towards cell capping, they get stretched on their back in the cell with head facing distal end of the cell.

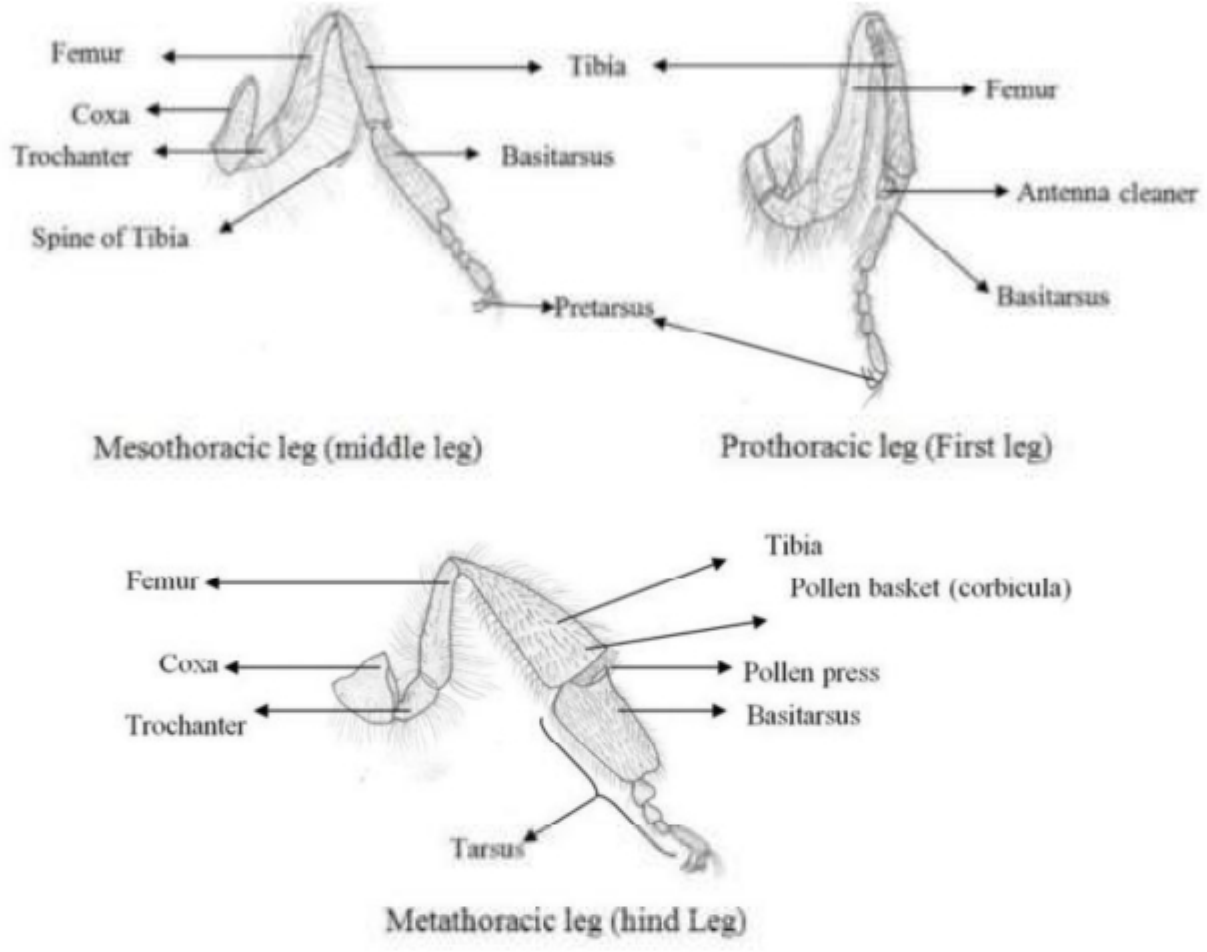


Figure 3.4 The legs of a worker honey bee

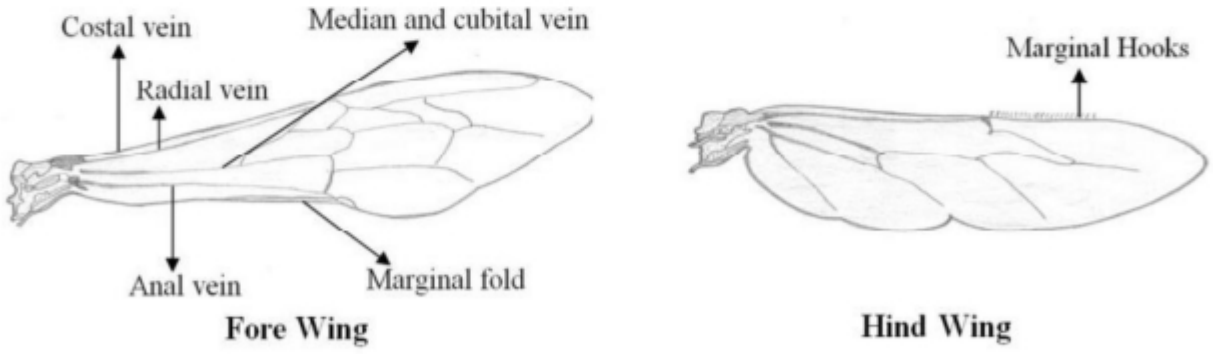


Figure 3.5 The wings of a worker honey bee

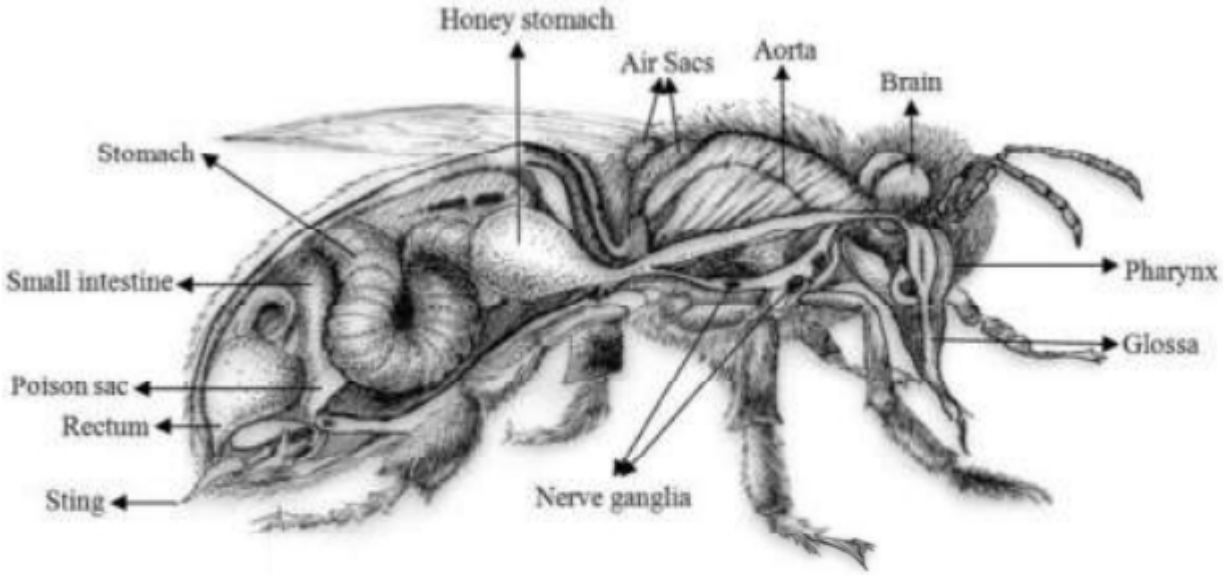


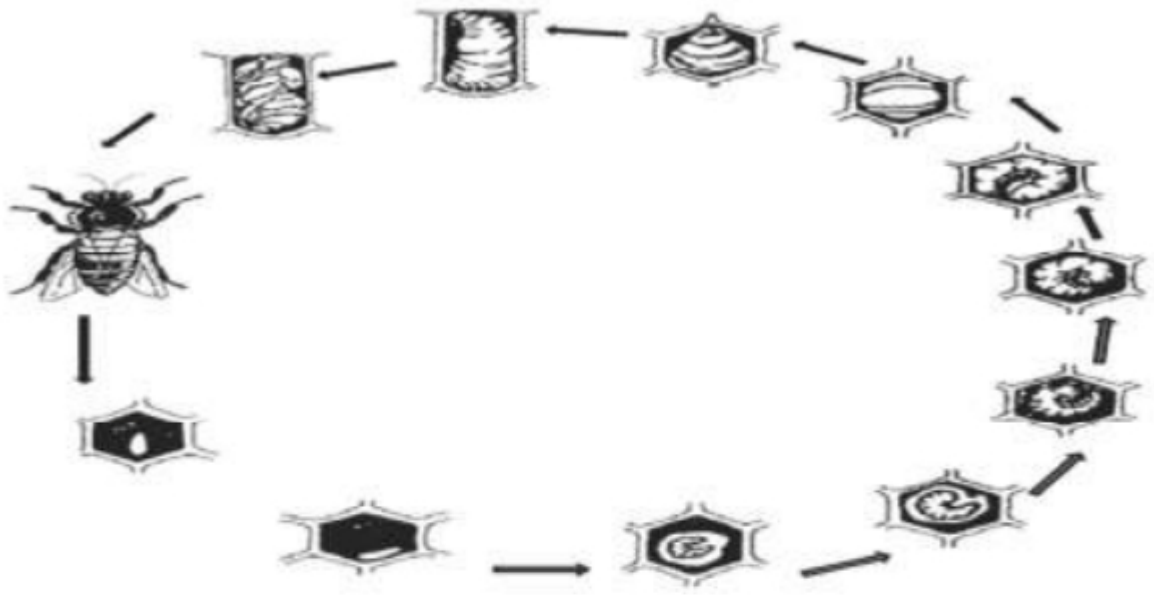
Figure 3.6 Anatomy of a worker bee

(Adapted from Grolier's Multimedia Encyclopedia)

Larvae of all the castes moult four times.The average larval period is 5 days for a queen, 6 for a worker, and 7 for a drone. After the cell is sealed (at the end of 8th day) and the cocoon has been spun (at theend of 9th day) the larva passes gradually and without moulting into pre-pupa.

(iii) Pupa: The pupal stage is the dormant stage. Worker bees seal the cells with a porous beeswaxcap and the larva spins a cocoon around itself. The developing bee remains inside the cocoon without eating or moving. The pupal stage lasts for 7–8 days for a queen, 11–12 days for a worker, and 14 daysfor a drone. Worker cells are a little smaller than drone cells. The comparative sizes are fiveworker cells per linear 25.4 mm of comb and four drone cells per linear 25.4 mm ofcomb in case of Italian bee. During this stage, the internal organs and body appendages develop. Finally theadult bees emerge.

(iv) Adult: The adults emerge from the cocoon and bite a hole in the top of the sealed cell tocome out. Immediately after emergence, the adult workers are a light colour, andthen become darker. The total time taken to develop from egg to adult is 15–16 days for a queen, 20–21days for a worker, and 24 days for a drone.



Sex Differentiation

The queen lays two types of eggs: (i) Fertilized, and (ii) Unfertilized. The queen andworkers comes out from the fertilized eggs, while the unfertilized eggs produce drones

(Fig. 2.11).

Worker — Queen — Drone

Light feeding — Heavy feeding + Royal jelly — Unfertilized

Fertilized Egg

Fig: 2.11: Sex differential in honey bees

Royal jelly is prepared and fed to the larvae by the nurse bees. The queen larvae are fedonly royal jelly. The queen gets the royal jelly throughout her life. Upto 3 days, all youngstages of bees get protein rich food known as 'royal jelly'. Royal jelly is fed to the workerand drone larvae only for the first 3 days and then they are fed "bee bread". Thus, theworker do not get the royal jelly after three days of development and so develop into sterile.

Giant / Rock Honey Bee (*Apis dorsata*):Rock bee has ferocious temperament and it is provoked by slight disturbance. They aresensitive to smoke. This species is found all over the Hind kush Himalayan region, in theplains as well as in the hills up to height of 2000 meters above the sea mean level. It builds

a single comb nest in an open cave under a roof or rock cliff. The size of single open aircomb of *Apis dorsata*, depending upon the season and development of the colony,measureing about 1.5 to 2 m from side to side and 0.6 to 1.20 m from top to bottom. Theupper portions of the comb contain honey and pollen and are generally 10 to 25 cm thick.Below this storage area is the brood nest. The average thickness of brood nest is 3.2 cm.The worker bee is light brown in colour. Queen is darker in colour than the worker andabout 1/5 as longer than worker and about 2 mm broader than worker bee. The drone isblack in colour and is as big as a worker. The giant or rock bee build their comb in such localities where flower with abundant nectar supply are available. As soon as the nectarsupply in a particular locality depletes, they migrate to other place. The productioncapability *of A. dorsata* is about 50 - 80 kg per colony per year. *Apis dorsata* prefersconstruction of nests on building and rocks as compared to open trees due to theavailability of more protection against rain or wind.

Life Cycle of *Apis dorsata:* The development period of *Apis dorsata* (in days) castes is given below:

Eggs stage Larva Pupa Young/

Immature Adult

Queen 2-3 days 4-5 days 6.5 – 7 days 13 – 14.5 days

Worker 2-3 days 4-5 days 9.5 – 12 days 20 days

Drone 2-3 days 4-5 days 13.5-15.5 days 23.5 days

The Little Bee, *Apis florae:* The little bee, *A. florea* is found in the plains and rarely in place higher than 1500 m abovesea level. This small bee also builds a single comb nest which is often suspended frombranches of bushes, hedges, trees, caves of buildings, house chimneys, empty caves andpiles of dried sticks.The comb measures about 35 cm in length. 18 cm in height and about 2 cm in thickness.Honey is stored in the upper part of the comb which is about 5.7 cm thick. Nests of *A.florea* are protected by a three to six layer curtain of bees over the comb.The average honey yield from a colony varies from 0.5-1.0 kg. It is believed that the honeyproduced by *A. florea* has higher dextrin content and has less tendency to granulate thanthe honey of other species. During active season, the brood area ranged from 10 - 627.74sq. cm and the queen lays about 365 eggs per day. Body colour of queen of *A. florea* isamber yellow. The head and thorax are dark in colour up to tibia but leg is amber yellow.The worker bees of *A. florea* with deep black and white stripes on the posterior half of theirbright orange abdomen are comparatively much smaller than the golden brown queen andblack drones with smoky grey hair. They are very prone to swarming. A swarm of A.*florea* bee colony consists of about 600 worker bees, a queen and some drones. In thisspecies absconding is very common and dancing behavior occurred in horizontal position.

Life Cycle of *Apis florea*

The development period of *Apis florea* (in days) castes is as follows:

Eggs stage Larva Pupa Young/ Immature

Adult

Queen 3- 4 days 5.8 days 7 – 8 days 16.5 days

Worker 3- 4 days 6.4 days 8 – 9 days 20-21 days

Drone 3- 4 days 6.7 days 11 – 12 days 22-23 days

Indian Honey Bee (*Apis cerana indica* Fabr.)

This bee species can be kept in beehive. They construct their combs in the cavities of treetrunks, hollows of rocks, holes and other covered places such as cracks and crevices ofwalls etc. It can be domesticated in all kinds of hollows and recesses. Hollowed out logs,wooden boxes, packing cases, kerosene tins mud receptacles, wall recesses and unusedalmirah are the common abodes. Indian honey bee construct series of parallel combs to thedirection of entrance. The number of combs vary from 7-8. The length and breadth of thecombs are about 300 mm and 175 mm respectively. The upper part of the comb is filled with honey and lower part of the comb is used for brood rearing and in middle partgenerally pollen is stored. The comb consists of three types of cells i.e. queen, worker anddrone cells. The worker comb cell is 4.3-5.0 mm in diameter and drone cells are 1.2 timeslarger than the worker cells. The honey production capability of *Apis cerana indica* is10 - 15 kg per colony per year. The egg laying capacity of the queen of *Apis cerena indica* is about 700-1600 eggs perday. The worker bees are smaller in size as compared to the worker of *Apis mellifera*. Thespace between two combs, known as bee space, is about 7-8 mm.***Bee Space – Bee space was discovered by L. L. Langstroth as the optimum distanceto be left in between two adjacent comb surfaces in a bee hive which is essential fornormal movement and functioning of bees. It varies with honeybee species eg. forIndian bees: 7-8 mm and Italian bees: 8-9 mm.***

Life Cycle of *Apis cerana indica:*Embryonic development and developmental stage of queen, worker and drone of *Apiscerana indica* (in days) is as follows:

Eggs stage Larva Pupa Young/ Immature

Adult

Queen 3 days 5.5-5 days 7-8 days 15-16 days

Worker 3 days 5.5-6 days 11-12 days 20 -21 days

Drone 3 days 6.5-7 days 14-14.5 days 23-24 days

This bee species is susceptible to Thai sac brood virus. The loss of 90% colonies of Indianhoney bee is caused by epidemic of Thai sac brood virus during late seventies and eightiesin eastern and northern Indian and during nineties in southern states of the country.

Italian/ European Honey Bee (*Apis mellifera*):This species of honey bee constructs their combs in dark, closed and covered places. Thenumber of combs in *A. mellifera* hive are 10. The combs are parallel to each other and tothe entrance of beehive. The space between two combs i.e. bee space is about 8-9 mm. Theaverage length and breadth of the combs are about 440mm and 228mm respectively. Theegg laying efficiency of the queen is 2500 – 3000 eggs per day. Consequently, more broodis reared by *A. mellifera* as compared to the *A. cerana indica*. The foraging range of theworker bee is about 2-3 km and flight ability is about 5 km. The wing length of *A.mellifera* is about 70% of its body length while the wing length of the Indian honey bee*A. cerana indica* is about 78% of its body length. The average speed of flight of *A.mellifera* is about 50m per 2.95 seconds. The temperature of bee colony is regulated byfanning i.e. about 32.5 – 37°C. The worker bees are larger in size as compared to theworker bees of *A. cerana indica* but smaller than that of *A. dorsata*. The *A. mellifera*maintains a prolific queens, swarms less, has gentle temperament and is good honeygatherer. The honey production capability is about 30-40 kg per colony per year. is reared by *A. mellifera* as compared to the *A. cerana indica*. The foraging range of theworker bee is about 2-3 km and flight ability is about 5 km. The wing length of *A.mellifera* is about 70% of its body length while the wing length of the Indian honey bee*A. cerana indica* is about 78% of its body length. The average speed of flight of *A.mellifera* is about 50m per 2.95 seconds. The temperature of bee colony is regulated byfanning i.e. about 32.5 – 37°C. The worker bees are larger in size as compared to theworker bees of *A. cerana indica* but smaller than that of *A. dorsata*. The *A. mellifera*maintains a

prolific queens, swarms less, has gentle temperament and is good honeygatherer. The honey production capability is about 30-40 kg per colony per year.

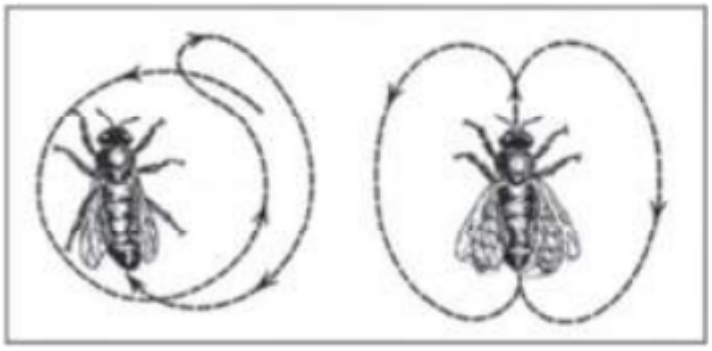
Life cycle of *Apis mellifera:* Development period of *Apis mellifera* (in days) castes is given below:

	Egg stage	**Larva**	**Pupa**	**Young/ Immature**
				Adult
Queen	3 days	5 days	8 days	16 days
Worker	3 days	5 days	12-13 days	21 days
Drone	3 days	6 days	14 days	24 days

Dammer Bee: Two species of stingless or dammer bees, viz. *Melipona* and *Trigona* occur in our countryin abundance. The honey is reported to be of high medicinal valuable compared to *Apis*honey. The tingless bees have the importance in the pollination of various food crops.They bite their enemies or intruders and can be domesticated. But the honey yield per hiveper year is only 100 gms. Queen is distinguished from the worker by her larger size, meanbody length of workers and queen measuring 4.07 and 10.07 mm respectively. Queen isgolden brown in colour and has a pointed abdomen. The workers are black pigmented andwith pale yellow. Mandibles in workers are smaller than that of the queen. The queen doesnot have pollen gathering baskets in her legs.

COMMUNICATION IN BEES

They communicate with each other and passtheir information using various pheromones. However, worker bees communicateinformation through their peculiar 'dance'.The following types of dances are noticed:



A bee can fly @35km/hr. They go as far as 5km from the hives for collecting nector.

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

Biological communication can be defined as an action on the part of one organism that altersthe probability pattern of behavior in another organism in an adaptive fashion. Adaptivemeans that

he signaling or the response or both which have been genetically programmed tosome extent by natural selection.**Trophallaxis** is food transmission (exchange of food) which is common between workersand also from workers to queen and drones. It is a sort of communication regardingavailability of food and water and also a medium for transfer of pheromone.In honey bees, recruit communication is very important mode of communication which isdefined as a communication that brings nest mates to some point in space where work isrequired. Dances of honey bees are important recruit communication.

DANCES OF HONEY BEES

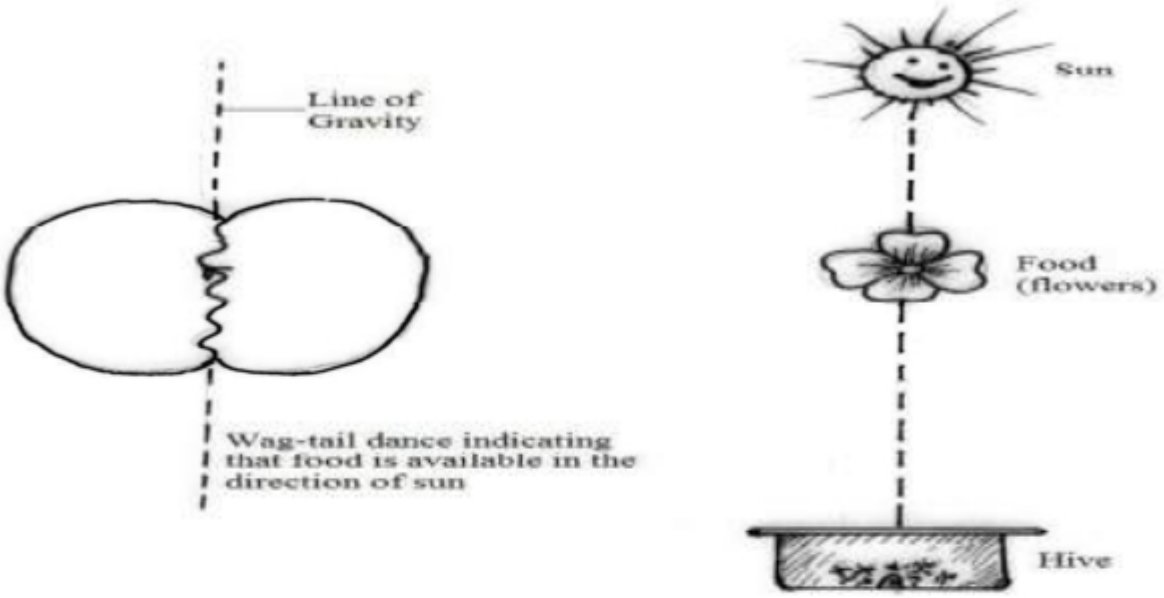
It was Father Spitzner in 1788 who for the first time described bee dances as method ofcommunication among inmates of the hive about volume of honey flow and place of sourceof nectar. These observations remained unnoticed till Frisch (1920) published hisobservations. Karl von Frisch got noble prize in 1973 (under physiology & medicine, whoshared 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 increaseforaging 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 fewhundred metres in gricultural areas and about 2km in forested areas. Scouts communicatedistance, direction and quality of flowers through different types of dances which in turnresults in recruitment of other workers to forage on the best available sources.The scout bees perform two types of dances

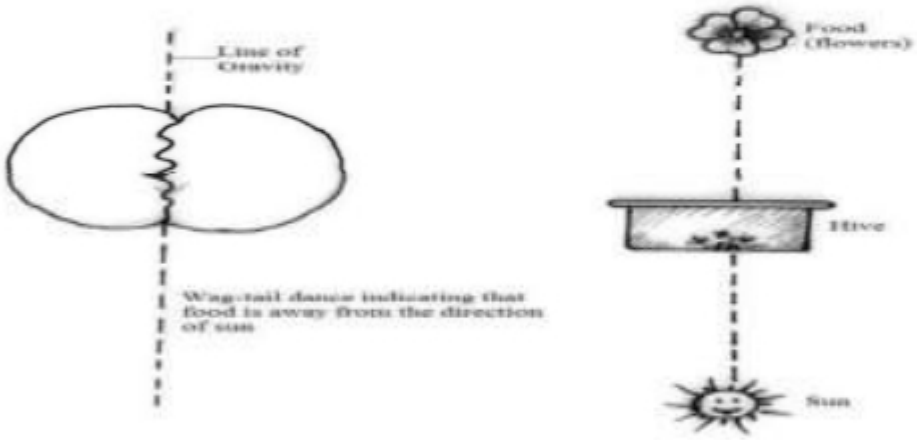
i) Round dance ii) Wag-tail dance

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 runsaround 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 theirantennae and then leave the hive in search of source of food. In this dance there is noindication of direction of food and the foragers search within 100 metres in all direction usingfloral odour clinging to hairy body of scout bee as cue as well as from the sips of nectarwhich they receive from the dancing bee.

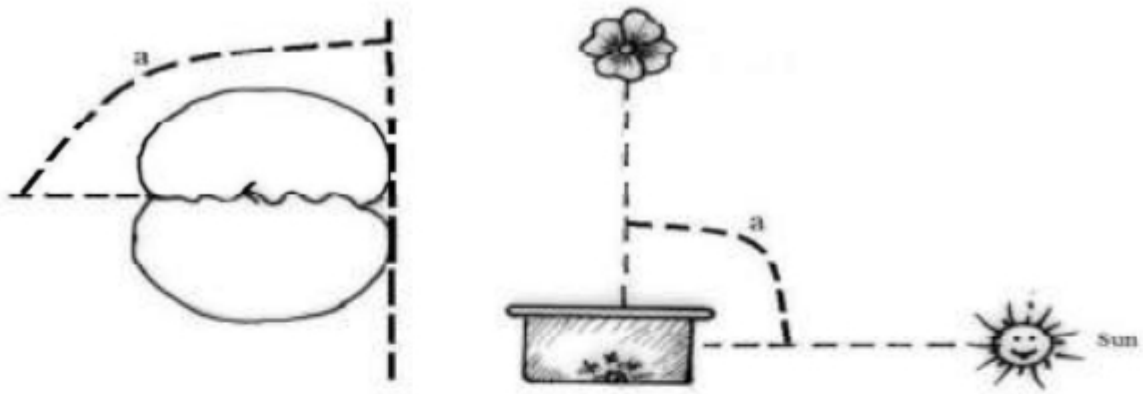
WAG-TAIL DANCE:This dance is performed when the distance of food source is more than 100 metres from the hive. In this dance the bee starts dancing on the comb making a half circle to one side and then takes a sharp turn and runs in a straight line to starting point. Thereafter takes another half circle 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 counter clockwise 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).



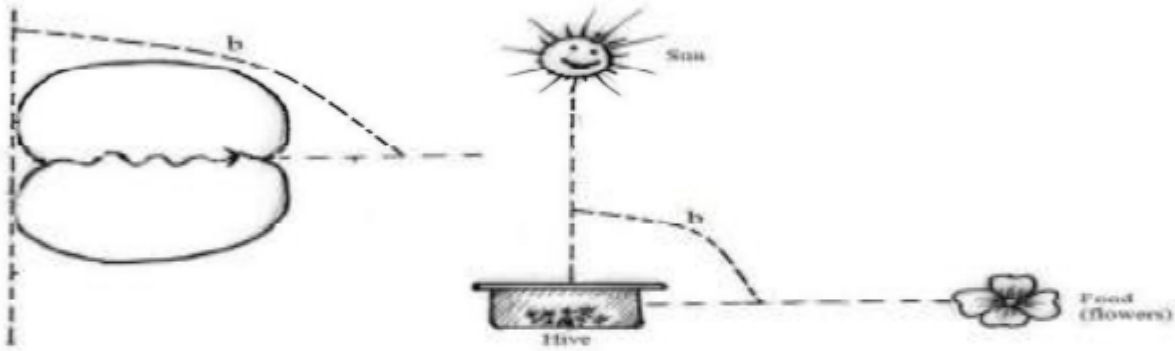
5.3a Direction indication in wag-tail dance when food is in the direction of sun



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 71000 4,6000 2

As a social unit a bee colony maintains its hive temperature between 32-35$_o$C in the broodarea. Queen substance 9-oxo-2-decenoic acid (9-ODA) from the queen bee, alarm pheromoneand alarm odour from worker bees play important role in the welfare of the colony and helpin the social organize

BEE FOOD PLANTS: The food of the bees comes from 'forage' or 'bee flora' i.e. the flowering plants whichprovide nector and/ or pollen for bees. The worker bees that collect pollen, nector, waterand propolis for the colony are also called as 'forager'. Thus, foragers collect followingsubstances for the colony:

(i) Nector(ii) Pollen(iii) Propolis(iv) Water

Bees get carbohydrate from honey and proteins from pollen. Water is mixed with honeyand pollen before bees eat it or feed it to the brood (egg, larvae & pupa). Bees visit flowersand extra- floral nectarines of about 500 flowering plants and trees to collect pollen andnector for food. Some of the commonly visited by bees in India for collecting nector fromthe flowers are as follows:

1. Vegetables: Okra, Cucumer, brinjal, tomato, bottle gourd, spinach, cauliflower,turnip, sweet gourd, onion, radish

2. Field crops: Mustard or toria, sunflower, cotton, jute, pulse, wheat, gram

3. Fruit plants: Litchi, apple, guava, jamun, imli, papaya, karonda, ber, jackfruit,anar, lemon, bel, mango, banana, papaya, drum stick, citrus, pear, apricot, malta, mausami, orange

4. Ornamental plants: Marigold, rose, cosmos

5. Trees: Eucalyptus, acacia, albizia, calliandra, gemelina, prosopis, babool, neem,arjun, palm, sandal wood, dhak, bottle brush, amaltas

6. Herbs and spices: Tulsi, coriander 7. Plantation crops: Rubber, coconut, cashewnut, coffee.

Commercial methods of bee rearing, equipments used, Seasonal management

BEEHIVE: A man-made or artificial structure created for domesticated honeybees is known as a beehive. A beehive is a rectangular wooden box filled with moveable wood or plastic frames, each of which holds a sheet of wax or plastic foundation. The bees build cells upon the sheets of foundation to create a complete honeycomb. Foundation comes in two cell sizes: (i) worker foundation, which enables the bees to create small, hexagonal worker cells and (ii) drone foundation, which allows the bees to build much larger cells for drones. The bottom box, known as brood chamber contains the queen and most of the bees and the upper boxes or supers contain just honey. The young nurse bees produce wax flakes tobuild honeycomb using the artificial wax foundation as a starting point, after which theymay raise brood or deposit honey and pollen in the cells of the comb. You may choose abeehive depending upon the bee species, cost, ease of production and expected returns.Different types of bee hives were in use in various parts of our country. They are pot hive,nucleous hive, single walled and double walled Dadant hives, British standard hive,Langstroth hive, Indian Standard Industries (ISI) hive, Jeolikote hive and Newton hive.Of all these types, Langstroth hives for rearing Italian bee and Newton's hives for rearingOf all these types, Langstroth hives for rearing Italian bee and Newton's hives for rearingIndian bees are most popular. Beehives may be divided into three types:

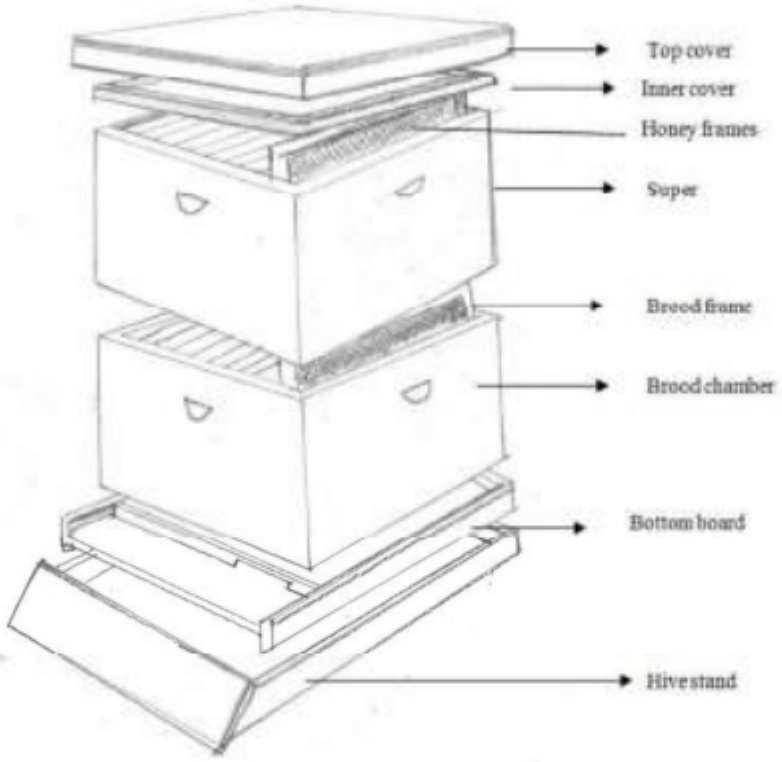
Fixed comb hives: These are traditional hive, which include structure made ofcylindrical bark and log hives and various other hives of many different forms and materials.

Movable-comb hives: These are the top- bar hives, where bees build their combattached to a top bar that can be lifted out of the hive. They have no frames.

Movable-frame hives: A modern beehive is known as the movable frame hive. Thesehives have movable frames which hold the wax sheets that serve as a starting pointfor the bees to build honeycomb. The top wooden box consists of honey while thebottom box consists of queen bee and the other worker bees. A beehive is selectedkeeping in view the race of bee to be reared. A standard movable frame hive Fig 3.1) has the following major parts:

1. **Bottom/floor board**: It forms the floor of the hive made up of a single pieceof wood or two pieces of wood joined together. There is a removable entrancerod in the front side with two entrance slits to alter the size of the hive entrancebased on need. A two inch wide extended part of the bottom board beyond andin front of the hive entrance is known as 'alighting board' for returning bees toalight on it before passing into the hive through entrance. Bees also take offflight from this board. Most of their movement and observation without openingthe hive can be observed at the alighting board.

2. **Brood Chamber:** It is rectangular box with 8 to 10 hanging wooden frames.Frames inside the brood chamber are called brood frames. The comb cells areused for food storage, clustering, raising baby bees, and air conditioning. Thequeen or egg laying workers lay eggs inside this chamber. Thus, a roodchamber is like a 'nursery' where the queen lays her eggs and where the colonystores its food. It contains young stages of honeybee (young larva and pupa)and food for them. The daily requirement of honey and pollen is stored in thischamber.



3. **Super Chamber:** It is kept over the brood chamber and its construction is similar to that of brood chamber. The frames inside this chamber are calledsuper chambers. The length and width of this chamber is similar to that ofbrood chamber. The height may be also similar if it is full depth super as inLangstroth hive. But the height will be only half if it in a Newton's hive.Surplus honey is stored in super chamber.

4. **Queen excluder:** Brood chamber and super chamber may be separated by aperforated sheet 'queen excluder' to restrict the movement of egg laying queenbee going into the honey super. This is a metal sheet with regular openings ofthe specified size, framed with wooden border. The size of opening is suchthat the worker can move through easily but the queen does not pass throughit. The queen bee is, thus, restricted into the lower 'brood chamber' so that thehoney is not contaminated.

5. **Hive Cover:** It insulates the interior of the hive. In Newton's hive it hassloping planks on either side. On the inner ceiling plank there is a squareventilation hole fitted with a wire gauze. Two holes present in the front andrear also help in air circulation. In Langstroth hive, the hive cover consists ofa crown board or inner cover and an outer cover (top cover). The inner coveris provided with a central ventilation hole covered with wire gauze. The outercover is covered over with a metallic sheet to make it impervious to

rainwater. Circular ventilation holes covered by wire gauze help in air circulation.It protects the hive against rain and sun.

6. **Frames:** The frames are so constructed that a series of them may be placed ina vertical position in the brood chamber or the super chamber so as to leavespace in between them for bees to move. Each frame consists of a top bar, twoside bars and a bottom bar nailed together. Both the ends of the top-bar rotrudeso that the frame can rest on the rabbet. The depth of the super frame is lessthan that of the brood frame in Newton's hive and India Standard Industries(ISI) hive. But in Langstroth hive it is same as that of brood frame.Hive bodies painted externally will last longer. The colour of the paint should be white,blue, yellow or green. White is generally preferred for hive construction. It offersdurability, flexibility, easy handling and improves the colony efficiency in regulating hiveinterior temperature and humidity.Bee hives are constructed mainly with seasonal timber such as teak, kail or toon. Thetimber should be free from insect holes, dead knots, shakes, splits and cracks. Thethickness of the wooden walls should be 20 mm.

Advantages of Rearing Bees in Modern Beehives

The advantages of rearing bees in modern beehives are as follows:

1. Provides sufficient space for free movement of bees.

2. Provide ample space for increasing number of workers through addition of supers.

3. Facilitates in regular and easy inspection of colonies.

4. Facilitates the bees to construct standard sized combs.

5. Pure honey can be extracted without damaging the combs.

6. Facilitates easy transportation of colonies from place to place whenever and wherever required.

7. It helps in increasing the productivity of honey and other bee products

SPECIFICATIONS OF BEEHIVES

Langstroth hives for rearing Italian bee and Newton's hives for rearing Indian bees aremost popular. The specifications of both the hives are given below:

Langstroth ten-frame hive

1. **Bottom board (floor board):** Bottom part of the hive length 22" long 16.25" broadand 7/8" thick. Another wooden rod 14.5" be nailed at the back and the front beprovided with similar rod (entrance rod but having an entrance in the middle) afterleaving 2" space so that these nailed rods make a rectangle of 2" x 16.5" .

2. **Alighting board:** The 2" space in front of the entrance rod meant for the bees totake off flight or land on it.

3. **Entrance**: In the middle of the entrance rod is given a cut 3" long and 3/8" deep asa passage for bees to enter or leave the hive.

4. **Brood Chamber:** Is a box, made of wooden planks, without bottom and is placedover the bottom board. It is 20" in length 16.25" in width and 9.5" in height and0.875" thick. A robbat 0.625"of deep and 0.5" wide is cut along the upper innerlength of its width planks. The internal dimensions of the chamber are 18.25" x14.25".

5. **Frames**: Each chamber contains 10 frames and a dummy board. A frame has fourwooden pieces – Top bar, bottom bar and two side bars.

(i) **Top bar**: 19" length x 1" width x 7/8" thickness. A groove is present on lowerside of top bar to insert comb foundation sheet.

(ii) **Side bar:** 9.125" length x 1.125" (upper half) and 1" (lower half) width 3/8"thickness. There are four holes in each of the side bar for wiring the frame.

(iii) **Bottom bar:** 17.625" length x 0.75" width x 0.375" thickness.

6. **Dummy board:** Just a wooden plank of the frame size Length 19" at the top and17.625" at the bottom x 9.125" width 0.375"and thickness.

7. **Super Chamber/honey chamber with bee frames:** Same as the brood chamber.

8. **Inner cover**: Wooden plank 20" long x 16.25" wide and 0.375". Inner cover isnailed 0.375" thick, 0.875" wide wooden rod on its four sides. In the centre of theplank a suitable cut (about 2 x 3") is given which is provided with a wire screen forventilation.

9. **Top/Upper cover**: It is the top most cover 21" long, 17" wide and 0.375" thick.This plank is provided with a frame, 2" wide 0.875" thick, its top side is covered byG.I/Aluminum sheet. Inner side of the outer cover is provided with four small woodenpieces to the inner cover so that the ventilation is not blocked.

Newton's bee hive

1. **Floor board:** 14" x 9.5" in size with an extension in front which serves as analighting board.

2. **Brood chamber:** 9.75'' x 8.25" x 6.75" in size with an entrance slit of 3.5" x 3/8"at the base; it is mounted over the floor board.

3. **Wooden frames:** Eight separate wooden frames 8.75" x 5.75" x 6" in size and 7/8"broad: they are hung inside the brood chamber

4. **Super chamber:** 9.75" x 8.25" x 3.125" in size: it is kept over the brood chamber.

5. **Top cover:** It is board having same dimensions of brood or super chamber. In thecentre there is an opening covered with wire gauge. It is kept on super or broodchamber.

Hive stand: A four legged wooden, metal pipe or angle iron, rectangular support tothe hive. It helps to protect the bottom board from rot and cold transfer.

2. **Smoker:** The smoker is used to protect beekeepers from bee stings and to controlthe bees. Smoke is the beekeeper's third line of defence. You may use "smoker"– adevice designed to generate smoke from the incomplete combustion of various fuelsto calm down the bees

Protective Clothing: To protect beekeepers eyes and nose from stings at the time ofwork near the apiary, proper cloths are required. As novice beekeepers you shouldalways wear gloves and a hooded suit or hat and veil. The face and neck are themost important areas to protect, hence you should wear atleast a veil.

Bee veil: It is a cap made of cloth and wire or fabric net. It is worn over facefor protection against stings. It should be made up of black nylon nettingscreen (12-mesh). Veils should be made to fit snugly around the hat and to fittightly to the shoulder leaving enough space between veil and face.

Overalls: Also known a bee suit, is a protecting garment worn loosely overthe clothes so that the bees cannot get under the clothes. Light coloured cotton

Beekeeping Equipments

materials are preferable since they are cooler and create less risk forantagonizing bees. It should be worn bee-tight so that the bees are not able toenter from the sleeves.

(iii) **Gloves:** Bee gloves are made of tightly-knit cloth (or) soft leather. They coverthe fore arms. The gloves are useful for the beginners to develop confidence inhandling bees. But handlings of frames will be cumbersome if gloves areworn.

(iv) **High boots:** A pair of gum boots will protect the ankles and prevent beesfrom climbing up under trousers.

4. **Comb foundation sheet –** is made up of wax. It is artificially provided for thecolonies during honey flow season by cutting them to a proper conical size andattaching them to super frames by means of thread or fibre. It is a thin sheet ofbeewax embossed with a pattern of hexagons of size equal to the base of naturalbrood cells on both sides. The size of the hexagon varies with bee species. The sheetis fixed to the frames on fine wires threaded through holes in the side bars andstretched tight. A spur or an electrical heating device is used to embed wires into thecomb foundation sheets which are prepared in a comb foundation mill. The bees construct superstructure of comb cells over the sheet.

5. **Dummy division board/Movable wall:** It is a wooden board slightly larger thanthe brood frame. It is placed inside the brood chamber. It prevents the bees from going beyond it. It can be used as a movable wall thereby limiting the volume of brood chamber which will help the bees to maintain the hive temperature and toprotect them from enemies. It is useful in managing small colonies.

6. **Porter bee escape board or super clearer:** It is a device which allows the bees to go through a self closing exit. A board having one way passage in the centre canalso is used. It is kept in between honey super chamber and brood chamber. It isused for clearing the bees from super chamber for extracting honey.

7. **Drone excluder or drone trap:** It is a rectangular box with one side open. Theother side is fitted with queen excluder sheet. At the bottom of the box there is aspace for movement of worker bees. There are two hollow cones at the bottom wall of the box. Drones entering through the cones into the box get trapped. The narrowend of the cone is wide enough to let the bees pass out but not large enough to attracttheir attention or re-entry. This device is used at the entrance to reduce the dronepopulation inside the hive.

8. **Swarm trap:** It is a rectangular box used to trap and carry the swarm. It is fixed near the hive entrance with one (or) two combs inside during the swarming period.This box traps and retains the queen only. But the swarm coming out from the hive.re-enter the hive and settles on the comb, since the queen is trapped. Thus the swarm is induced to settle in the frame, which can now be transferred to a hive at a desired place.

9. **Pollen trap:** Pollen trapping screen inside this trap scrapes pellets from the legs ofthereturning foragers. It is set at the hive entrance. The collected pollen pellets fallinto a drawer type of receiving tray.

10. **Division Board / Sugar Feeder:** It can be hung along with the frames. A wooden strip or cut bits of leaves kept inside serve as float which prevents the drowning ofbees in the sugar syrup.

11. **Hive tool:** It is a piece of flattened iron with flattened down edge at one end. It isuseful to separate ive parts and frames glued together with propolis. It is alsouseful in scrapping excess propolis or wax and superfluous combs or wax fromvarious parts of the hive.

12. **Queen excluder:** It is made up of perforated zinc sheet. The slots are large enoughto allow the workers to pass through but too narrow for the queen. A wire grid/dividing grid with parallel wire mounts can also be used as a queen excluder. It isinserted in between the brood frames in single storey hive. It is useful to confine thequeen to brood chamber. But it allows the workers to have access to super. It reventsthe queen from laying eggs in honey combs. It is also used in producing royal jelly in queen rearing and in forming multi-queen colonies.

13. **Queen Gate:** It is a piece of queen excluder sheet. It is fitted on the slot of entrance gate. It confines the queen inside the hive. It is useful to prevent swarming andabsconding. It also prevents the entry of bee enemies like wasps into the hive.

14. **Queen Cage:** It is a cage made up of wire gauze. It is useful for queen introduction.

15. **Queen Cell Protector:** It is a cone shaped structure made of a piece of wire woundspirally. It fits around a queen cell. It is used to protect the queen cell, given from aqueen right to a queenless colony until its acceptance by bees.

16. **Bee brush:** A soft-camel-hair brush is used to brush the bees off the honeycombbefore it is taken for extraction.

17. **Decapping knife:** Single (or) double edged steel knife is used for removing waxcappings from the honey comb.

18. **Honey extractor:** This equipment consists of cylindrical drum containing a rack orbox inside to hold the super frames. The box is fixed to a rod at the centre and it canbe rotated by a set of two gear wheels. The frames with honey cells are decapped bya sharp knife after dipping it in hot water and fixed to the slots provided in the boxwhich is rotated by the handle. The rotation should be very gentle and slow at first and the speed of revolution increased gradually. With some experience the correct speed can be learnt. The honey in the cells is forced out in droplets by the action of the centrifugal force and can be collected in vessels through an exit in the drum. As cells are constructed on both sides of the comb, by changing the sides of the frames and again rotating, the honey contained in the cells on the other side can also be drained off. Particular care should be taken while handling heavy combs or those which are flimsily attached to the frames.

19. **Embedder:** It is a device just like screw-driver to embed the frame wires in the comb foundation sheets.

20. **Drip Tray:** It is a tray made up of stainless steel or zinc coated iron used to collect the droppings of honey and wax cappings while uncapping the sealed combs of honey.

21. **Feeders:** Used to feed sugar syrup to honeybees during dearth period.

Selection of good bee:

Beekeeping can be taken up with either of the two domesticated honey bee species (*Apiscerana* and *A. mellifera* . 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.

EXAMINATION OF A BEE COLONY

Success of beekeeping also depends upon proper understanding of bee behaviour and anipulating 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, tinging 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.

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 absentcolony 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-upperiod 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.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 whichwould induce bees to sting, should be removed before handling the bees.• Do not be shaky while handling bees. Take care and avoid quick and jerkingmovements.• If a bee stings .do not get nervous. Gently pull out the sting with the sharpedge of hive tool or finger nail from the base .and not from the top withoutsqueezing the venom out of it. Rub some grass on the stung area to mask the smell ofalarm 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.

SEASONAL MANAGEMENT OF HONEY BEE COLONIES (SPRINGMANAGEMENT)

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 onlywhen daily maximum temperature has reached 16^{o}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 unitedwith other needy normal colonies. If these are strong, then provide amated queen and if not available, give a frame of brood with eggs andyoung larvae for rearing new queen.Give stimulatory feeding of sugar syrup (dilute syrup; 30 per cent) to thebee colonies on the onset of spring which is indicated by the start ofblooming of spring flowers. Take all the steps to guard against therobbing 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 broodrearing. But be careful not to over expand the brood in the uncertainweather 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 colonyalways 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 percent), 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.

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 beesdirect their efforts towards building queen cells and searching for newhome sites.Colonies show great variations in respect of swarming. Some colonies donot swarm even after becoming quite populous yet many swarm withoutany apparent reason indicating genetic variations to the instinct ofswarming. *A. cerana* is more prone to swarming than *A. mellifera*.

Indication of swarming: The colonies start raising large number of queen cells usually along thelower edges of combs . However, few emergency queen cells are alsoraised 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**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 forhoney 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.

(SUMMER,MONSOON AND AUTUMN 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 preparedpieces 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; checkwhether queen is present or not and whether laying satisfactorily becauseafter the honey flow starts, the bee keeper becomes too busy in puttingand 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 chamberSupers 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 bereturned 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 ofhoney 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 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 periodsHoney extraction room should be bee tight. After bringing the honey frames for extraction, these can be uncapped 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

• 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.

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$_o$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$_o$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 climaticand 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.

(WINTERMANAGEMENT AND MIGRATORY BEE KEEPING)

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 ollowing 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.Strong colonies with young bees and good food stores, with proper packing need no careduring 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 arked 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 or 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.

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.**

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 (*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 thismite dead brood is thrown outside the hive by workers. The bee colonies may even abscond ifcontrol 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. This mite develops and reproduces in the sealed brood cells of honey bees feeding on haemolymph of bee pupa 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.

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 adultbee 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 tobacterial 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 sugarpowder. Count the number of mites- Natural mite drop in 24 hours is also taken as assessment tool for mite infestation but forthis purpose screened bottom boards (with 8 mesh wire screen) with sticky paper need to beinserted in the bee hives. A drop of more than 30 mites in 24 hours is considered highinfestation 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 withperforated

polythene bags. Level of mite infestation can be kept low by putting sugar (finelypowdered sugar) @ 30g/frame and then sweeping sugar down between the frame spacesusing a bee brush.

VERTEBRATE PESTS

Frogs and Lizards: The frogs and toads prey upon varieties of insects and occasionally feed on bees at the hive entrance. These are proficient in capturing bees and are less affected by bee stings and bee venom. Lizards are occasional predators of honeybee colonies and eat both brood and adult bees.

Management: Place bee colonies on hive stands smeared with grease to prevent the entry of toads and lizards into the hive.Use of beehives free from cracks and crevices and also maintaining colonies with hygienic conditions and would prevent the lizard problem.

Birds: Birds are the major predators of honeybees. The beaks of the birds are well adapted to catch bees easily during flight. They are able to manipulate the prey, dislodge the sting and remove the poison sac of the bees. The green bee-eater, *Merops orientalis,* blue bearded bee-eater, *Nyctyornis athertoni* and the drango, *Dicrurus leucophaeus* are the most common bird predators of bee colonies. They catch up bees and are smapped up in the bill, returns to their perch and beat the prey against the perch until they die. Similarly, the oriental honey buzzard, *Pernis ptilorhyncus,* swifts, wood peckers also act as predators of honeybees.Woodpeckers have a strong, sharp pointed bill for excavating insect brood holes in trees and a very long sticky tongue for extracting the bee prey.

Management: The methods such as scaring, producing distress voice at a high volume, restricting the flight using reflective tapes, compact discs etc. have been successful to prevent the bird menace in and around apiaries.Covering apiaries with strong mesh would prevent the entry and attack of birds.

Mammals

Mice are known to invade bee colonies for shelter and destroy the combs. They feed on bees and hive products such as honey and pollen. Bears usually dismantle the hives to feed on the honey, pollen, brood and adult bees. They tear the hives into pieces and carry off combs with honey to escape from mass stinging of bees. The monkeys remove the adult bees from the combs and feed on the honey and brood. Monkeys generally in troops jump on to the beehives and carry away both super and brood combs by shooking the bees to fly away.

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.

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 preads 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: **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 as compared to glittering white in case of normal brood 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 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 sugarsyrup feedingFeed Terramycin @ 0.2g in500ml conc. Sugar syrup No effective cure

Adult diseases:Nosema disease Acarine disease Causativeorganism:*Nosemaapis*(protozoan*) Acarapiswoodi* (Endoparasiticmite)

Symptoms Infected bees collect in front of hive, sluggish,crawlers on leaf blades, distended abdomen, dysentric .Bees gather in front of hive as crawler bees and unable to fly;disjointed wings aving 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 antity after every 24 h for 21 days

Viral Diseases: Viruses are microscopic entities causing diseases in honeybees. About 18 viruses have been identified in honeybees and most of them cause sub-lethal infections. Only a few have been reported in *A.cerana indica* in contrast to many viruses from *A.mellifera.*Though a few viruses infect brood, most of the viruses infect both brood as well as adultbees. The major viral diseases of honeybees are Thai sac brood, Sac brood, Kashmir bee virus, paralysis and *Apis* iridescent virus. Filamentous virus, black queen cell virus, Arkansas virus, Egypt bee virus, viruses X and Y, cloudy wing virus, deformed wing virus are other viruses infecting honeybee colonies.

Disease Causal organism Susceptible Honeybee Species

Thai sac brood Thai sac brood virus *Apis cerana indica* Sac brood Sac brood virus *Apis mellifera*

Paralysis Paralysis viruses *Apis mellifera* Kashmir bee virus Kashmir bee virus *Apis cerana indica*

*Apis mellifera*American Foul Brood *Paenibacillus larvae Apis mellifera larvae Apis cerana indica*

European Foul Brood *Melissococcus Apis mellifera plutonius Apis cerana indica Apis laboriosa*

Chalk brood *Ascosphaera apis Apis mellifera Apis cerana indica* Stone brood *Aspergillus flavus Apis mellifera* Nosemosis *Nosema apis Apis mellifera Apis cerana indica* Amoeba disease *Malpighamoeba Apis mellifera mellificae*

A. Thai Sac Brood Disease

Thai sac brood disease is one of the deadly diseases of *Apis cerana indica* colonies. It was originated for first time in Thailand during 1976 and caused greater losses to beekeeping industry by killing over 80 to 90% bee colonies during 1980s. Thai sac brood virus is confined to the brood and quite evidently the larvae exhibit disease symptoms. Its prevalence is quite evident in brood rearing seasons in honeybee colonies.

Symptoms: The symptoms are seen in early larval stages and death occurs either in late larval or in the pre-pupal stage. The dead larvae usually lie at the bottom of the cell with the head typically turned up. Such larvae become scale like and adhere to one side of the cell at the bottom. Infected pupae are irregularly scattered on combs with perforations on the capping. Adult bees become sluggish with extreamly low foraging activity.

Diagnosis: The disease can be diagnosed by lifting infected larva with a pointed needle which shows a sac like appearance. Examination of ultra thin sections of midgut of infected adult bees reveals bundles of virions accumulated next to the peritrophic membranes in the gut lumen.

B. Sac Brood: Sac brood virus (SBV) is one of the foremost viruses reported from *A.mellifera* colonies. It infects and multiplies in the tissues of young larvae. Such larvae generally fail to pupatebut remain stretched on their back by extruding their head towards cell capping. The larval cuticle looks like a transparent sac accumulated with a fluid between the epidermal layers. The infected larvae changes from pearly white to pale yellow followed by dark brown in colour.

C. Kashmir Bee Virus: Kashmir bee virus is a pathogen of *A. cerana* that killed thousands of colonies in Kashmir.The major symptoms of its infection are gradual weakening of bee colonies with large numbers of dead and dying bees near the hive. The infected bees are partly or completely hairless with dark upper thoracic surface and exhibit trembling uncoordinated movements.

D. Paralysis Viruses: Four types of viruses' *viz.* chronic paralysis, chronic paralysis associate, acute paralysis and slow paralysis are known to cause paralyses in adults of *A.mellifera.* The infected bees become hairless, shiny and have bloated abdomen with partially spread dislocated wings. They show an abnormal trembling motion of the wings and body. They fail to fly out often crawling on the ground and cluster on top of the hive.

E. *Apis* Iridescent Virus:*Apis* iridescent virus multiplies in the tissues of fat body, alimentary canal, hypopharyngeal glands and ovaries of adult honeybees. The tissues of the diseased bees become blue-violet to green on illumination with bright white light. It is known to reduce the egg-laying capacity of the queen and the worker bees become sluggish and form clusters at the hive entrance.

Management of Viral Diseases: The adult population of diseased colonies may be transferred to a new or disinfectedhive provided with comb foundation. They are fed most frequently with sugar syrup and pollen supplements. During severe infection, the combs containing diseased larvae may be burnt to prevent further contamination. A break in brood rearing either by de-queening or by caging the queen encourage bees to remove infected dead brood efficiently and thereby keeping the infection under control. Avoid exchange of infected combs and use only sterilized beekeeping equipment in the bee colonies. The control measures followed to prevent the transmission of viruses through bee mites, protozoan parasites and other vectors would reduce the problem of viral diseases.

Bacterial Diseases: Bacteria cause many diseases in honeybee colonies. They are classified into two broad categories such as non spore- forming bacteria and spore-forming bacteria. American foul brood and European foul brood are highly destructive and widely distributed bacterial diseases of honeybees.

A. American Foul Brood: American foul brood (AFB) is one of the most destructive infectious brood diseaseskilling millions of *A.mellifera* colonies throughout the world. It is highly contagious and occurs in all seasons on bee brood. *Paenibacillus (*formerly *Bacillus) larvae subsp. Larva* causes the disease.

Symptoms: The diseased brood is irregularly intermingled with healthy brood with uncapped, punctured or sunken capping in the form of 'pepper box'. The diseased brood is initially dull white in colour and gradually changes to light brown or dark brown. Death of an infected larva usually takes place after the cell is sealed and the cocoonhas been spun. The segmentation of the larva is well marked and gives off fish-glue like foul odour.

Diagnosis: The spores of the pathogen exhibit Brownian movement in the regions of the smear where pockets of water are formed in the oil. This movement is an extremely valuable diagnostic tool as the spores of other pathogens of honeybees are usually remained fixed. Stretch test is followed where the dead larval contents are easily adhering to the tip of the pointed stick on dipped into the larval extract by stretching in an elastic way when lifted. Microscopic examination of infected larval scales stained with nigrosin show a mass of bacterial spores. Holst test essentially consists of placing the suspected material such as dried scales into dilute warm milk. The spores turn the milk curdled and cleared within few minutes. The immuno fluorescence and immuno diffusion and use of monoclonal antibody in enzyme linked immuno sorbent assay (ELISA) are the other diagnostic techniques followed in detection of AFB.

Management: Honeybee colonies could be placed in the areas rich with plenty of nectar and pollen flow during active season. Artificial swarming or shook swarm technique is followed in AFB infected colonies during post honey flow seasons. This technique involves transferring of adult bees to a disease free hive followed by destroying diseased brood combs. Depleting adult bees supplied with comb foundation leads to break in survival of the pathogen in absence of the brood. The combs and equipment may be sterilized by fumigation with formaldehyde. Sodium sulphathiozole (1.5g/15*l*) and oxytetracyclin hydrochloride (0.4g in 5 *l*) suppress the disease when fed with strong sugar syrup.

B. European Foul Brood: European foul brood is caused by *Melissococcus plutonius*, a non-spore formingbacterium. It is an infectious and contagious disease primarily infecting 2-3 days old young larvae. The virulence of the pathogen is common in high brood rearing season.

Symptoms: A slight yellow or grey discolouration of the larvae. Most of the bee larvae die at coiled stage on the bottom of the cells. The dead larvae appear like collapsed mass giving melted appearance. The larvae undergo decaying often giving off a foul odour and are sour in taste. An infected larva may spins cocoon with poorly developed silk glands but become flaccid and the tracheal system becomes quite visible. The diseased larva dries up into rubbery scales in the cell.

Diagnosis: Exposing the smears of diseased larvae stained with carbol fuschin under a microscope before appearance of secondary bacteria shows bacteria. The Enzyme Linked Immuno Sorbent Assay (ELISA) Polymerase Chain Reactions (PCR) are efficient in detection of the pathogen in the larvae and beehive products.

Management: The severely infected colonies may be destroyed. Sodium sulphathiazole 1.5g/15 *l*) suppress the disease on feeding in strong sugar syrup. Oxytetracycline hydrochloride (Terramycin®) may be fed or sprinkled with sugar syrup over the bees cluster in the hive in warm weather.

C. Para Foul Brood: The bacterium, *Bacillus paraalvei* causes Para foul brood disease in honeybees. The worker, queen and drone larvae and sometimes pupae are affected by Para foul brood disease.

Symptoms and Management: The larvae infected are slightly less plumpy and change in colour from glisteningwhite to a dull white. The cell capping are dark, sunken and greasy in nature. The infected

brood produces a sour odour. ◴ A large number of larvae are coiled or irregularly twisted in the cells, although many larvae die in an extended position. ◴ The larvae in later stages turn reddish brown and form dark coloured scales. ◴ Since the epidemiology of Para foul brood is almost similar to that of EFB, similar control measures would also be effective.

Septicemia: Septicemia is a disease associated with adult honeybees and is caused by a bacterium, *Pseudomonas apiseptica*. It is most prevalent in the bee colonies placed near moist soil.

Symptoms and Management: A change in the colour of the haemolymph of infected bees from apple brown to chalky white followed by rapid regeneration of muscles. ◴ Severe infection causes the haemolymph to become turbid and milky.

Dead or dying bees emit a putrid odour.◴ Placing bee colonies in well-drained apiary sites and exposing them to the sunlightfor at least a part of the day would minimize the disease.

Fungal Diseases: Fungi infect brood, adult bees and combs containing stored products in honeybeecolonies. The most common fungal diseases of honeybees are chalk brood and stone brood.

A. Chalk Brood: The fungus, *Ascosphaera apis* causes chalk brood disease. It infects larval and pre-pupal stages of the bee brood. The chalk brood causes severe damage to bee colonies most frequently in spring and early summer seasons.

Symptoms: The fungus infects younger larvae and pre-pupae usually located in outer fringes. The infected larvae die after cell capping and turn white followed by grey and black colour on formation of fruiting bodies.◴ Larva is over grown by fluffy like mycelia and swells.he infected larva dries into hard, shrunken white chalk mummies.

Diagnosis: Presence of stained mummies containing spore cysts under the microscope. Identification of the pathogen by a polymerase chain reaction technique.

Management: Strengthening of weak colonies by uniting adult bees and brood combs. Periodic renewal of old combs with new ones. Fumigation of hive equipment and combs with Ethylene oxide and methyl bromide. Trichloro isocyanouric acid (TCA) dissolved water is effective in control of chalk brood.

B. Stone Brood: Stone brood disease is generally caused by the fungus, *Asperigillus flavus* and occasionally by *Aspergillus fumigatus*. It is more prevalent in beehives under damp conditions with poor ventilation.

Symptoms and Management: The spores are found abundant near the head of the infected larvae and pupae and form green stone like solid mummies. ◴ The infected larva becomes hardened and quite difficult to crush after its death hence the name stone brood. ◴ The management practices followed in control of chalk brood disease are also effective against stone brood.

Protozoan Diseases: Protozoans are either parasitic or symbiotic on honeybees and cause greater losses to the beekeeping industry throughout the world. The microsporadian and protozoan diseases of honeybees are nosemosis and amoeba disease respectively.

A. Nosemosis: Nosemosis is one of the most widespread adult honeybee diseases caused by the microsporadian parasite, *Nosema apis*. It is distributed worldwide and has also been reported from many parts of India on *A.cerana* colonies. It is an obligate parasite which develops in the gut tissues of adult bees and has been known to shorten the life span of honeybees.

Symptoms: The bees of diseased colonies show restlessness and are unable to fly but drop loose excreta on the combs and hive parts. The hind wings of infected bees may get unlocked from the fore wings and held at unusual angles. The infected nurse bees do not produce sufficient royal jelly due to deterioration of food glands. The hypopharyngeal glands of the newly emerged adult bees with the pathogen fail to develop completely and eventually undergo atrophy.

Diagnosis: Nosemosis can be diagnosed by microscopic examination of ventriculus of the infected bees. The ventriculus, which is normally brown in colour becomes white and fragile on infection Giemsa (10% 0.02 M phosphate buffer) stained air-dried ethanol fixed smears ofinfected tissues shows spores with thick unstained walls without visible nuclei.

Management: Maintenance of bee colonies strong with a prolific queen and sufficient food stores. Old combs which are constant source of pathogen may be replaced with new combs. Fumes of cetic acid (60 per cent) would inactivate the *Nosema* spores. The antibiotic, fumagillin suppresses *Nosema* infection when fed to bees at the concentrations of 0.5 to 3 mg/100 ml sugar syrup.

B. Amoeba Disease: Amoeba disease is caused by the protozoan, *Malpighamoeba mellificae*. It is widely distributed in temperate regions. The *M. mellificae* cysts ingested by the adult bees germinate possibly at the posterior end of the ventriculus of bees where solid food particles are accumulated.

(i) Symptoms: Gradual decline in adult bee population. Infected Malpighian tubules are slightly distended, glassy in appearance and easilybroken. The infection causes the epithelium of malpighian tubules to undergo atrophy.

(ii) Diagnosis and Management: Presence of cysts in the abdominal suspension of the suspected bees examined undermicroscope. Phenyl salicylate, quinosol, fumagillin, furazolodone and dichloroxyquinaldine areeffective against the amoeba diease.

SERICULTURE

Glossary in Sericulture

Anaphae Silk -	Anaphe a uni-voltine green silkworm (20-100) Collectively produce silk cocoons.
Ant -	A Common name to freshly hatched silkworm larvae.
Antennae/Feelers -	There are a pair of sensory receptive organs present on the dorsal side of the head.
Ant Well -	An equipment used to prevent crawling of ants on to rearing trays.
Acid Treatment -	A process to make the eggs to hatch especially bi-voltine eggs.
Breeding Stations -	Place to multiply reproductive seed.
Bi-Voltine -	The silkworms have two generation in a year.
Cellule -	A plastic black conical cup used to cover paired moths and female moth during ovi position
. Chawki worms-	Worms of I to III instar age.
Cocoon -	A compact structure spun by silkworm larvae as a protective covering for undergoing population.
Commercial -	Specific hybrids between two or more pure lines of Industrial seed races of silkworms.
Seed Crop -	Cacoon production which is used to produce eggs in commercial egg production center
Crumpled Wings -	Wings which are having numerous folds but not uniform.
Defloss -	Removing of floss from seed cacoons before moth emergence.
DFL -	Disease Free Laying.
Disease -	Any deviation from the regular physiological activities in the body of an organism
Disinfection -	This is the process of cleaning the room and appliances for hygienic.
Domestication -	Rearing any animal under laboratory conditions.
Eri silk -	A domesticated silkworm Philosamia ricini feed Castor leaves to produce white or brick-red silk.
Fagra silk -	A giant silk moth Attacus atlas produce light brown colour cocoons.
Fish Wool -	It is a silk obtained from a bi-valve Pinna Squamosa.
Floss -	An outermost loose, fragmented layer of cocoon. It is waste silk to be removed before reeling and moth emergence.
Grain -	The term given to the eggs of silk moth.
Grainage -	A centre aimed to produce disease free seeds.
Hibernating eggs -	These breeds do not hatch normally in 10 – 11days and enter diapause stage.
Hygrometer -	It is an equipment to measure humidity. Instar - It is the satge between two moults in larval development of an insect (feeding periodically.)
Incubation -	A process aimed at uniform development of an egg, to ensure uniform hatching through proper maintenance of environmental conditions.
Kego-	A common name of freshly hatched larvae.
Micropyle -	A small microscopic opening present on egg
Multi-voltine -	The silkworms have many generations in year.

Pro thetel -	An intermediate form between larva and pupa of an Insect.
Reproductive seed -	Used to produce seed cocoons which are required in large number for producing commercial seeds.
Silk -	A fibrous proteinous secretion secreted by certain Insects.
Spinneret -	It is a special organ used to spin the cocoon in certaingroup of insects.
Sexual Dimorphism -	It is a phenomenon where male and female are identified by their external morphological features.
Synchronization -	The moths of different races are made to hatch simultaneously on the same day, so are available for hybridization.
Sterilization -	A process to eliminate harmful microorganisms, and to make the room clean and hygienic.
Uni-voltine	The sillworms have only one generation in a year.
Voltinism -	- It is a character which indicates the number of generations per year.
Seed Cocoon	Cocoon are produced by larva of a pure silkworm race. These are used for production of hybrid seed.
Cocoon	Cocoon is a protective covering over the pupa. In silkworms it is made of silk. Cocoons are boiled in water to extract silk.
Cross breed (C.B.)	Hybrid silkworm eggs between to silkworm races. In Karnataka hybrid of multivoltine female and bivoltine male iscommon
Green Cocoon	Newly formed cocoon
Double Cocoon	In singal cocoon two pupa are present
Denier-	The denier is basedon a natural reference- a single strand of silk is approximately one denier :a 9000 meter strand of silk weighs about one gram.

Sericulture :The word 'Sericulture' is derived from the Greek 'Sericos' meaning 'silk' and the English 'culture' meaning ' rearing'. It is a multidisciplinary programme. It involves the cultivation of mulberry to produce leaf, rearing of silkworm to convert leaf to cocoon, reeling of the cocoon to obtain silk yarn and weaving to convert yarn to fabrics. Silk is a natural fibre where two independent fibroins called brins are completely covered with sericin.

Importance of sericulture

1. Sericulture is an agro based rural industry with large labour involvement and higher income generation potential.
2. India, the second largest silk producer next to China, has a unique position in the world, being the only country producing all the four commercial types of natural silk *viz.,* mulberry, tasar, eri and muga.
3. Once the plantation is established it will continue to yield for 10 to 12 years with minimum expenditure for maintenance. Therefore maximum turnout can be obtained with minimum investment.
4. It is suitable to small and marginal farmers also.
5. All the sericultural activities are village based and hence prevents migration of people from rural to urban areas in search of jobs.
6. Silk being an expensive commodity used mostly by the affluent society, transfer of money from rich to poor is ensured.

7. Mulberry ensures higher income per unit area than that from a number of agricultural crops. Sericulture gives income 5 to 6 times a year.p
8. Sericulture mostly requires use of simple appliances which are easily available in rural areas.
9. In drought conditions, when most of the agricultural crops do not revive even after a few showers, mulberry being a perennial crop sprout and yield leaves for rearing silkworms.
10. Sericulture provides self-employment opportunities to the educated unemployed youth in the varied sectors.
11. Many by products are obtained from sericulture activities.
12. Mulberry and silkworm have pharmaceutical values
13. Silkworm is used as a tool for genetic and biotechnological studies
14. Silkworm gives products which are used as human medicines

Economic importance

There is high export possibility creating trade surplus. Sericulture is a good source for earning foreign exchange. The export earnings from fabric and garments in 2004 – 2005 was Rs. 2,880 crores. Mulberry silk production accounts for about 92% of total silk produced in India.

Sericulture at a glance (2004 – 2005)

World scenario		
Raw silk production	:	1,17,042 MT
China	:	94,600 MT (80%)
Indian Scenario		
Total Raw silk production	:	16,500 MT
Mulberry raw silk production :	14,620 MT	
Demand for raw silk	:	22,000 MT
Silk export	:	Rs.2,880 crores
People engaged	:	64 lakhs
Raw silk production in major states		
Karnataka (Silk bowl of India)	:	7,302 MT
Andhra Pradesh	:	5,084 MT
Tamil Nadu	:	443 MT
West Bengal	:	1,520 MT
Mulberry area in India	:	1,71,958.57 ha
Tamil Nadu	:	5,073 ha

History of Sericulture

Silk was discovered in China by the Empress, Si- Ling and later spread to other parts of the world. The first authentic reference to silk is found in the Chronicles of the Chou- King of China (2,200 BC). The king is reported to have pointed out to the Empress Si-Ling the worms destroying the mulberry trees in his garden. As she tried to gather the cocoons she accidentally dropped one of them into a bowl of hot tea. While trying to recover the cocoon from the hot liquid with a spoon, she discovered that a very fine and very long lustrous thread unwound itself from the cocoon. She discovered silk and the process of obtaining it from the cocoons. The silk industry came into being. In the beginning, silk was worn only by the royal family. The Chinese guarded the secret of silk making for hundreds of years in the 'Chang –Tong' Province.

From China, the secret of silk making spread first to Korea through Chinese immigrants in 1,200 BC. From there it spread to Japan, when Semiramus, the Japanese General conquered

Korea and took as slaves the prisoners-of-war farmers and artisans dealing with the cultivation, rearing and weaving of mulberry silk.

From China, the secret of sericulture spread to Tibet when a Chinese Princess, who married the King of Khoten, carried mulberry and silkworm seeds in her head apparel.

From Tibet, it spread to India in l40 BC. There is evidence in ancient Sanskrit literature. Silkworm was first domesticated in foot hills of Himalayas. British East India company exploited silk industry and exported large quantities from West Bengal to England. Denied on privatization. Sericulture was developed in Mysore and Jammu and Kasmir.

Each sericultural state in India has a traditional reputation for a particular kind of silk goods from ancient times. Eg. Banaras silk, Kashmir silk, Bengal silk, Mysore silk and Kanchipuram silk.

Silk Road: The Silk Road was a prestigious network of trade routes linking the civilization of the East represented by China with the civilization of the West represented by Rome. It was the route used by Buddhist priests and also the traders who exchanged goods as well as ideas of the two great civilizations of the time. Chinese silk was exchanged for gold, wool, horses, jade and glass of the west and ideas from Buddhism was exchanged for those from Christianity. The 6,400 km long Silk Road (actually a caravan tract) started in Sian followed the Great Wall of China, Afghanistan, Syria, Egypt, Mediterranean ports to Europe.

Organizations in sericulture industry: International Sericulture Commission (ISC) was established in Lyon, France in the year 1948. It is the only inter-governmental organization of silk producing countries. The fourteen Member countries of ISC are Brazil, Egypt, France, Greece, India, Indonesia, Iran, Japan, Lebanon, Madagascar, Rumania, Tunisia and Turkey.

The ISC encourages and promotes the development of sericulture and allied activities of sericulture industry in the member countries.

Central silk Board (CSB) established in 1949 is one of the earliest statutory bodies of the government of India, with its head quarters located in Bangalore, under the Ministry of Textiles, it is the apex body responsible for promotion and over all development of sericulture and silk industry in India.

The institutes under CSB are,

1. Central Sericultural Research and Training Institute (CSR&TI), Mysore, Berhampore, Pampoor
2. Central Silk Technological Research Institute (CSTRI), Bangalore
3. National Silkworm Seed Organization (NSSO), Bangalore
4. Silkworm Seed Technology Laboratory (SSTL), Kodathi, Bangalore
5. Central Sericultural Germplasm Resources Centre (CSGRC), Hosur
6. Seri Biotech Research Laboratory (SBRL), Bangalore
7. Central Tasar Research and Training Institute (CTR &TI), Ranchi, Jharkhand
8. Central Muga Eri Research and Training Institute (CMER&TI), Jorhat, Assam.

At the state level, sericultural interests are looked after by the respective governments. Eg. Department of Sericulture, Karnataka, Department of Sericulture, Andhra Pradesh, Department of Sericulture, West Bengal, Department of Sericulture, Jammu and Kashmir.

Karnataka State Sericultural Research and Development Institute, Thalaghattapura, Bangalore and Andhra Pradesh State Sericultural Research and Development Institute, Hindpur are the state level research institutes.

Silk Mark organization of India (SMOI) is a registered, society, sponsored by the CSB, which gives 'Silk mark label' to the silk goods.

Types of silkworm

Silk is a fibrous protein of animal origin. A number of organisms secrete silk, which is used by them for anchorage (mussels), entangling their prey (spiders), or forming a protective sheath with or without other materials (Lepidopteron cocoons). Nearly 400 - 500 species are known to produce silk but only very few are commercially exploited. Based on the organism producing it, silk is classified into Insect silk and Non- insect silk. Insect silk is commercially more important. The majority of silk producing insects belong to the order : Lepidoptera, Super family. Bombycoidea and Families. Bombycidae and Saturniidae.

Nearly 95% of commercial insect silk comes from the mulberry silkworm *Bombyx mori* and is known as mulberry silk. The commercial silk from all other sources is collectively called Non-mulberry silk. Hence, the major insect species producing silk are,

1. Mulberry silkworm : *Bombyx mori*

2. Tasar silkworms : i) Tropical tasar - *Antheraea mylitta* ii) Temperate tasar - *Antheraea proylei* iii) Chinese tasar - *Antheraea pernyi* iv) Japanese tasar – *Antheraea yamamai* 3. Eri silkworm – *Samia ricini* 4. Muga silkworm – *Antheraea assamensis*

SILK WORM – TYPES:: There are five major types of silk of commercial importance, obtained from different species of silkworms which in turn feed on a number of food plants: Except mulberry, other varieties of silks are generally termed as non-mulberry silks. India has the unique distinction of producing all these commercial varieties of silk.

1. **Mulberry:** Mulberry silkworm : *Bombyx mori* . The bulk of the commercial silk produced in the world comes from this variety and often silk generally refers to mulberry silk. Mulberry silk comes from the silkworm, *Bombyx mori* L. which solely feeds on the leaves of mulberry plant. These silkworms are completely domesticated and reared indoors. In India, the major mulberry silk producing states are Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir which together accounts for 92 % of country's total mulberry raw silk production

2. **Tasar silkworm**: Tasar (Tussah) is copperish colour, coarse silk mainly used for furnishings and interiors. It is less lustrous than mulberry silk, but has its own feel and appeal. Tasar silk is generated by the silkworm, *Antheraea mylitta* which mainly thrive on the food plants Asan and Arjun. The rearings are conducted in nature on the trees in the open. In India, tasar silk is mainly produced in the states of Jharkhand, Chattisgarh and Orissa, besides Maharashtra, West Bengal and Andhra Pradesh. Tasar culture is the main stay for many a tribal community in India.i)

Tropical tasar - *Antheraea mylitta* ii) Temperate tasar - *Antheraea proylei* iii) Chinese tasar - *Antheraea pernyi* iv) Japanese tasar – *Antheraea yamamai*

3. **Eri silkworm** – *Samia ricini:* Also known as Endi or Errandi, Eri is a multivoltine silk spun from open-ended cocoons, unlike other varieties of silk. Eri silk is the product of the domesticated silkworm, *Philosamia ricini* that feeds mainly on castor leaves. Ericulture is a household activity practiced mainly for protein rich pupae, a delicacy for the tribal. Resultantly, the eri cocoons are open-mouthed and are spun. The silk is used indigenously for preparation of *chaddars* (wraps) for own use by these tribals. In India, this culture is practiced mainly in the north-eastern states and Assam. It is also found in Bihar, West Bengal and Orissa

4. Muga silkworm – *Antheraea assamensis :* This golden yellow colour silk is prerogative of India and the pride of Assam state. It is obtained from semi-domesticated multivoltine silkworm, *Antheraea assamensis*. These silkworms feed on the aromatic leaves of Som and Soalu plants and are reared on trees similar to that of tasar. Muga culture is specific to the state of Assam and an integral part of the tradition and culture of that state. The muga silk, an high value product is used in products like sarees, mekhalas, chaddars, etc.

A. Classification :1. Based on voltinism : Based on the number of generations, it is classified as Uni, Bi and multivoltines. Diapause can be broken artificially in bivoltines but not in univoltines. In case of univoltines larval period is long and rearing is unsuitable during unfavourable seasons.

Univoltines: Only one generation per year; Diapauses during eggs; Unsuitable for rearing in summer and autumn; larval period is long; Cocoons are of superior quality. Eg. European races.

Bivoltines: Two generations in a year; White cocoons; Larvae are robust; tolerant to environmental conditions; Diapause can be artificially broken. Eg. Japanese and Chinese races
Multivoltines: More than three generations per year; Golden yellow coloured cocoons; Larvae can withstand high temperature and humidity; well adapted to tropical conditions; comparatively the cocoons are of poor quality.Eg. Indian and Chinese races.

Silkworm Biology

Egg :Egg is round and white. The weight of newly laid 2,000 eggs is about 1.0 g. It measures 1-1.3 mm in length and 0.9-1.2 mm in width. With time, eggs become darker and darker. Races producing white cocoons lay pale yellow eggs; while races producing yellow cocoons lay deep yellow eggs. In case of hibernating eggs laid by bi-voltine and univoltine races, the egg colour changes to dark brown or purple with the deepening of colour of the serosal pigments. The eggs may be of diapause or non-diapause type. The diapause type of eggs are laid by the silkworms inhabiting in temperate regions; whereas silkworms belonging to subtropical regions like India lay non-diapause type of eggs. During diapause all vital activities of the eggs cease.

Larva : After 10 days of incubation, the eggs hatch into larva called caterpillar. Newly hatched caterpillar is about 0.3 cm in length and pale yellowish white. The larval body in densely covered with bristles. As the larva grows, it becomes smoother and lighter in 5 colour due to rapid stretching of the cuticular skin during different instars of the larval stage. The prementum is also chitinized, and its distal part carries a median process known as spinneret through which silk is extruded out from the silk gland. The sensory labial palpi are found on both sides of the spinneret.. In females, the sexual marking appear as a pair of milky white spot in each of the eighth and ninth segments and are referred to as Ishiwata's Fore Gland and Ishiwata's Hind Gland respectively. In males a small milky white body known as Herold's Gland appears ventrally in the centre between eighth and ninth segments. The larval growth is marked by four moultings and five instar stages. The full-grown caterpillar develops a pair of sericteries or silk glands. Sericteries or silk glands are modified labial glands. These glands are cylindrical and divided into three segments: Anterior-, middle- and posterior-segments. The inner lining cells are characterized by the presence of large and branched nucleus. These glands secrete silk which consists of an inner tough protein, fibroin, enclosed by a water soluble gelatinous protein, sericin. In Bombyx, the fibrinogen which on extrusion is denatured to fibroin is secreted in the posterior segment of the gland and form the core of the silk filament in the form of two very thin fibres called brins. The sericin, a hot water soluble protein, secreted by middle segment of the gland, holds the brins together and covers them. The duct from another small gland called Lyonnet's gland, that lubricates the tube through which the silk passes, joins the ducts of the silk glands. Finally, the silk is moulded to a thread as it passes through the silk press or spinneret.

Pupa :Pupa is the inactive resting stage of silkworm. It is a transitional period during which definite changes take place.. Sex markings are prominent and it is much easier to determine the sex of pupa. The female has a fine longitudinal line on the eighth abdominal segment, where as such marking is absent in case of male. The pupa is covered within a thick, oval, white or yellow silken case called cocoon. The pupal period may last for 8-14 days after which the adult moth emerges slitting through the pupal skin and piercing the fibrous cocoon shell with the aid of the alkaline salivary secretion that softens the tough cocoon shell.

Adult: The adult of Bombyx mori is about 2.5 cm in length and pale creamy white. After emergence the adult is incapable of flight because of its feeble wings and heavy body. It does not feed during its short adult life. The moth is unisexual and shows sexual dimorphism. In male eight abdominal segments are visible; while in female, seven. The female has comparatively smaller antennae. Its body and the abdomen are stouter and larger, and it is generally less active than male. The male moth possesses a pair of hooks known as harpes at its caudal end; while the female has a knob like projection with sensory hair. Just after emergence, male moths copulate with female for about 2-3 hours, and die after that. The female starts laying eggs just after copulation, which is completed within 24 hours. A female lays 400-500 eggs. The eggs are laid in clusters and are covered with gelatinous secretion of the female moth.

Life cycle : Egg : 7 -8 days; Larvae: 20 – 22 days; Pupa: 10 days; Adult : 7 days

Sexual dimorphism in *Bombyx mori*

Sex can be distinguished by district markings in the larval, pupal and adult stages.

Sexual dimorphism in larva

Ishiwata's fore glands and Ishiwata's hind glands lie on the ventral side of eight and ninth abdominal segments of female larvae.

Single median opening present at the junction of 8^{th} and 9^{th} segment of male larvae is called Herold's gland. These glands can be seen in the freshly moulted 4^{th} / 5^{th} instar larvae.

Sexual dimorphism in pupa

Female pupa is larger with broader abdomen. A vertical line is seen at the centre of eighth abdominal segment on the ventral side

Male pupa is thinly built with narrow abdomen. A small round spot is seen on the ninth segment

Sexual dimorphism in adult

Male & Female moths can be distinguished using morphological characters

Characters	Female	Male
Colour	Pale	Darker
Activity	Less active	More active
Antennae	Small	Large
Body size	Large	Small
Abdomen	Large and flat	Long and narrow
External genitalia	Caudal end has a median knob like projection with sensory hairs. This knob is protruded and retracted to expel the pheromone	Caudal end has a pair of hooks known as harps helping in copulation

Moriculture: Cultivation of mulberry plants for rearing the silkworm called as moriculture.

Mulberry:Origin : Mulberry, *Morus* spp. is believed to be a native of the lower slopes of the Himalayas either in India or China. Towards the year 2800 BC, Chin-Nong, one of the successors of Emperor Fo-Hi taught cultivation of mulberry in China. Mulberry is cultivated in 29 countries.

Species : There is no unanimity in the classification of the genus *Morus* into species. There are four common species of the genus that occur throughout India.

1. *Morus alba* *2.Morus nigra* *3.Morus latifolia* *4.Morus laevigata*

Apart from these,

5.Morus indica and 6.*Morus serrata* also occur in Himalayan ranges.

Morphology of Mulberry plant :

Mulberry belongs to the Family Moraceae. The characteristic feature of this family is the presence of idioblasts. Mulberry is a deep rooted perennial plant with highly branching root and shoot systems with primary, secondary and tertiary branches. Normally it grows into a tree, but in cultivation, it is raised as a middling or bush by pruning. The colour of the bark of the stem varies from green, grey to pink or brown and has a number of lenticels which are important for classification purposes.

Each node bears a bud and two accessory buds. These axillary buds are green at first and turn to brown later on. These are two types of buds- vegetative and reproductive. Vegetative buds give rise to vegetative parts of the plants like leaves and branches. Reproductive buds give rise to the male and female inflorescence in addition to leaves.

The leaves are simple alternate, stipulate and petiolate. They may be entire or lobed but rarely both types are found in the same plant. Leaf may be glossy or scabrous in texture. Leaf tip (apex) may be long caudate (tailed), caudate or acute. Leaf margin may be acute or crenate or serrate or dentate. The base may be straight, shallow, deep or overlapping.

The inflorescence is a catkin or spike. Flowers are unisexual. Trees may be monoecious or diocious. The male catkin is usually longer than the female catkin.

A male flower has four perianths and four stamens. The stamen is composed of anther and filaments. The female flower has a pistil and four perianths. The pistil is composed of stigma, style and ovary. After pollination and fertilization the entire inflorescence becomes a multiple or aggregate fruit.

Importance of different morphological characters influencing leaf yield.

1. Internodal length: As the internodal length increases, yield decreases.

2. Leaf area and lobation: As the leaf area increases, yield increases.

3. Lobation: Lobation and yield are negatively correlated.

4. Specific leaf weight: Leaf weight per unit area is positively correlated with yield.

5. Leaf shoot ratio: Normally the leaf: shoot ratio will be 40 : 60. ` The weight of leaves should be higher and that of shoot should be lower.

6. No. of branches per plant: More number of branches will result in higher yield.

1.Ecological requirements for mulberry cultivation

Climate : The optimum elevation for mulberry growth is about 700 m above MSL. For cultivation purposes, an elevation of 300 to 900 m above MSL is the optimum range. The ideal

temperature is 24 to 28° C, relative humidity is 65 to 80% and sunshine duration 5 to 12 hours per day. Mulberry cannot sprout below 13°C or above 38°C.

Rainfall : A rainfall range from 600 m to 2500 mm per year is considered ideal. During the growth period, mulberry requires about 280 – 400 ml of water to synthesize one gram of dry matter.

Soil : As mulberry is a perennial, deep -rooted plant, soil structure must be sufficiently porous to supply air and water to the root zone. Soil should be deep, fertile, porous, well drained and with good water holding capacity. Loamy, clayey- loamy or sandy - loamy soils are the best. Slightly acidic soils (6.2 to 6.8pH) free from injurious salts are ideal.

2. Mulberry varieties

Irrigated : Kanva 2 (M5) , MR 2, S 30, S36, S 54, DD (Viswa), V1.

Semi irrigated : Kanva 2, MR 2.

Rainfed : S 13, S 34, RFS, 135, RFS, 175, S 1635.

Variety	Yield (ton/ha/year)
Local	25
Kanva2, MR2, S 30	35
S 36, DD	40
S 54	45
V1	60
Rainfed conditions	17-18

3. Methods of propagation:

The methods of propagation of mulberry are,

1. Sexual propagation
2. Vegetative propagation
3. Micro propagation.

1. Sexual propagation / seedling propagation

This method is rarely practiced for breeding purposes in research institutes. Here the flowers are protected from cross pollination and only controlled pollination allowed.

2. Vegetative propagation

This is the most popular method used for commercial plantation. Its chief advantages are,

i) The desired hereditary characters can be maintained throughout.

ii) Large number of plants can be raised quickly and economically.

iii) Pest and disease resistant plants can be grown.

The vegetative propagation methods are,

1. Cutting
2. Grafting
3. Layering

1. Cutting :

This is the most popular method of cultivation in South India. This method is adopted for growing varieties fully acclimated to local conditions. It is the easiest method.

Demerit : Under temperate conditions, rooting and establishment is slow.

2. Grafting : Grafting is a technique of joining the parts of two plants in such a way that they unite and grow as one plant. Scion, which forms the upper portion is the desired variety and the stock, which forms the lower portion is local hardy variety. This method is not popular because of laborious process, high cost and skill involved. Large number of planting materials cannot be obtained in short period of time.

3. Layering : This method of propagation involves the development of roots from a stem while it is still attached to the mother plant. The rooted stem is then detachted, to be grown as a new plant. Such a rooted stem is known as 'layer'.

Merits : Simplicity; there is no fear of the roots getting dried up as in cuttings; used to obtain a large sized plant in a short time; used to fill in the gaps in the field where cuttings have failed to grow.

Demerits: Time consuming, expensive, unsuitability for large scale multiplication, poor rooting varieties cannot be layered.

4. Micro-propagation methods: Conventional vegetative propagation methods like cutting, grafting and layering require a locally adapted variety for rooting to take place. They also take long time for establishment. They do not allow any room for genetic manipulation or improvement of the varieties.

In order to develop new varieties as well as to propagate them in as short a period as possible and also in as large numbers as possible, new micro propagation methods involving tissue culture have been evolved.

Selection of semi hard wood cuttings: Cuttings are selected from well established garden of 8 - 12 months old. Only full grown thick main stems (pencil thickness size) free from pest and disease damages having a diameter of 10-12 mm are chosen for preparation of cuttings. The cutting should be of 15-20 cm with 3-4 active buds and should have 45^{o} slanting cut at the bottom end. Care should be taken to make a sharp cut at both the ends of cuttings without splitting the bark. Manually or power operated mulberry cutter (stem cutting machine) may be used for quick cutting of propagation materials.

Nursery propagation: An area of 800 m^2 red loamy soil near water source is to be selected for raising saplings for planting one hectare of main field. 1600 kg of farm yard manure

is applied in the nursery area and mixed well with the soil. Nursery beds of 4 x 1.5 m size are raised. The length may be of convenient size depending upon the slope and irrigation source. A drainage channel is provided.

Pre-treatment of cuttings: One kg of *Azospirillum* culture is mixed in 40 liters of water. The bottom ends of the cuttings are kept or 30 minutes in it before planting. *Azospirillum* is applied for inducement of early rooting.

Nursery planting: *Vesicular Arbuscular Mycorrhiza* (VAM) is applied at 100 g/m² of nursery area. Nursery bed is irrigated. Cuttings are planted in the nursery at 15 cm x 7 cm spacing at an angle of 45^{o}. Exposure of one active bud in each cutting is to be ensured.

Nursery management: Nursery is irrigated once in three days. To avoid termite attack one kg of endosulfan 4 D or malathion 5 D or quinalphos1.5 D is applied around the nursery bed. To avoid root rot and collar rot, soil is drenched with carbendazim 50 WP (2 g/l) using rose can or *Trichoderma viride* is applied at 0.5 g/m^2. After weeding, 100 g of urea/m^2 is applied between 45 and 50 days after planting.

Age of sapling: The saplings are ready for transplanting in the main field after 90-120 days of planting.

Mainfield preparation : The field is leveled first. It is ploughed deeply initially using heavy mould board plough followed by country plough upto a depth of 12" to 15" in order to loosen the soil. Weeds and gravel are removed. FYM is applied at 20 t/ha (irrigated) or 10 t/ha (rainfed). The manure is incorporated by repeated ploughing.

Planting is done during monsoon period. Winters and summer months are avoided.

Planting methods: Pit system; Row system; Paired row system; Kolar system

1. Pit system: This system is followed for rainfed crop. Instead of ploughing the entire field, pits of standard size (45 x 45 x 45 cm) are dug. Equal quantities of organic manure, red soil and sand are placed in each pit after mixing and a sapling is planted. Spacing is 90 x 90 cm.

2. Row system: Row system is followed for irrigated mulberry. Ridges and furrows are formed. Spacing is 60 x 60 cm (rainfed - 90 x 0 cm). This method is suited to high yielding varieties likes V1.

3. Paired row system: The spacing is 75/105 x 90 cm. Inter crops can be raised in the wider spacing. The advantages are less weeds, additional income, mechanization is possible and water saving. Inter crop should not compete with mulberry. Space created should be effectively utilized. Incompatible crop invites pest and disease problem.

Kolar system: This is similar to the row system except that the distance between the plants is very much less. Spacing between row is 30 - 45 cm and the distance between plants is 10 -15 cm. This is followed in Kolar district of Karnataka and so is called the Kolar system.

Merits : Less weed. More leaf shoot ratio (thin stem). Suited to local varieties.

Demerits : Mechanization is not possible. Microclimate (dense) favours mildew disease.

Population/ha : 60 x 60 cm = 27,777

90 x 90 cm = 12,345

Inorganic manures

The nutrient requirement of mulberry / ha/y is the highest compared to any other field crops. Nearly 30-40% of total cost of cocoon production goes to Fertilizers and manures alone. Recommended schedule is 300: 120 : 120 NPK kg/ha/y. N is applied in 5 split doses and P and K in two split doses.

Micro nutrients: Fe, Zn, Cu, Mn, Cu, Mo and B

Apply foliar spray of micro nutrients when deficiency symptoms are exhibited

Spray micronutrient nutrient mixture containing $FeSO_4$ 10 g , $ZnSO_4$ 5g, Borax 2.5 g, $CuSO_4$- 2.5 g, $MnSO_4$ – 2.5 g and Sodium molybdate–100 g @ 600 litres of spray fluid /ha.

Water management : Water requirement of mulberry is 1100 mm /1200 mm/ha/year. To produce 1.0 kg of mulberry leaves, 320 liters of water is required irrigation can be better regulated through ridges furrows. **Frequency :** 8 -10 days for sandy soils , 15 days for clayey soils **Methods of irrigation**: Surface and drip irrigation, Drip irrigation can save up to 40% of water. Fertigation through drip system can provide better nutrition to crops.

Methods of harvesting of leaves: the nutritive value of leaves changes according to to photosynthesis activity and respiratory activities of the leaf. leaf harvested in noon contain less water and more carbohydrate. so harvesting can be done in morning.

Leaf picking: Leaf picking can be done ten weeks after bottom cutting or pruning and subsequent picking can be done after seven to eight weeks. Leaves are picked from the main stem with petiole and terminal buds are nipped off so that lateral shoot develops rapidly. The main advantage of this method is that leaves can be selected to suit the growth stages of larvae .it required more labour.

Branch cutting: this method is called Batchi system in Kashmir. In this method entire branch is harvested and used to feed worms after III moult directly. this method saves labour for harvesting easy to cleaning. leaves of branches retain for longer period.

Whole shoot harvest: in this method of harvest cutting of the branches to ground level by bottom pruning and feeding entire shoot to larva after IV moult. Harvesting of shoot can be done at intervals of 10-12 weeks and 5-6 harvests can br done in a year. this method is popular in kolhar Karnataka ,malda in WB.

Preservation of leaves: The leaves can be kept in small leaf preservation bags of 2'x3; size, having a capacity for holding -4 kg leaves. these bags of gunny or polythene they should be double layered. They are god than traditional method of storing in heaps and covering them with wet gunny cloth.

Silkworm Rearing House:

- A separate house is ideal for rearing of silkworm
- The rearing house should have sufficient number of windows to permit cross ventilation.
- Provision should be made to make it air tight for proper disinfection.
- Rearing house has to be built in such a way to provide optimum temperature of 26-28º c and RH of 60-70% for the growth of silkworm at minimum operational cost

Importantprinciples

The most important principles to be remembered in silkworm rearing house are :

Avoid

* Damp condition * Stagnation of air

* Direct and strong drift of air * Exposure to bright sun light and radiation

Ensure

* An equable temperature and humidity * Good ventilation.

Features:

- Rearing house should be built depending on the brusing capacity and the method of rearing. The rearing area of 2 sq.ft/ dfl for floor rearing and 3 sq. ft/ dfl for shoot rearing is the general criteria.
- Rearing house should have a main rearing hall, an ante room (8 x 8 ft) and leaf preservation room. Maintaining a separate chawki room (a must for two- plot rearing system; rearing room of size 10' x 14' with a height of 9-10 ft for an acre of garden) ideal.
- Rearing house should face east-west direction.
- Rearing houose should have facilities to maintain the required environmental conditions.
- Growing trees around rearing house helps to maintain favourable environment
- Rearing house should be constructed taking consideration he following points such as effective is disinfection, washable floor, etc.
- 480 sq.ft area is required for rearing 100 dfls.

Preparation of rearing house

- Rearing room is to be kept ready after disinfection atleast 3-4 days in advance of commencement of rearing.
- Preconditioning of the rearing house is essential *ie,* arrangement of rearing appliances and provision of essential environmental conditions one day in advance.

Preparation for brushing

- Before commencement of each rearing, the rearing equipments and rearing houses must be thoroughly washed and disinfected with chlorine dioxide.
- Chlorine dioxide is sprayed on equipments, walls, roof and floor uniformly to destroy the disease causing organisms.

- The rooms should be kept closed for about 24 hours after disinfection.
- The doors and windows should be kept open at least for 24 hours before commencement of rearing to avoid traces of disinfectants.
- To disinfect rearing room and rearing appliances, chlorine dioxide can be used. 500 ml of chloride dioxide is mixed with 50 g of activator and this is dissolved in 20 litres of water. To this, 100 g of lime powder has to be mixed.

Rearing appliances:Non recurring (General)

- Disinfection mask and protective gum shes .Sprayer for disinfection
- Room heater , Water air cooler Kerosene blow lap ,Wet and dry thermometer
- 6" forceps

Non-recurring (specific)

- Egg transportation box ,Egg incubation chamber ,Loose egg incubation frame
- Black box ,Chawki rearing trays ,Rearing bottom stand,Feeding Stand ,Ant wells
- Leaf chopping board ,Leaf chopping knife,Leaf mat,Bed cleaning nets
- Earthen pot,Litter basket,Late age rearing trays,Rearing stand ,Shoot rearing rack
- Chandrike,Plastic basin,Buckets,Mug,Plastic box,Foam pads,Foot rugs
- Leaf chamber for late age, Leaf basket,Cleaning nets

Recurring

- Paraffin paper,Formalin ,Bleaching powder ,Lime powder ,Bed disinfectants
- Slides and cover slips ,Gunny cloth,Cora cloth

Disinfectants and Disinfection Methods

Disinfection is an integral part of healthy and successful silkworm rearing. It aims at the total destruction of disease causing pathogens. Several diseases caused by bacteria, viruses, fungi and protozoa affect the silkworms. These pathogens released by diseased silkworms easily accumulate and spread in the rearing environment through different routes. They are not easily destroyed and can persist / survive for long periods under congenial conditions. The spores of the pathogens, especially those of fungi are light and can easily be drifted by air current resulting in easy spread of diseases. There are no curative methods for any of the silkworm diseases and they are best prevented than cured. This is achieved by adoption of proper and effective methods of disinfection and stepwise maintenance of hygiene during rearing. To realize the benefit of disinfection (mass) and rearing at village or block level considering them as one unit.

Chemical Disinfectants available for use in Sericulture

Formalin

It is commercially available as 36% formaldehyde in solution form. A mixture of 2 % formalin + 0.05 % detergent is an effective solution that can be used for disinfection purpose as spray. Formalin is effective only in rearing houses, which can be made airtight

and it is faster and more pronounced at temperature above 25 ^{0} C and humidity more than 70 %.

Bleaching powder

It is white amorphous powder, with a pungent smell of chlorine. For effective disinfection, a high-grade bleaching powder with an active chlorine content of 30 % must be used. It should be stored in sealed bags, away from moisture, failing which it will be rendered ineffective. The action of bleaching powder is optimal under wet and contact conditions and therefore the surfaces of equipment and walls should be drenched with this solution. A 2% bleaching powder in 0.3 % slaked lime solution is used for disinfection as spray.

Slaked lime

A very useful bed disinfectant in sericulture. especially against viruses. It absorbs moisture and can be used to regulate bed humidity and maintain hygiene. Application of lime dust in combination with bleaching powder in and around rearing houses and premises improves hygiene in the environment.

Chlorine dioxide

Chlorine dioxide marketed as sanitech is an ideal disinfectant available at 20,000 ppm concentration is a strong oxidizing agent, effective at broader pH range and at 2.5 % concentration in combination with 0.5 % slaked lime is effective against all silkworm pathogens. It is stable and may be activated at the time of its use. it possesses tolerable odour and is least corrosive at the suggested concentration.

Material required for disinfection

Disinfectants, detergent, sprayer – Rocking or Power sprayer, buckets, measuring jar, weighing scales, gas masks, metal pans, room heaters, slaked lime powder, hand gloves and muslin cloth.

Technology for Prevention / Control of Diseases in Silkworm

The technology for prevention / control of diseases in Silkworm rearing is as sequential steps.

Cleaning of rearing house and appliances

(after completion of silkworm rearing and cocoon disposal)

Immediately after the disposal of cocoons, collect at one place inside the rearing house, all diseased and dead larvae, pupae, floss, left over mulberry, bed refuse, silkworm faeces, dust, dirt, etc., and disinfect by sprinkling 5 % bleaching powder solution and dispose off by burying at 2 ft.depth or burning.

Disinfection of rearing house and appliances

(with appliances inside the rearing house)

Measure the length and breadth of the rearing house including leaf preservation room, mounting room/place, etc., and calculate the floor area for disinfection

Estimation of the quantity of disinfectant required

The disinfectant required for disinfection of rearing house is 2lt/sq.m floor area or 185 ml/sq.ft. floor area.

To estimate the quantity of disinfectant solution required, multiply the floor area in square meter by 2.0 or the floor area in sq.ft. by 0.185 which gives the actual disinfectant required in litres for disinfection of inside of the rearing house.

Disinfection

Disinfect the rearing house using 2 % bleaching powder in 0.3 % slaked lime, 2.5 % Chlorine dioxide in 0.5 % slaked lime or 2 % formalin + 0.05 % detergent solution.

Disinfection of rearing house, appliances, etc., inside the rearing house

Spray using powerful jet sprayer, the required quantity of disinfectant (@2.0 lt/m^2 floor area of rearing house +25 % of disinfectant solution for appliances + 10 % for outside of rearing house) uniformly to drench all parts of rearing house inside appliances and outside. Keep the rearing house closed for a minimum period of 6 to 10 hours. After minimum period of 18-24 hours, shift the rearing appliances out of rearing house and sundry for 10 – 12 hours.

Silkworm rearing using the mulberry shoot do not require the rearing trays but uses the platform. Rearing trays are the main source of infectious agent and most difficult and expensive to achieve disinfection. To avoid this, changing over to rearing silkworm on shoot is advantageous. This method does not require additional disinfectant for appliances as only the rack and nylon nets are used.

Disinfection prior to brushing

Disinfection process should start 4-5 days prior to brushing. However, the eggs may be incubated in separate disinfected incubation room.

Five days before brushing

The rearing house and appliances are cleaned, washed in water. if trays and other appliances namely, basins, Vinyl sheet,leaf basket, etc., are used, conduct additional disinfection by dipping them in disinfectant or spraying disinfectant.

Dipping in disinfectant

Disinfect the rearing appliances that could be disinfected with 2 % bleaching powder in 0.3 % slaked lime solution by dipping them for 10 minutes in the solution in a disinfection tank. A tank of 2 feet depth and 4 feet diameter is suitable for disinfection. Prepare the disinfectant solution to fill half of the height of the tank. To determine the quantity of disinfectant solution to be prepared in the tank, calculate the volume of the tank using the formula 22/7 * r^2 h (where r is the radius and h is the height of the tank)

Disinfection by spraying

Disinfection of appliances by dipping in disinfectant is the best method. However, where the facility of disinfection tank is not available, the following method is advised.

Disinfect the appliances using 2 % formalin + 0.05 % detergent solution or 2.5 % of Sanitech in 0.5 % slaked lime or with 2 % bleaching powder in 0.3 % slaked lime solution. Spray disinfectant @ 35 ml/sq.ft. surface area or 700 ml for a tray of 3.6 feet diameter. After the spray, put them together and keep completely covered with vinyl sheet for a minimum period of 6 hours. Disinfect the mountages also, following the above method.

Four days before brushing

Sun dry the appliances. If the prevalence of viral diseases (Grasserie and flacherie) were high during the previous crop, spray 0.3 % slaked lime in water (3 g/lt) to the rearing house and appliances @ 2 lt/sq.m floor area + additional requirements. Sun dry the appliances after 1-2 hour of spray.

Three days before brushing

Conduct second disinfection of rearing house and appliances. Shift all the disinfected appliances into the disinfected rearing house and arrange in the room. Disinfect the rearing house and appliances by spraying 2 % bleaching powder in 0.3 % slaked lime solution or 2.5 % Sanitech in 0.5 % slaked lime or 2 % formalin + 0.05 % detergent solution. The quantity of disinfectant solution required is calculated and sprayed as per the **first** disinfection. After disinfectant spray, keep the room closed preferably for 24 hours. The second disinfection may follow the first if the gap between the two is not much.

Two days before brushing

Dust 5 % bleaching powder in slaked lime powder @ 200 g/sq.m at the entrance of the rearing house and the passage to it. Sprinkle water @ 1 lt/sq.m floor area. Open the windows of the rearing house and ventilate to drive off all the odour of disinfectant. Prevent contamination of rearing house and appliances.

One day before brushing

Arrange appliances for chawkie rearing and maintenance of hygiene. Keep the rearing room and mounting hall closed and open only one day before the larvae are to be shifted.

Silkworm rearing:

Rearing Equipments

i) **Rearing house**: The rearing house should meet certain specification, as the silk worms are very sensitive to weather conditions like humidity and temperature. The rearing room

should have proper ventilation optimum temperature and proper humidity. It should be ensured that dampness, stagnation of air, exposure to bright sunlight and strong wind should be avoided.

ii) **Rearing stand:** Rearing stands are made up of wood or bamboo and are portable. These are the frames at which rearing trays are kept. A rearing stand should be 2.5 m high, 1.5 m long and 1.0 m wide and should have 10 shelves with a space of 20 cm between the shelves. The trays are arranged on the shelves, and each stand can accommodate 10 rearing trays.

iii) **Ant well:** Ant wells are provided to stop ants from crawling on to trays, as ants are serious menace to silk worms. They are made of concrete or stone blocks 20 cm square and 7.5 cm high with a deep groove of 2.5 cm running all round the top. The legs of the rearing stands rest on the centre of well filled with water.

iv) **Rearing tray:** These are made of bamboo or wood so that they are light and easy to handle. These are either round or rectangular.

v) **Paraffin paper:** This is a thick craft paper coated with paraffin wax with a melting point of 55^{o} C. It is used for rearing early stages of silk worms and prevents withering of the chopped leaves and also help to maintain proper humidity in the rearing bed.

vi) **Foam rubber strips:** Long foam rubber strips 2.5 cm wide and 2.5 cm thick dipped in water are kept around the silkworm rearing bed during first two instar stages to maintain optimum humidity. Newspaper strips may also be used as a substitute.

vii) **Chopsticks:** These are tapering bamboo rods (1cm in diameter) and meant for picking younger stages of larvae to ensure the hygienic handling.

viii) **Feathers:** Bird feathers preferably white and large are important items of silkworm rearing room. These are used for brushing newly hatched worms to prevent injuries.

ix) **Chopping board and Knife:** The chopping board is made up of soft wood it is used as a base for cutting leaves with knife to the suitable size required for feeding the worms in different instar stages.

x) Leaf chambers: These are used for storing harvested leaves. The sidewalls and bottom are made of wooden strips. The chamber is covered on all sides with a wet gunny cloth.

xi) **Cleaning net:** These are cotton or nylon nets of different mesh size to suit the size variations of different instars of the silk worm. These are used for cleaning the rearing beds, and at least two nets are required for each rearing tray.

xii) **Mountages:** These are used to support silkworm for spinning cocoons. These are made up of bamboo, usually 1.8 m long and 1.2 m wide. Over a mat base, tapes (woven out of bamboo and 5-6 cm wide) are fixed in the form of spirals leaving a gap of 5-6 cm. They are also called **chandrikes**. Other types of mountage such as **centipede rope mountage**, **straw cocooning frames** etc. are also used.

xiii) **Hygrometers and Thermometers:** These are used to record humidity and temperature of the rearing room.

xiv) **Feeding stands:** These are small wooden stands (0.9 m height) used for holding the trays during feeding and bed cleaning.

Other equipments like feeding basins, sprayer, and leaf baskets may also be required.

Mulberry production for chawki rearing – Chawki rearing refers to rearing of young age silkworms.Chawki in Japanese means young age.

Need for chawki mulberry garden : Leaf quality plays an important role for healthy, chawki rearing. The nutrient requirements of chawki worms are totally different from that of late age worms. Chawki worms require soft, succulent leaves rich in carbohydrates while late age worms require coarse leaves with less moisture but high protein content. A separate chawki garden is required for quality leaf production to meet the requirement of chawki worms

i. Establishment of chawki garden/ production of Mulberry leaves for chawki rearing

Mulberry garden would be ready for first harvest of leaves six months after establishment. However for the sake of well establishment, it is advisable to go for three light harvests of leaves till one year of planting. The garden will be well established in one year after planting.

ii. Pruning : Different pruning cum harvest schedules have been standardized in chawki gardens depending upon the requirement of leaves for chwki rearing. Twelve and eight harvest schedules are widely followed in chawki gardens

Twelve harvest schedule for Chawki rearing

First basal pruning is done at 30 cm above ground during monsoon. After three leaf harvests at 15 days interval, go for middle pruning at 60-70 cm above ground. Following this three more leaf harvests can be done. Repeat the pruning sequence. Thus two basal pruning, two middle cuts are done in a year facilitating 12 harvests for chawki rearing. Remove weak branches 20 days after each pruning.

Principles of chawki rearing :

Chawki rearing – Rearing of young age worms

Nutrient requirements of chawki worms are soft succulent leaves rich in protein and carbohydrates. For healthy chawki rearing, leaf quality plays an important role. From the general mulberry garden, the leaves contain very less moisture (<76%) and are not satisfying nutritional requirements of chawki worms. Hence a separate chawki garden is to be established for chawki rearing. Maintenance of temperature and humidity is to be ideal for rearing healthy chawki worms. Rearing conditions are just different from that late age worms. Hence a separate chawki rearing room is imperative.

Characters of chawki larvae: Withstand high temp, high humidity and bad ventilation.Weak against pesticides and chemicals.Disease resistance is less.Ingestion is less ; but digestion is

more.High growth rate : By consuming 6 % of leaf, the larvae grows 300 times body size; 400 times body weight, 500 times increase in silk gland weight. Good nutrition is essential.Body water content is very low in the newborn larvae but increases rapidly till second instar. So it requires high water content in mulberry leaves and humid conditions in rearing house.

Chawki rearing methods

Chawki rearing methods are: 1.Stand rearing 2.Box rearing3.Chamber rearing

Stand rearing: Chawki larvae are reared in plastic trays of 3'x 4' size. The trays are arranged in rearing stand. Paraffin paper is used us seat and cover. This method acquires more floor area.

Isolation chamber rearing: Chambers are made of plywood sheets with double doors fitted with heaters humidifiers; temp & RH are maintained by thermostat and humidistat. Rearing is done in the chamber by piling up the trays on chawki stand. This is useful for large scale brushing of 500-1000 dfl at a time.

Box rearing: Plastic trays are used for rearing. The trays are kept one over other as a box. This method helps to maintain temperature and humidity. The trays are arranged in crisscross pattern to allow aeration. Thirty minutes before feeding and during moult, paraffin papers are removed.

Rearing house: A separate rearing house with adequate spacing, sunlight and aeration is essential. This will enable effective disinfection. The rearing house should be constructed far away from dwelling houses**.**

Feeding: Harvest mulberry leaves during cool hours of the day.Preserve the larvae with gunny cloth.2-3 feeds / day is essential.Leaves need to be chopped to enable uniform feeding.

Quantum of leaf and space required for 100 dfl

	CSR hybrid			**Cross breed**		
	Leaf kg	**Space**	**Trays**	**Leaf**	**Space**	**Trays**
I instar	5.0	24.0 sq.ft	2 No.	4.0 kg	24.0 sq.ft	2 No.
II instar	15.0 kg	60.0 sq.ft	5 No.	12.0 kg	48.0 sq.ft	4 No.

Bed cleaning: No cleaning for first instar.Twice during second instar

Moulting care: Remove the top paraffin papers when larvae settle for moult.Dust a thin layer of lime @ 3 g / ft^2 .When 95% larvae are out of moult apply bed disinfectant, Vijetha.

Transportation of chawki larvae

- Check for disease occurrence before distributing the larvae to farmers.
- Distribute the larvae when they are settled for second moult.
- Transport during cooler hours of the day.

Concept of community chawki rearing centers (CRC)

Chawki rearing requires technical skill and necessary equipments to maintain temperature and humidity. Expertise is often not available with sericulture farmers. To overcome these difficulties, establishment of community chawki rearing center is recommended. Chawki larvae are reared at CRCs at ideal temp of 28°C of humidity of 85 – 90% with the leaves obtained from well maintained chawki garden. The worms distributed from CRCs tend to grow vigorous, healthy and give stable yield at rearers' house.

Advantages of CRC: Supply of healthy disease free chawki worms .Cut down the cost of chawki rearing.Saving of time and energy of sericulture farmers.More silkworm crops/year can be realized.Opens up enterprising avenues for youth.

Plan for CRC with 8 harvest schedule: Area : 1.6 acres – Four plots of 0.4 acre each, Number of dfl/ crop : 2500 dflNumber of crops/annhum : 32 ,Number of dfl/ annum : 80,000 dfl Leaf requirement : 500 kg/100 dfl

Schematic plan for eight harvest schedule- Leaf picking : I, III, V, VII harvests, Shoot harvest: II, IV, VI, VIII

Rearing of late age worms: Rearing of silkworm larvae from third instar to spinning is termed as late age rearing and is usually completed in 14- 16 days. During this phase silkworms consume 94.5 % of total leaf requirement accounting for 133 times increases in body size, 125 times increase in body weight and 1000 times increase in silk gland weight. Late age worms are sensitive to high temp and humidity bedsides diseases.

Rearing of late age worms is by:a. Tray method – by leaf picking b.Shoot rearing – by providing shoots

Shoot rearing technology

- Larvae are reared in shelves arranged in 2-3 tiers with a gap 2 ½ feet in between. The racks can be constructed using wood/Bamboo/steel. Netting can be done with Nylon

mesh, ropes covered with old news papers. Cost of the rack for rearing 150 dfl is Rs.3000/-

- Entire shoots are harvested and fed to the silkworms. Shoots are arranged alternately to provide uniform spacing and aeration.
- It is possible to keep more worms per unit area compared to tray rearing method.
- Bed cleaning is to the minimum. After two to three feeds, the bed is cleaned by passing ropes and removing the old branches and litter.

Advantages: Better keeping quality of leaf during storing and in the rearing bed.Handling of the silkworm is minimized and as such spread of disease by contamination is eliminated.Bed cleaning is to the minimum.Worms and leaves do not come into contact with litter and chances of secondary contamination is less.Better aeration is ensured.Effective rate of rearing (ERR) and cocoon characters are improved.Leaf saving is up to 20%Labour saving is up to 70%.Cost of production is reduced and hence productivity increases.

Disadvantages: Requirement of floor area is more.Planting materials are not available.Separate rearing house is necessary.Bed refuse is not available for cattle.Rearing house.There should be separate rearing house for late age worms.The height of the building is to be about 12 feet.Each rearing house should have an independent rearing hall with a storage room and an ante room.

Leaf quality: Late age worms require mature leaves with less moisture content.Medium coarse and coarse leaf but nutritious leaf.50-60 day old leaf.Preserve the leaves in leaf chamber covering with gunny cloth.

Environmental conditions: Temperature: 24-26^{o}C; RH: 70-75 % ; Good aeration is required

Bed spacing and feeding: Spacing : For cross breeds - 400 sq.ft / 100 dfl; for bivoltines – 600 sq.ft / 100 dfl

Feeding: Shoot requirement - CB – 1200 kg / 100 dfl Bivoltines – 1400 kg / 100 dfl

Moulting care: Worms require dry conditions during moulting. Keep the rearing beds thin and apply lime powder @ 50g/m^2 .Stop feeding when 90-95% of worms settle for moult.When 5% of worms mature, apply *sampoorna* @ 20 ml in 4l of water over feed. It will ensure uniform maturity.

Maturity of larvae: At the end of 6th day of final instar, larvae reduce leaf consumption, release wet faecal matter, shrink in size with the body becomes translucent and start crawling with raised

head.On seeing the above indications of larvae, stop feeding as the larvae are ready for spinning.When 5% of worms mature, apply ***Sampoorna*** @ 20 ml in 4l of water over feed. It all ensures uniform maturity.

Mounting and harvesting: When 40% worms are mature, collect the ripe worms for mounting on to mountages

Different mountages: Bamboo mountage,Bottle brush mountage,Plastic collapsible mountage/Netrike / self mountage.Rotary mountage

Mounting: All the gaps in the rearing bed should be filled one day before of spinning to avoid cocoon formation in the rearing bed (patch feeding).50 cleaned disinfected mountages (6'x4') or 35 rotary mountages are required to mount 100 dfls.Mountages should be kept in verandah under shade.

Harvesting: Harvest the cocoons on 5^{th} or 6^{th} day after spinning for cross breeds and for bivoltines harvest it after 7^{th} day of spinning.Remove the flimsy/stained/double cocoons before harvesting the good cocoons.Transport the cocoons in loose gunny bags during cooler house of the day.

Harvesting of Cocoons

The larva undergoes metamorphosis inside the cocoon and becomes pupa. In early days, pupal skin is tender and ruptures easily. Thus, early harvest may result in injury of pupa, and this may damage the silk thread. Late harvest has a risk of threads being broken by the emerging moth. It is, therefore, crucial to harvest cocoons at proper time. Cocoons are harvested by hand. After harvesting the cocoons are sorted out. The good cocoons are cleaned by removing silk wool and faecal matter and are then marketed.

The cocoons are sold by farmers to filature units through Cooperative or State Govt. Agencies. The cocoons are priced on the basis Rendita and reeling parameters. Rendita may be defined as number of kg of cocoon producing 1 kg of raw silk.

Post Cocoon Processing

It includes all processes to obtain silk thread from cocoon.

Pruning for productivity – bottom and middle forms fist and Non fist – Methods of harvesting – preservation of leaves

Pruning : Periodically some branches of the mulberry plant are methodically cut off and this operation is called pruning. Removal of branches will not devitalize the plant but on the other hand invigorate and rejuvenate it. As the available energy is directed to fewer branches and fresh, young shoots, sprout from auxiliary buds.

Pruning vis a vis productivity : Pruning helps to maintain a convenient height for harvest.It induces more vegetative growth .Maintains the shape and size of the plant .Adjust the leaf production to synchronize with the leaf requirements silkworm rearing

- It extends the leaf production period with respect to the season
- It removes the defunct and dead wood
- Facilitates better aeration and sunlight for luxurious growth
- Facilitates easier cultural operations.

Types of pruning : The methods of pruning varies with the place, season, cropping pattern (irrigated / rainfed), method of leaf harvest etc.

Three types of pruning :i. Low cut pruning ii.Middle cut pruning iii.High cut pruning

Low cut pruning Branches are cut to close to the base at 30 cm above ground level.

Merits : Harvesting and preparation of cuttings are easy as the stumps are erect .Harvesting rate increases because sprouting occurs easily.Damage by pests and diseases are removed.High utility .

Demerits : Plants are susceptible to frost and injury during pruning.Aggravates disease incidence and quick disease spread .During rainy season, leaves get spoiled easily

Kolar / strip system of pruning : This system requires heavy fertilization and irrigation. Whole shoot is cut to the ground level at each harvest. Thus pruning and harvesting are

combined together five harvests are made in a year. This is suitable for tropical mulberry where the bud sprouts all through the year.

Middle Pruning: Branches are cut around mid height 60-70 cm .Most widely followed pruning method.Middle pruning stimulates sprouting of lower buds in the bush mulberry

High cut pruning : Branches are cut at the top or to the soft position .The plants mature easily.Wastes content of the leaves is less.Recommended for colder regions

Training : Without pruning, mulberry grows into a tree. Harvesting of leaves for rearing different instars will be difficult. Pruning ensures that quality leaves are available. Pruning done systematically to give specific shape to the mulberry plant is called training.

Two types of training are given to mulberry – fist non fist forms

Fist form : Due to repeated pruning of branches at the same place every year, the top part of the trunk gradually increases in diameter without increase in height. It resembles the shape of a closed fist and is called fist form of training. The latent buds at the base of the fist, sprout into shoots. Pest and disease control becomes easy.

Non fist form : Branches are cut at a level higher than the branching point every year. As a result the branching at the point of the shoot increases in height every year. Hence, the fist does not develop. However retaining old growth leads to recurrence of pests and disease. Different styles of Nonfist form of training are:

Non fist form by low cut - ***ono*** style

Non fist form by Middle cut -***yamagata*** style

Non fist form by high cut - ***akita*** style

Generally low, middle and high cut pruning are followed to get both fist and non fist forms.

Harvesting : There are two method of harvesting *viz*., leaf picking and shoot harvest

Shoot harvest is preferred over leaf picking owing to lesser labour requirement of reduced cost of leaf production. But due to repeated pruning, there will be adverse compact in the growth and yield of mulberry plants. To overcome their problem step-up method of shoot harvest has been developed.

Step up method of shoot harvest : Basal crown height is maintained at 20 cm above ground level .First harvest is done after annual bottom pruning at 20 cm height and subsequent two leaf harvests are made by adding 10 cm each time.After third harvest plants are pruned at 20 cm basal crown height and the cycle is repeated.

Advantage : Maintenance of plant height .Leaf yield is increased by about 6000 kg/ha / years over traditional shoot harvest .Saving of manpower of 100 man days or Rs.5000/ha over leaf picking system.

Leaf yield: It varies with mulberry variety, system of cultivation and region. Average expected yield is 35 mt / ha/5 shoot harvest.

Leaf preservation :i. Leaf storage chamber ii.Storage of harvested shoots

Harvest the leaves at cooler hours of the day in the early morning hours to avoid moisture loss.

Insect pests of mulberry

I. Sucking pests

1.Pink mealy bug : *Macconellicoccus hirsutus* Pseudococcidae : Hemiptera

Symptoms:Malformation of apical shoots, retarded growth.Wrinkling and curling of affected leaves become dark green in colour.Due to secretion of honeydew, sooty mould evelops all over the leaves. Leaves become brittle. Leaves become yellow on severe infestation. Symptoms are collectively called as Tukra (Bushy top).

Nature of damage:Nymphs and adults of *M.hirsutus* suck the sap from tender leaves and buds by piercing the plant tissue. It causes hypertrophy of cells. The infestation occurs in the nodal joints and succulent apical region. Nutritive value of leaves, leaf yield and plant height are

drastically reduced.The affected leaves when fed to silkworm cause a significant reduction in larval weight, cocoon weight, shell weight and shell ratio.

Season: Prevalent throughout the year with higher incidence during summer.

Biology:The mealy bug lays eggs (=250 no) in a loose cottony terminal ovisac. Freshly laid eggs are orange in colour, smooth a smooth and oval with slightly tapering ends. Eggs turn pink before they hatch. Mealy bug completes its life cycle in 23 – 29 days. Egg: 5 – 6 days; Nymph: 2 –3 months.

Management:Destroy the affected parts,Release Australian lady bird beetle C*ryptolaemus montrouzieri* @ 150 No./ ha.,Release *Scymnus coccivora* @ 1000 beetles / ha Follow sequential release of predators.Spray DDVP (1l/ha) or Fors 25 mg/l. safe period : 17 days.

2. Leaf hopper / jassids : *Empoasca flavescens* (F) Cicadellidae, Hemiptera

Diagnostic symptoms:Triangular dark brown spot at the tips and margin of leaves. Drying starts from periphery to midrib of leaves. Finally leaves become cup shaped and leathery.Hopper burn symptoms on the leaves.

Nature of damage: Nymphs and adults suck the sap from lower side of the leaves and deplete nutritive value of leaves. Also, suck the sap from tendor shoots and twigs causing characteristic hopper burn symptoms. Hopper burns are due to the phytotoxemia caused by the reaction of the insects salvia with the plant sap.

Season : Spreads during Oct-May; severe in summer.

Biology:Female lays pale yellow coloured elongated eggs in the epidermis on the under surface of leaf blade. Nymphs are pale green colour, elongated. Egg : 4 – 9 days; Nymphs : 4 instars.

Management:Setting up of light traps for attacking and trapping adults.Spraying of DDPV (Dichlorovas) 76% - 0.05% or dithioate 0.1%. Safe period – 11 days.

3. Black scale : *Saissetia nigra* (Coccidae : Hemiptera)

Diagnostic symptoms:It occurs on the stem, branches and also as small scales on the bark, Generally observed in hilly regions on medium sized trees.

Nature of damage:Nymphs and adults suck the sap and kill the plants,The surface of the stem is covered all over with scales.The lenticells are completely hidden and so the respiration rate of the plant cell is considerately lowered. Season : Throughout the year

Biology :Adult female of S. *nigra* lays 300 –600 eggs – minute white elongated. Eggs later become reddish brown. Nymphs crawl and select the place of feeding on the stem. It secretes a fibrous wacky material which hardens to form the scale. ♀ moults three twice ♂ moults twice. They lose appendages in reproduction. Parthenogenetic reproduction.

b. Red scale : *Aonidiella auranti* Coccidae : Hemiptera

A common pest of citrus found to attack mulberry in hilly areas of India. Nymphs and adults attack twigs branches and stems causing a loss of vitality. The maximum damage is done during the first one and half years of planting. It does not attack the older plants. In case of heavy infestation, leaves turn yellow and finally the plant while plant dries up. Plants shoots are covered with reddish brown scales with dark patches of sooty mould growing on honey decoration.

c. Soft scale / Mealy scale : *Pulvinaria mori* Coccidae Hemiptera

White colured nymphs and adults are distributed more on leaves than on branches causing yellowing and wilting symptoms.

Management of scale insects:Prune and destroy the affected branches.Mechanical removal of insects in the initial stages of infestation.Apply Fish Oil Resin Soap (FPRS) @ 40 g / l in branches; add wetting agents for better adherence on the scales.In endemic areas smear with insecticidal solutions, just after pruning.Release of *Cryptolaemus montrouzieri* @ 750 No. / ha.

4. Thrips *Pseudodentrothrips mori* , Thripidae. Thysonoptera

Diagnostic symptoms:Thrips affect the leaves of mulberry plant.Affected leaves show streaks in the early stages and beetles in the advanced stage of attack. Leaves turn to yellowish brown on maturity.

Damage:Thrips injure the epidermal shoots.Early maturity, depletion of moisture, reduction in crude protein and total sugars are noticed in the affected leaves.Leaves become unsuitable for silkworm rearing.Season : Throughout the year but high in summer

Biology : Adult : ♂ - Brownish yellow ♀ are larger than males. A female adult lays 30 –50 bean shaped yellow coloured eggs on the ventral side of the leaves. Egg period : 6-8 days .Egg is oblong. Nymp:hs: pale yellow coloured. Four instars. – Duration 15 – 18 days.

Management: Spray DDVP @ 1 l/ha to kill nymphs and adults.Safe period : 15 days Spray or malathion @ 1ml/l : waiting period : 7 days,Sprinkler irrigation disperses nymphs and adults.

5. Spiralling whitefly : *Aleurodicus dispersus* Aleyrodidae : Hemiptera

Diagnostic symptoms:Adults and nymphs congregate on the lower surface of leaves Yellowish speckling on leaves Leaves crinkle and curl,Infestation spreads from bottom to top leaves,Eggs are deposited on lower leaves with irregularly spiraling deposits of wavy white flocculence.

Season: Occurs throughout the year; Severe during winter

Type of damage:Desapping of the leaves by nymphs and adults.Depletes nutritive value of leaves Adults are much larger than common white flies. *Bemiita tabaci* and are with white powdery waxy scales all over the body and wings.

Biology:Adults lay yellow elliptical eggs. Egg period : 4- 6 days; Nymphs : 14 – 21 days. Life cycle : 21 – 30 days

Management :Collection and destruction of leaves with eggs, nymphs and adults ,Setting up light traps,Removal of weed bushes (as the pest is extremely Polyphagous,Release the coccinellids, *Menochilus sexmaculatus, Scymnus sp, Cryptolaemus montrouzieri, Coccinella septumpunctala* and *Mallada boensis.,* Spray FORS @40 ml/l or dichlorvas 76 WSC @ 2 ml/l.

II. Foliage feeders

1. Tobacco leaf caterpillar, *Spodoptera litura* (F)

Symptoms:Newly sprouted mulberry or young plants are found with out branches with dried leaves.Scrapping of chlorophyll and defoliation in older leaves.

Types of damage: Larvae cut the shoot of young plants. The cut portion of the shoot dries up and falls down. Larvae defoliate the plant at severe infestation.Season: August to February.

Management:Deep ploughing to exposé the pupae,Setting up of light traps and pheromone traps Collection and destruction of leaves with egg masses and larvae,Spray dichlorvos 76 WSC @ 2ml / l,Safe period : 7 days

2. Leaf webber, *Diaphania pulverulentalis*. Pyraustidae, Lepidoptera

Symptoms:Webbing of leaves and tender shoots,Skeletonization: The larvae web the leaves together and feed from inside on soft tissues and skeletonize them.Grown up caterpillars feed voraciously on tender leaves.Apical leaves are preferred for feeding resulting in stunting. Apical shoots are destroyed due to egg laying. Quality of leaf and yield is severely affected. Season : October to February

Biology:Egg : 0.7mm, semi-transparent; ♀ moth lays 100-400 eggs. Eggs are laid one each along the leaf vein on the under side of mulberry leaf. Larvae: 5 instars. Life cycle : 18 – 25 days. Adult : Pale brown spots on yellow back ground of wings.

Management :Collection and destruction of affected shoots along with the larvae.Setting up of light traps to attract the adult moths,Follow the TNAU – IPM package.

i) Flooding of mulberry field to expose the leaf webber pupae.

ii) Release of pupal parasitoid *Tetrastichus howardi* @ 50,000 / ha (1 day after pruning)

iii) Release of egg parasitoid *Trichogramma chilonis* @ 5cc/ha (10 days after pruning

iv) Spraying of dichlovos @ 1ml/lit (500ml/ha)

v) Mechanical clipping and burning of affected shoots (40 days after pruning)

3. Hairy caterpillars

i) Tussock caterpillar – *Euproctis fraterna* – Lymantridae Lepidoptera

ii) Moringa hairy caterpillar – *Eupterote mollifera* Eupterotidae Lepidoptera

iii) Brown hairy caterpillar – *Porthesia scintillans* Lymantridae Lepidoptera

iv) Bihar hairy caterpillar – *Spilosoma obliqua* Arctidae Lepidoptera

Symptoms:Branches of mulberry plant without leaves,Gregarious young caterpillars(Bihar hairy caterpillars) feed upon chlorophyll layer leaving alone the veins.

Type of damage:Adult moth lays 1000 – 2000 eggs. Later instar larvae voraciously feed on the mulberry leaves.Biologya. Bihar hairy caterpillar :Adults light brown with brick red abdomen peppered with dark row of spots laterally and dorsally, lay 1000 – 2000 eggs are laid on batches. Eggs hatch in 5 –7 days. Larvae : 6-7 instars Life cycle : 48 days.

b. Moringa hairy caterpillar:Male moth : Light yellow colour smaller in size. Females are larger and dark brown in colour. Eggs : Sulphur yellow coloured. Eggs are closely laid around the tender twigs or petiole of the leaf.

c. Tussock moth: Moths are yellow in colour. ♀ - Two dark spots are present on the apical angle and two layer ones on the cubital angle forewings. ♂ - One additional spot on the costal margin if forewing. Eggs : Adults lay 100 – 120 pale yellow coloured eggs covered wit on the underside of mulberry leaves. Caterpillars : yellow in colour; Dark of hairs on the 2nd and 3rd abdominal segments. Larval duration : 60 days – 5 instars.

d. Brown hairy caterpillar, *Porthesia scintillans* Season: October – February

Management of hairy caterpillars:Install light traps,Collection and destruction of egg masses and gregarious young larvae.Deep ploughing and flood irrigation Spray dichlorvos 76 WSC @ 2 ml /l (safe period: 15 days)Spray FORS 40 ml /l on trunk during day time to kill resting larvae of E*upterote mollitera*

4. Ashweeils – *Myllocerus subfasciatus; M. viridanus; M.discolor*

Symptoms:Irregular notching on leaf margins,Wilting and drying up of plants under severe attack

Type of damage:Grubs and adults cause injury to mulberry.Adults feed on leaves and buds. Grubs feed on rootlets.Season: July – October

Biology:Adults are grey – black coloured; Eggs are laid in superficial layers of soil; ♀ lays 150 – 300 eggs over a period of 20-90 days; Grubs – 4 instars – 40 –75 days. Life cycle : 3 –5 generations / year

Management:Hand pick the adults in early morning hours and kill them Digging the soil upto 7-8 cm depth and destruction of pupae and grubs ,Spray dichlorvos 76 WSC@2ml/l.

5. Grasshopper : *Neoorthacris acuticeps nilgriensis* (Green Wingless)

***Cytocanthacries ranacea* (Winged) Acrididae, orthoptera**

Symptoms : Branches of plants without leaves

Type of damage:Nymphs and adults feed voraciously on mulberry leaves.Reduction in leaf yield.

Season: July – OctoberBiology:Wingless grasshopper: Short horned brown nymphs and greenish adults. Winged - brown in color with spots; Adults lay egg pods in loose soil of field bunds. Life cycle: 5 – 6 months

Management:Trimming of bunds.Deep ploughing,Spray malathion @ 4 ml /l or dichlorvos 76 WSC 2ml /l.

III. Internal feeders

Stem girdler – *Sthenias grisator* Cerambycidae Coleoptera

Symptoms:The beetles cut around the main stem leaving a clear girdle.The portion above the girdle gradually wilts and dries.

Damage:The beetle has the peculiar habit of ringing the stem; the bark and wood are neatly cut around the main stem leaving a clear girdle. Season: Through out the year.

Life cycle:Adult is a longihorn beetle. Female deposit eggs underneath the girdled branch at night. Incubation of egg 8 days. The grub tunnels into main stem and feeds. Life cycle : 7 – 8 months.

Management:Cutting and burning of affected branches,Swabbing the base of the main stem or branches with 0.1% malathion 50 EC emulsion.

2. Termite: *Odontotermes* sp . Termitidae Isoptera

Symptoms:Drying up and dieing of damaged plants.

Type of damage:Workers of the colony cause the damage.Drying of plants and reduction in leaf yield.Mulching with dry twigs favours the population build up in endemic areas.

Season: October – February

Management:Location and destruction of termite colonies by removing the queen.Treatment of mounds with 50 ml chlorpyrifos 20 EC.Swabbing or drenching of established plants with 0.1% malathion.

Care in insecticide usage in mulberry gardens:Silkworm is highly sensitive to insecticide residues. Avoid applying insecticide in mulberry garden. If insecticidal application is essential allow a waiting period of 15 days from spraying to picking of mulberry leaves. Always select safe chemicals with short persistence like dichlorvos, malathion and FORS and plant products.

Diseases of mulberry – foliar diseases – soil borne pathogens – Nematodes - integrated management practices

Mulberry crop is infested by a number of foliar and soil borne pathogens. Some of the major diseases include leaf spot, powdery mildew, root rot, leaf rust and blight diseases.

Foliar diseases :

1. Leafspot : *Cercospora moricola* Class **: Deutoromycetes** Order **: Moniliales**

Symptoms : Brownish irregular leaf spot in the initial stage enlarge neat circular dark brown lesions coalesce and form shot holes (in later stages). Severely affected leaves become yellowish and fall off prematurely.

Epidemiology : The disease is common in rainy and winter season (June – December) ,Maximum occurrence is during August – September,Optimum temperature for disease development is 24-26º C with 60% RH. Disease spreads through rain splash and dispersal of conidia is by rain droplets and wind.Disease incidence is higher in bottom pruned plants than top/ middle pruned ones.

Management : The mulberry genotypes viz., MR2, S36, S54, K2 and Palladam / Mysore – Local showed resistance to the disease under natural conditions and high load of inoculums Removal of weeds (alternate and collateral hosts) Application of FYM @ 40T/ha + NPK @ 225: 150: 150 kg/ha reduce the disease incidence. When P and K and FYM dose are reduced higher will be the disease incidence

2. Powdery mildew *Phyllactenia corylea* Class **: Ascomycetes** Order **: Erysiphales**

Symptoms : Initially white powdery patches appear on the lower surface of leaves which cover the entire leaf surface ,At a later stage and term black to brown in colour

Epidemiology :*P. corylea* is an ecto-parasite ,It obtainer nutrients by sending haustoria into the epidermal cells through the stomata ,The fungus propagates by both asexual and sexual methods The diseases is more prevalent during rainy in hills seasons in plains during cooler months.

Management : Leaves with thick cuticle and epidermises, less number of stomata and more of leaf hairs are less susceptible to the disease ,Spraying of Dianocap 2% / Wettable sulfur are effective ,Leaves can be used 10 days after spray

3. Leaf rust : *Cerotelium fici* Class **Bacidiomycetes** Order **: Uredinales**

Symptoms : Numerous pin lead sized circular to oval brownish to black eruptive lesions on the lower surface of leaves Leaves become yellow and withers off prematurely

Epidemiology / Diseases cycle : Obligate microcylic rust pathogen ,Uredospores are oval to round; uninucleate ,The spores germinate into hyphae which enter the leaf through stomata Spores disperse through rain droplets and wind currents and spread the disease.

4. Bacterialblight: P*seudomonas mori* Class**: Scizomycetes** Order**: Pseudomonodales**

Symptoms : Numerous irregular water soaked patches appear on the lower surface of leaves Leaves become curled, rotten and turn black in severe cases. Black longitudinal lesions are also seen on the back of young shoots

II. Soil Borne pathogen

1. Root rot : *Fusaricum, solani, F. oxysporium , Macrophamina phaseolina*

Symptoms : Sudden wilting / withering and defoliation of leaves followed by drying / death of affected plants ,Decaying of root bark & rolling of primary of secondary roots,Rotten roots turn black & contain white powdery debris below the bark

Disease cycle : The fungi reproduce by producing chlamydospores, sclerotia and rarely through conidia. Sclerotia and sexual spores remain as resting spores and perpetuate under favourable conditions

Management : Removal of affected plants ,Drenching of plants with 0.2% carbendazim Spraying of 5 % mancozeb when initial symptom of wilting of leaves and drying of branches are noticed ,Application of *Trichoderma harzianum* ,Application of neemcake

Other minor diseases :

Stem canker : *Lasiodiplodia theobromae*

Nematodes:1. Root knot nematode *Meloidogyne incognita* Class **: Secernentea Order : Tylenchoidea**

Symptoms : Stunted growth, marginal necrosis and yellowing of leaves ,Formation of characteristic knots on the roots ,Nematodes damage the xylem and phloem of roots disrupting the flow of water and food ,Death of plants in severe cases

Disease cycle : Three stages larva and adult comprise the life cycle ,II stage female larvae enter the root and harbour in the epidermal layer ,After entry it starts feeding on parenechymatous cells. Due to stimulus inducted by nematode, cells undergo repeated division and enlargement causing cankerous knots / galls on the roots. The larvae mature into oval adult and lay 200-300 ellipsoid eggs.

Management : Neem cake application ,Application of carbofuran @30 kg/ha ,After application digging of soils .

Diseases And Pests Of Silkworms

Diseases

- *Pebrine:* Pebrine is also known as **pepper disease** or **corpuscle disease**. The disease is caused by a sporozoan, *Nosema bombycis* (family Nosematidae). The main source of infection is food contaminated with spores. Infection can be carried from one larva to another by the spores contained in faeces or liberated in other ways by the moths carrying infection. Pebrinized eggs easily get detached from the egg cards. They may be laid in lumps. The eggs may die before hatching. The larva shows black spots. They may become sluggish and dull, and the cuticle gets wrinkled. Pupa may show dark spots. Moths emerging from pebrinized cocoons have deformed wings and distorted antennae. The egg laying capacityof the moth becomes poor.
- *Flacherie:* Flacherie is a common term to denote bacterial and viral diseases. It has been classified into following types:-

i) **Bacterial diseases of digestive organs**: Due to the poor supply of quality mulberry leaves, the digestive physiology of the silkworm is disturbed, and multiplication of bacteria occurs in the gastric cavity. Bacteria like *Streptococci, Coli,* etc. have been found associated with this disease. Symptoms, like diarrhoea, vomiting, shrinkage of larval body may be seen.

ii) **Septicemia**: Penetration and multiplication of certain kinds of bacteria in haemolymph cause septicemia. The principal pathogenic bacteria are large and small *Bacilli, Streptococci, and Staphylococci* etc. Symptoms like diarrhoea, vomiting, shrinkage of larval body may be seen. Appearance of foul odor is also a common symptom.

iii) **Sotto disease**: It is caused by toxin of *Bacillus thuringensis*. The larvae become unconscious, soft, and darkish and rot off.

iv) **Infectious Flacherie**: It is caused by a virus called *Morator* Virus which does not form polyhedra in the body of silkworm larvae. The infection occurs mainly through oral cavity. The virus multiplies in the midgut and is released into the gastric juice and is excreted in faeces.

v) **Cytoplasmic polyhedrosis**: It is caused by a virus called *Smithia* which form Polyhedra are formed in the cytoplasm of the cylindrical cells of the midgut. The larva loses appetite. The head may become disproportionately large. Infection occurs through the oral cavity.

- *Grasserie:* The disease is also known as **Jaundice** or **Nuclear Polyhedrosis** It is caused by a virus called *Borrelina,* which form polyhedra in the nuclei of the cells of fatty tissues , dermal tissues, muscles, tracheal membrane ,basement membrane , epithelial cells of midgut and blood corpuscles. The infected larvae lose appetite, become inactive, membranes become swollen, skin becomes tender and pus leaks out from skin. The larvae finally die.

- *Muscardine or Calcino*: It is of 3 types- i) **White Muscardine**: It is caused by the fungus, *Beuveria bassiana*. The larva loses appetite, body loses elasticity and they cease to move and finally die.

ii) **Green Muscardine**: It is caused by *Metarrhizium anisopliae*. The larva loses appetite, appears yellowish, becomes feeble and dies.

iii) **Yellow Muscardine**: It is caused by *Isaria farinosa*. Many small black specks appear on the skin. Larvae lose appetite and dies.

Pests

- ***Tricholyga bombycis***, a dipteran fly of the family tachinidae, commonly known as **Uzi fly**.It is a serious pest of silkworm larvae and pupae. It parasitizes Mulberry and Tasar silkworm.
- **Dermestid beetles**: These insects belong to the order Coleoptera, family dermestidae. This family contains many genera and a large number of destructive species. Some of them are: *Dermestes cadverinus, D.valpinus, D.vorax, D.frishchi, and Trogoderma versicolor*. The larvae bore inside the cocoon and eat the pupa. These pests cause great damage and economical loss, as the damaged cocoons cannot be reeled.
- **Mites:** *Pediculoides ventricosus* (order Acarina, class Arachnida) damage the larvae. The toxic substance produced by the mite kills the silkworms.
- In addition, ants, lizards, birds, rats and squirrel also cause considerable damage to silkworm larvae as well as the cocoons.

LAC CULTURE

Lac is a resinous exudation from the body of female scale insect. Since Vedic period, it has been in use in India. Its earliest reference is found in Atherva Veda. There, the insect is termed as 'Laksha', and its habit and behaviour are described. The great Indian epic'Mahabharata' also mentions a 'Laksha Griha', an inflammable house of lac, cunningly onstructed by 'Kauravas' through their architect 'Purocha' for the purpose of burning their great nemy 'Pandavas' alive.The English word lac synonyms **Lakh** in Hindi which itself is derivative of Sanskrit word**Laksh** meaning a lakh or hundred thousand. It would appear that Vedic people knew that the lacis obtained from numerous insects and must also know the biological and commercial aspects oflac industry. It is also worth to mention that a laksh griha would need a lot of lac which couldonly come from a flourishing lac industry in that period.

Since ancient times, Greeks and Romans were familiar with the use of lac. The cultivation of lac insects has a long history in Asia, with some suggestion that it is as old as 4000 years in China where its cultivation accompanied the development of the silk industry. Lac is Nature's gift to mankind and the only known commercial resin of animal origin. It is the hardened resin secreted by tiny lac insects belonging to a bug family. To produce 1 kg of lac resin, around 300,000 insects lose their life. The lac insects yields resin, lac dye and lac wax. Application of these products has been changing with time. Lac resin, dye etc. still find extensive use in Ayurveda and Siddha systems of medicine.With increasing universal environment awareness, the importance of lac has assumedspecial relevance in the present age, being an eco-friendly, biodegradable and self-sustainingnatural material. Since lac insects are cultured on host trees which are growing primarily inwasteland areas, promotion of lac and its culture can help in eco-system development as well asreasonably high economic returns. It is a source of livelihood of tribal and poor inhabiting forestand sub-forest areas.

LAC INSECT TAXONOMY:

The first scientific account of the lac insect was given by J. Kerr in 1782 which waspublished in Philosophical Transaction of Royal Society of London (vol. 71, pp.374-382). Thefirst scientific name given to it was *Tachardia lacca* following the name of French MissionaryFather 'Tachardia'. It was later changed to *Laccifer lacca* Kerr. The other name given to it hasbeen *Kerria Lac* Kerr.

Phylum - ArthropodaClass – Insecta Order – Hemiptera Suborder – Homoptera Super family – Coccoidea Family – Lacciferidae Genus - *Laccifer*Species - *lacca*

Lac insect belongs to super family Coccoidea which includes all scale insects. Scale insect is a common name for about 2000 insect species found all over the world. Scale insects range from almost microscopic size to more than 2.5 cm. These insects attach themselves in great numbers to plants. The mouth part of these insects is piercing and sucking type. They can be very destructive to tree-stunting or killing twigs and branches by draining the sap. There are six genera of lac insects, out of which only five secrete lac, and only one, i.e. *Laccifer* secretes recoverable or commercial lac. The commonest and most widely occurring species of lac insect in India is *Laccifer lacca* (Kerr) which produces the bulk of commercial lac. Lac insect of South East Asia is referred to as *Kerria chinensis*.

DISTRIBUTION: Since the lac insects thrive and feed on certain species of the tropical trees, it is found distributed in South-East Asian countries. Lac is currently produced in India, Myanmar, Thailand, Malaya, Lao and Yuan province of China. India and Thailand are main areas in the world, while India has prime position in relation to lac production. Lac cultivation is introduced

into Thailand from India.Over 90% of Indian lac produced comes from the states of Bihar, Jharkhand, West Bengal, Madhya Pradesh, Chattisgarh, Eastern Maharashtra and northern Orissa. Some pockets of lac cultivation also exist in Andhra Pradesh, Punjab, Rajasthan, Mysore, Gujarat, and Mirzapur and Sonebhdra districts of Uttar Pradesh.

LIFE CYCLE: Lac insect is a minute crawling scale insect which inserts its suctorial proboscis into plant tissue,sucks juices, grows and secretes resinous lac from the body. Its own body ultimately gets covered with lac in the so called 'CELL'. Lac is secreted by insects for protection from predators. Male is red in colour and measures 1.2 - 1.5mm in length. It has reduced eyes and antennae. Thorax bears a pair of hyaline wings. Female is larger than male, measures 4-5 mm in length and has a pyriform body. The head, thorax and abdomen are not clearly distinct. The antennae and legs are in degenerated form, and wings are absent. The Life cycle of lac insect takes about six months and consists of stages: egg, nymph instars, pupa and adult. The lac insects have an ovoviviparous mode of reproduction. Female lays 200-500 ready to hatch eggs, i.e. the embryos are already fully developed in eggs when these are laid. Eggs hatch within a few hours of laying, and a crimson-red first instar nymph called **crawlers** come out. The crawler measures 0.6 x .25 mm in size. The emergence of nymph is called swarming, and it may continue for 5 weeks. The nymphs crawl about on branches. On reaching soft succulent twigs, the nymphs settle down close together at rate of 200-300 insects per squire inch. At this stage, both male and female nymphs live on the sap of the trees. They insert their suctorial proboscis into plant tissue and suck the sap. After a day or so of settling, the nymphs start secreting resin from the glands distributed under the cuticle throughout the body, except mouth parts, breathing spiracles and anus. The resin secreted is semi-solid which hardens on exposure to air into a protective covering. The nymphs molt thrice inside the cells beforereaching maturity. The duration of each instar is dependent on several factors, viz. temperature, humidity and host plant.

LAC NYMPH **(ADULT LAC Winged)**

Fig.1. Nymph and adults of lac insects.

After the first moult, both male and female nymphs lose their appendages, eye and become degenerate. While still inside their cells, the nymphs cast off their second and third moult and mature into adult. Both the male and female larvae become sexually mature in about eight weeks. Only the male one undergoes a complete metamorphosis or transformation into another form; it loses its proboscis and develops antennae, legs and a single pair of wings. It is contained in a brood cell somewhat slipper like with a round trap door (operculum) through which it

emerges. The adult male is winged and walks over the females to fertilize them.The female brood cell is larger and globular in shape and remains fixed to the twig. The female retains her mouth parts but fails to develop any wings, eyes or appendages. While developing, it really becomes an immobile organism with little resemblance to an insect. Females become little more than egg producing organisms. The female increases in size to accommodate her growing number of eggs. Lac resin is secreted at a faster rate, and a continuous layer coalesces or grows into one body. After fourteen weeks, the female shrinks in size allowing light to pass into the cell and the space for the eggs. About this time, two yellow spots appear at the rear end of the cell. The spots enlarge and become orange coloured. When this happens, the female has oviposit a large number of eggs in the space called 'Ovisac'. The ovisac appears orange due to crimson fluid called lac dye which resembles cochineal. It indicates that the eggs will hatch in a week time. When the eggs hatch, larvae emerge and the whole process begins all over again After the cycle has been completed and around the time when the next generation begin to emerge, the resin encrusted branches are harvested. They are scraped off, dried and processed for various lac products. A portion of brood lac is retained from the previous crop for the purpose of inoculation to new trees.

HOST PLANTS: Lac insects thrive on twigs of certain plant species, suck the plant sap, and grow all the while secreting lac resin from their bodies. These plants are called host plants. Although lac insect is natural pest on host plant, these insects enjoy the privileged position not being treated as pest. This is because: i) they yield a useful product, ii) the host plants are economically not so important, and iii) the insects cause only temporary and recoverable damage to the host plants. About 113 varieties of host plants are mentioned as lac host plant. Out of which the followings are very common in India:

1. *Butea monosperma* (Vern. Palas) 2. *Zizyphus* spp (vern. Ber) 3. *Schleichera oleosa* (Vern. Kusum) 4. *Acacia catechu* (Vern. Khair) 5. *Acacia arabica* (Vern. Babul) 6. *Acacia auriculiformis* (Vern. Akashmani) 7. *Zizyphus xylopyrus* (Vern. Khatber- grown in part of M.P. & U.P.) 8. *Shorea talura* (Vern. Sal grown in mysore) 9. *Cajanus cajan* (Vern. Pigeon-pea or Arhar) 10. *Grewia teliaefolia* (Vern. Dhaman preferred in Assam) 11. *Albizzia lebbek* (Vern. Siris/Gulwang) 12. *Flemingia macrophylla* (Vern. Bholia) 13. *Ficus benghalensis* (Vern. Bargad) 14. *Ficus religiosa* (Vern. Peepal) of these host plants, palas, kusum, ber and khair are of major importance, while others are of regional and minor importance. It is also important to mention that the quality of lac is directly related to the host plant and to the strain of lac insects. Based on industrial parameters, **kusumi lac** is better and fetches higher price in market. In this respect, ber tree as a potential kusumi lac host is already getting momentum. This host species is available in plenty and can supplement and fulfill the kusmi brood lac requirement in many areas. Similarly, siris (*Albizzia* sp.) has also been identified as good host for kusumi brood lac. The trees can be raised and utilized within a period of 5-6 years of plantation in comparison to around 15 years for kusum. *Flemingia semialata* is a bushy host plant and has also been identified as well as established as a good kusumi lac host on plantation basis. Thus, these three hosts viz., ber, siris, semialata and lately *Prosopis juliflora* (in Gujarat areas) are expected to enhance kusumi lac cultivation. Adoption of this activity may enhance lac production to the tune of 3-4%.

STRAINS OF LAC INSECT: In India, Lac insect is known to have two distinct strains: **kusumi** and **rangeeni**. The kusumi strain is grown on kusum or on other host plants using kusumi brood. The rageeni strain thrives on host plants other than kusum. The life cycle of lac

insects take about six months, hence, two crops a year can be obtained. In case of kusumi strain, two crops are: i) Jethwi (June / July) and ii) Aghani (Jan. / Feb).
In case of rangeeni, tow crops are: i). Karrtiki (Oct. / Nov.) and ii) Baisakhi (May / June). The crops have been named after Hindi months during which these are harvested. The lac of rangeeni crops is harvested while it is still immature. Aghani and baisakhi of rangeeni strain are the main corps contributing about 90% of lac production, remaining 10% is contributed by kusumi crops. However, the kusumi crop lac is considered superior resin, because of the lighter colour of resin, and it fetches better price.

LAC CULTIVATION

Lac cultivation is done by putting brood lac on suitably prepared specific host plants. The brood lac contains gravid females which are about to lay eggs to give birth to young larvae. After emergence from mother cells, the young larvae settle on fresh twigs of host plants, suck the plant sap and grow to form encrustations.

Local practice

Lac cultivation is simple, does not need any large investment and requires only part-time attention. In India, lac cultivation is carried out casually, and the cultivator is satisfied with what he gets, as it is being regarded as subsidiary crop. The local practices in lac cultivation has some disadvantages like –

i) The same host plants are continuously exploited without giving rest for recoupment.
ii) Only natural inoculation occurs.
iii) Partial harvest is done leaving few branches untouched for auto inoculation of next crop and no pruning is done.

As a result of the defective local practices, host trees loss the vigour and unable to throw out new succulent shoots, and in course of time, the trees become weak and die. The self inoculation leadsto heterogeneous infestation of nymphs, which results in wholesome mortality of brood in seasons of extreme heat, and thereby, the cultivator is forced to abandon lac cultivation.

Improved practice

Sustained production of lac and steady returns can be achieved by adopting improved method of cultivation. The underlying principle in improved method of lac cultivation is to provide much needed rest to the host plants after a harvest has been taken. For this purpose, **coupe system** of lac cultivation is adopted. As the term coupe means a chamber, the host plant trees are divided into coupes i.e. groups that consist of certain number of trees. In practice, only few numbers of trees in a coupe are inoculated. Following harvest, these trees are made to rest and recoup the lost vigour, while other trees (which have till now been restring) are ready with succulent twigs for inoculation. Thus, in a coupe system, alternate groups of trees are put to lac cultivation. Full inoculation and full cropping is the rule under this system. In addition, the following considerations are desirable in improved lac cultivation:- The mean lac productivity (per tree and per unit area) of 2, 5 and 15 kg per tree or 3, 4 and 5 q/ha for *palas, ber* and *kusum* respectively in traditional lac culture is very low. This is all due to poor sustainability, continuous exploitation and increased threat from pests. So,the technology of improved scientific method of lac cultivation should be adopted, thatincludes superior breeds of lac insect, providing proper rest to host plants, use of goodquality brood lac in appropriate quantity, post harvest management of lac crop, host plantmanagement and lac pest management.

Ø As the lac cultivation is mainly practiced by the forest and forest fringe dwellers, their involvement in the Joint Forest Management (JFM) programmes in different lac growing states is likely to enhance the lac production. Lac host trees under the custody of state forest

department are out of reach of the forest dwellers and interested lac growers and are not being utilized for lac cultivation. If these are jointly managed by forest department and forest dwellers and they work in close association, it will be a boon for lac cultivation and production.

Ø Timely availability of pest free and quality brood lac is the most important input for lac cultivation. Quality brood lac ensures high fecundity of insects and fewer requirements of inoculums. Timely harvesting of mature crop and proper inoculation will reduce the risk of loss of lac insect to a large extent.

Propagation of Lac Insects Propagation means the spread of lac insects on the same or different host plants. This is done by inoculation of newly hatched (Brood) nymphs. Inoculation is of two types.

i) *Natural or self/auto – inoculation*: This type of inoculation occurs naturally. It is very simple and common process, when the swarmed nymphs infect the same host plant again. Natural inoculation, being repeated on the same host, makes in host plant weak, and thereby, nymphs do not get proper nutrition. Also in natural inoculation, it is not sure that uniform sequence of inoculation take place. Therefore, natural inoculation should be discouraged. ii) *Artificial Inoculation*: Artificial inoculation is brought about by the agency of man. The main idea behind the artificial inoculation is to check the drawbacks of natural inoculation. In this method, the host plants are first of all pruned in Jan. or June. Pruning means cutting away old, weak and diseased twigs. It induces host plants to throw out new succulent twigs and is as important in lac culture as plouging is for seed sowing in agriculture. Pruning should be done with a sharp instrument (scateur, pruning Shaw and pruning knife) to give a sharp and neat cut. Only light pruning should be carried out.In artificial inoculation, brood twigs are cut in size 20 - 30 cm in length. Then, the cut pieces of brood twig are tied to fresh tree twigs in such a way that each stick touches the tender branches of trees at several places. The nymphs swarm from brood and migrate to tender and succulent twigs and infest them. Following swarming, the brood twigs should be removed from the host plant, as this would decrease the chance of pest infestation. Following precautions are desirable is artificial inoculation:-

i) Fully mature and healthy brood free from pest infestations should be taken.

ii) Brood meant for inoculation should not be kept for long and used immediately after crop cutting.

iii) Tying of the brood lac stick should be done securely on the upper surface of branches. This will prevent falling of twigs and provide full contact for quick and easy crawling of the nymphs. One should keep a watch on the brood lac dropping down.

iv) Some times due to bad weather, swarming of nymphs from brood is prevented. Hence, the room storing brood lac sticks is moderately heated to 200C to induce swarming, and then sticks are tied.

v) Generally, cultivation of kusumi in rangeeni area and vice versa should be avoided.Brood lac from a particular host used year after year is likely to deteriorate in quality. Therefore, alternation of brood and host give production of a better quality of brood lac.

Inoculation period

As discussed above, each strain of lac insects (Kusumi and Rangeeni) yield two crops a year: jethwi and aghani in case of kusumi strain, and kartiki and baisakhi in case of rangeeni. The inoculation period of all the four types of crops is different: for kartiki, June/July; for baisakhi,Oct. /Nov. for agahani, June/July; for jethwi, Jan. /Feb.

Harvesting of lac

Harvesting is the process of collection of ready lac from host trees. It is done by cutting

the lac encrusted twigs when is crop is mature. It may be of two types:-

a) In **Immature harvesting**, lac is collected before swarming, and lac thus obtained is known as 'ARI LAC'. The immature harvesting has drawbacks, as the lac insects may be damaged at the time of harvesting. However, incase of palas lac (Rangeeni lac), it is found that ARI Lac gives better production. Hence, ARI lac harvesting is recommended in case of palas only.

b) In mature harvesting, lac is collected after swarming. The lac obtained is known as mature Lac. To know the exact date emergence and swarming of nymph, a simple visual method is adopted. A yellow spot develops on the posterior side of lac cell towards crop maturity. This spot spread forwards until it covers half of the cell. Cutting of twigs for harvest can be done at any time between the stages while yellow spot occupies one third to one half of the cell area. It is sometimes desirable to wait till the emergence of the first few nymphs. The harvesting periods of different crops are different. The kartiki crop is harvested in Oct. /Nov.; baisakhi, in May/June; aghani in Jan/Feb.; and jethwi, in June/July.When the nymphs have escaped from the brood lac, what is left is the stick lac or phunki lac. These sticks should be tied in bundles and immersed in water, preferably running water for 3-4 days, keeping them well under waters with help of heavy stones. The stick lac should then be kept in shade for drying. The raw lac should be scraped while sticks are still moist.Following consideration are recommended for harvesting:

i) Lac crop should be harvested only when mature. Immature or ARI lac cutting should be avoided, though it is recommended in case of palas.

ii) A mature crop is said to be the one from which nymphs will emerge in 7-10 days. So, the crop should be harvested within the above said days prior to nymphal emergence. If cut earlier, there is a chance of nymphs dying. If cut later, the nymphs may already have emerged before noculation is adopted.

iii) Attempt should be made to reap the entire crop, if self inoculation is not required. In the case of rangeeni crop, only lac encrusted twigs are cut, while in the case of kusumi one, reaping should combine with pruning.

iv) The brood sticks harvested should be utilized for inoculation as soon as possible. If storage is needed, these have to be stored in a well ventilated room or under shade in open prevented from rain and heat.

v) Harvesting of lac crop at maturity can solve the crisis of brood lac dearth to a large extent without affecting the quality of lac obtained as phunki lac. This will also reduce the loss of brood lac and enhance the yield.

COMPOSITION OF LAC: The major constituent of lac is the resin. Lac resin is a polyester complex of straight- chain hydroxy fatty acids of C14 – C18 carbon chain (such as Aleuritic acid, butolic acids), mono- and di – hydroxy acids along with hydroxy terpenic acids. Other constituents present are: dye, wax,sugar, proteins, soluble salts, sand, woody matter, insect body debris etc. Lac wax is a mixture of anthroquinoid derivatives. Percent-wise composition of lac given below (adopted from ILRI data): -

Constituent Percentage: Lac resin 68,Lac wax 6,Lac dye 1-2,Others 25

LAC PROCESSING:

Stick lac : Following harvest, lac encrustations are removed from the twigs of host plant by scraping.The raw lac thus obtained is known as raw or crude lac or scraped lac or stick lac. This crude lack consists of resin, encrusted insect body, lac dye, sand and twig debris. The freshly scraped lac contains a lot of moisture and usually left to dry. The quality and value of stick lac depend very much upon variety of factors, viz. host tree, climate, whether the crop is harvested before or after emergence of larvae, and the method of drying and storage. The stick lac can not

be stored for longer duration, as the lac has tendency to form lump, and there is loss in quality of lac. High moisture content is responsible for lump formation. The optimum moisture content has been identified to be 4% for storage of stick lac to avoid lump formation. It is recommended to store the stick lac on floor in layers less than 30 cm. in height and racked frequently. If stick lac is converted into seed lac, it can be stored for longer duration like food grains. Establishment of small scale lac processing unit in lac grower villages will help in overcoming this problem.

Seed lac

The primary processing to seed lac soon after harvesting is necessary, because the storage of stick lac is more congenial for lump formation and breeding of storage pests, and thereby causing substantial loses and deterioration in quality of desired industrial parameters. The stick lac is crushed and sieved to remove sand and dust. It is then washed in large vats again and again to break open the encrusted insect bodies, to wash out the lac dye and twig debris. Decaying bug bodies turn the water a deep red that is processed further to get the byproduct lac dye. The remaining resin is dried, winnowed and sieved to get the semi refined commercial variety product called seed lac. The dusty lac eliminated by sieving is refuse lac known as **molamma**. The seed lac is in form of grain of 10 mesh or smaller and yellow or reddish brown in colour in general appearance. Adhering impurities on the grains of seed lac may be to 3 - 8% (Average 5%). Following grades of hand made seed lac are commonly available in the market:-

· Ordinary/ Genuine bysakhi · Fine bysakhi · Golden bysakhi · Golden kusumi
· Golden bysakhi – bold grain· Goden kusumi – boldgrain · Golden kusumi seedlac – Medium
· Manbhum fine seedlac

(In lac trade, baisakhi crop is commonly referred to as bysakhi or bysacki)

Shellac :

The shellac is the name of finished product and is commonly used across the world. Seed lac is processed into shellac by any of the three methods: hand made country Process or heat process or solvent process. 9.3.1. *Hand made Process* Traditionally seed lac is processed by hand. The seed lac is filled into long sausage shaped cloth bag of about 2 inch diameter and 30 feet long. The long bag is passed gradually in front of a charcoal-fired hearth hot enough to melt the lac. By twisting the bag, molten lac is squeezed out through cloth. The residue left inside cloth bag is another variety of refuse lac known as **kirilac**. The molten filtered mass is stretched into sheets approximately 0.5 cm thick and thinner by skilled work man with the help of glazed ceramic cylinder. Alternatively, the molten mass is allowed to solidify in form of discs, and then it is called as 'button lac'. The following grades of hand made shellac are commercially available.

· Lemon one shellac ,· Lemon tow shellac ,· Standard one shellac,· Superior shellac
· Superior kusumi lemon ,· Kusumi button lac ,· superior kusumi button lac
· light pure button lac ,· Pure one button lac

HeatProcess: In this process of manufacturing of shellac, the seed lac is melted by steam heat. The molten soft lac is squeezed through filter by means of hydraulic pressure. The filtered molten lac is drawn into long and continuous sheets with help of roller. The sheet is then broken into pieces called flakes. Following grades of machine made shellac are commercially available:

· Orange shellac ,· Lemon one shellac ,· Lemon twoshellac ,· standard one shellac
· Black T.N. shellac,· Kusumi lemon shellac, · Orange fine shellac

Solvent Processes

If the solvent process is used to purify the semi refined lac, dewaxed and decolorized shellac can be obtained as end product. The normally amber colour resin can also be bleached to

get leached shellac.Seed lac is dissolved in a refrigerated alcohol and filter through filter press to remove wax and impurities. The colour may be removed to any required standard by charging with the activated carbon and then alcohol is recovered. The molten shellac is stretched with a roller. The solvent process of lac manufacture yields the following grades:

· Dewaxed platina , Dewaxed blonde ,· Dewaxed super blonde ,· Dewaxed lemon

· Dewaxed orange · Dewaxed Garnet

(Actually above nomenclature is based on the colour of and product. For instance, the colour index of platina is about 0.6, of Garnet is 35 and of other varieties fall in between.) In manufacturing bleached shellac, the basic procedure consists of - i) dissolving seed lac in aqueous sodium carbonate solution at 90- 1000 C, ii) stirring off solution with sodium ypochlorite and iii) filtering after cooling. The bleached shellac is reclaimed from the filtered solution with sulphuric acid. The reclaimed bleached shellac is then filtered, washed with water for removal of acid and dried. Bleached lac is white in colour. It has specialized demand and manufactured commercially in two grades:

· Dewaxed bleached shellacWaxy bleached shellac

Aleuritic acid (Shellac aleuritic powder) is also isolated further by saponification from resin lac.

LAC PRODUCTS AND THEIR USE:

Lac dye:

Lac dye is a mixture of anthroquinoid derivatives. It is traditionally used to color wool and silk.Its colour varies between purple red, brown and orange often depending upon the mordant used.It is used in food and beverages industry for coloring. In recent past, lac dye has been replaced by synthetic dye. But, now-a-days with increasing stress and awareness on use of eco-friendly and safe material particularly associated with human contact and consumption has made revival of great demand of lac dye as a coloring material.

Lac wax:

Lac wax is a mixture of higher alcohols, acids and their esters. It is used in –Polishes applied on shoes, floor, automobiles etc. Food and confectionary, and drug tablet finishing, lipsticks, Crayons

Shellac

Shellac is a natural gum resin, a nature's gift to the mankind and is used in over 100 industries. It is natural, non toxic, physiologically harmless and edible resin. Shellac is a hard, tough,amorphous, and brittle resin containing small amount of wax and a substance responsible for its characteristic pleasant odour. The lac resin is not a single chemical compound, but an intimate mixture of several components. Shellac is slightly heavier than water. Its natural colour varies from dark red to light yellow. When slowly heated, it softens at 65-70oC and melts at 84-90oC. Shellac is insoluble in water, glycerol, hydrocarbon solvents and esters, but dissolves readily in alcohols and organic acids. The solvent most commonly employed to dissolve shellac ismethylated spirit. Usually the milder alkalis, ammonia, borax and sodium carbonate can also be employed to prepare aqueous solutions.

Shellac is acidic in character. Acid value is 70. It is an ester. Saponification value 230. It has free five hydroxyl groups and has hydroxyl number 260. It has unsaturation indicated by iodine valueof 18. Free aldehydic group also has been indicated by carboxyl value of 18. Its average molecular weight is 1000. Normal wax content of shellac is 5% which is insoluble in alcohol. It is soluble in n-hexane, pure terpentine, and other hydrocarbon oils. It is hard and having melting point 840 C. It has the following extra ordinary properties:

i) It is thermoplastic.

ii) It is approved for various applications in the food industry.
iii) It is uv-resistant.
iv) It has excellent dielectric properties, dielectric strength, a low dielectric consent, good tracking resistance etc.
v) It has excellent film forming properties. Its film shows excellent adhesion to wide variety of surfaces and possess high gloss, hardness and strength
vi) Shellac is a powerful bonding material with low thermal conductivity and a small coefficient of expansion. Its thermal plasticity and capacity of absorbing large amounts of fillers is noteworthy.
vii) Shellac under tropical conditions of storage, may soften and form a solid block, without adverse effects on its properties. Long storage under adverse conditions, however, may lead to deterioration in properties
viii) When shellac is heated for a long time above its melting point, it gradually loses its fluidity and passes through a rubbery stage to hard, horn-like and infusible.
Use: It is used in fruit coatings, e.g. for citrus fruits and apples, parting and glazing agents for sweets, marzipan, chocolate etc. Also used as binder for foodstuff stamp inks, e.g. for cheese and eggs. It is used as binder for mascara, nail varnish additive conditioning shampoo, film.forming agent for hair spray, micro-encapsulation for perfumes. It is used for enteric (i.e. digestive juice-resistant) coatings for tablets and as odour barrier for dragées.It is used in anufacturing of photographic material, lithographic ink and for stiffening felt and hat material.
It is utilized in preparation of gramophone records. Jewellers and goldsmiths use lac as a filling material in the hollows in ornaments. It is also used in preparation of toys, buttons, pottery and artificial leather. It is also used commonly as sealing wax. vii) Shellac under tropical conditions of storage, may soften and form a solid block,without adverse effects on its properties. Long storage under adverse conditions, however,may lead to deterioration in properties
viii) When shellac is heated for a long time above its melting point, it gradually loses its fluidity and passes through a rubbery stage to hard, horn-like and infusible.
Few to name: Leather**:** Seasoning, Leather care products
Ø Printing inks**:** As binder for flexographic printing inks for non-toxic printing of food packaging
Ø Wood treatment: Primers, polishes, matt finishes
Ø Textiles: As stiffeners
Ø Electrical: Insulation, capping, lamination
Ø Abrasives**:** Binder for grinding wheels
Ø Others: Binder for inks and water colours, Micro-encapsulation for dyes

Bleached shellac

Bleached shellac is non-toxic, physiologically harmless (edible), and is widely used in the food industries, food packaging and allied industries. Apart from the above, bleached shellac is also used for its qualities i.e. binding, adhesive, hardening, gloss, odourless, fast drying, and xtending shelf life (in absence of refrigeration) etc. Clear and transparent or very light coloured alcoholic or water - alkali solutions can be obtained from bleached shellac.
Use: Bleached shellac is widely used in the following industry: Paints (primer for plastic parts and plastic film) Aluminium industry (primer for Aluminium and Aluminium foils) Flexographic printing inks, Pharmaceuticals (for coating of pills, tables and gel caps and coating for controlled release preparation) , Confectionery (in coating of confections, chewing gums, marzipan chocolates, nutties, jelly- and coffee-beans etc), Binder for food marking and stamping

inks and Binder for egg coating, Barrier coating for processed food, vegetables, fruits and dry flowers Textiles (used as textile auxiliaries and felt hat stiffening agents), Cosmetics(used in hair spray, hair and lacquers, hair shampoos, and binder for mascara),v Wood finishing (as binder for wood coatings and wood stains and as filler/sealer for porous surfaces and cracks) v Antique frames for paintings and Wood polish (French polish) Fire works and pyrotechnics (as binder for fireworks, matches etc and used in coating of magnesia, Electric (as binder for lamp cements), Electronics (it is binder for insulation materials, serves as additive to moulding,compounds. Mass coating for print-plates and is adhesive for si-cells.),v Grinding wheels (it is binder for additive of grinding wheels), Plastic (it is primer for plastic parts and films), Rubber (it is additive to natural rubber),Leather (in leather auxiliaries),

Dewaxed bleached shellac

Dewaxed white shellac is used in the same way as any other grade of shellac. The major difference between this shellac and the others is that it is a bit harder, shines a bit brighter, is completely free from wax. Bleached lac has super characteristics and qualities i.e. adhesive, binding, hardening, gloss, odorless. It has good film forming properties, a high gloss and excellent adhesion to various substrates including the human hair.It is non-toxic and physiologically harmless. Good solution can be obtained in ethanol and lower alcohols. It can also be dissolved in water by adding an alkali like Ammonia. It is compatible with many other resins, raw materials and additives used in cosmetics, pharmaceuticals and food formulations.

Use: Coating of fruits and vegetables, Coating in tablets & capsules, Coating in confectionary, Coating in aluminium foil, paper, Coating in cosmetic industry, In cosmetics, it is used in hair sprays (pump sprays or aerosol sprays, hair setting,lotions, hair shampoos, mascara, eyeliners, nail polishes, lipsticks, micro encapsulationby coacervation of fragrances and perfume oils. v In food, it is used for coating of confections, chewing gum, candles, cakes, eggs,citrus fruits and apples, and printing inks for eggs and cheese.

Aleuritic Acid (Shellac Aleuritic Powder)

Aleuritic Acid (9, 10, 16-trihydroxypalmitic acid), obtained from shellac by saponification, is a unique acid containing three hydroxyl groups of which two are of adjacent carbon atoms. Aleuritic Acid is white powder or granule. It is moderately soluble in hot water or lower alcohols (viz. methyl alcohol, ethyl alcohol, and isopropyl alcohol) and crystallizes out on cooling the solution. It is soluble in the lower alcohols such as methyl, ethyl and isopropyl alcohols. Technical grade Aleuritic Acid (purity 99%) a slight yellow and almost odourless solid.

Use: There is a continuous growing demand of Aleuritic acid in the fields of perfumery and pharmaceuticals due to it being an excellent starting material for the synthesis of civetone, ambrettolide, isoambrettolide etc, which have the musk like odour. Civetone is obtained from Shellac Aleuritic Acid. It is used for manufacturing of perfumes and is very much in demand with perfume manufacturing companies in France, Italy, Germany, USA etc. The other suggested applications of Aleuritic acid are the following: Synthesis of Glucose monoaleuritate (a non-toxic non-hemolytic water-soluble,compound) in medicine as an isocaloric substitute for dietary tripalmitin. Preparation of plastics with good adhesive properties by the condensation of Aleuritic acid with pithalic andydride and glycerin, rosin etc. Aleuritic acid esters used in the preparation of lacquers, plastics and fibres.

LAC PESTS:

The insects are serious and damaging pests to the lac crop also, like the other agricultural crops. These insect pests destroy 30-40% of lac. The insects damage the lac crop is two ways:

i) As *Parasites*: Lac insects are parasitized by small winged eight species of insect belonging to family chalcidae order Hymenoptera. These insect pests lay eggs in lac cells. Their grubs on hatching feed on lac insects within the cells. Loss due these parasites is 5-10%

ii) As *Predators:* The predators account major damage (up to 35%) of lac crop.

There are three main insect predators on lac:

a. *Eublemma amabilis* Moori: commonly known as white lac moth, order Lepidoptera

b. *Holocerca pulverea* Meyr : commonly known as black lac moth, order lepidoptera

c. *Chrysopa spp*.: Commonly known as lac wing fly, order Diptera

These predators moths and fly lay their eggs on the lac encrusted twigs. On hatching, their larvae make their way inside the lac encrustation and feed on the lac insects as well as on lac encrustations. The white lac moth is more destructive on trees; while black lac moth, on the stored lac.In addition to insect pests, squirrels and monkeys also damage lac. The rodents could damage greatly. These pests gnaw the mature lac encrustations on the trees or brood lac sticks tied for inoculation, and thus, consuming gravid females. The brood lac can be made to fall on the ground by these animals preventing inoculation. Forest fires too often break out in deciduous forests in summer season and destroy both lac insects and their host plants.

Following precaution should be taken to prevent the damage caused by insect pests:-

i) Only healthy pest-free brood lac should be used for inoculation. The twigs for inoculation should be cut just before swarming to get healthy brood.

ii) Entire crop should be harvested, as left over may attract the pests.

iii) The stick or phunki lac should be fumigated or immersed in water to kill the pest, if any.

iv) Scrapping of encrusted lac from twigs should be done as soon as possible, and lac, thus obtained should be immediately converted into seed lac and not left near the inoculated lac hosts.

v) Infected stick lac should be destroyed along with predators and pests.

POTENTIAL OF INDIA IN LAC PRODUCTION

Now-a-days, there is increased stress on use of eco-friendly and safe material particularly associated with human contact and consumption. Lac is natural, renewable, biodegradable, versatile and non toxic resin. Thus, a very good increase in demand for lac worldwide is envisaged. The envisaged objective of enhancing lac production has relevance and importance. It is a source of livelihood of tribal and poor inhabiting forest and sub forest areas. India is the principal lac producing country of the world, producing approximately 18,000 metric tones of unrefined raw lac annually. About 85% of the country's production is exported to various countries. The USA, Germany and Egypt are some of the major lac importing countries of the world. Export of lac from India is in the form of shellac / button lac, seed lac, dewaxed lac, bleached lac and Aleuritic acid.India has great potential for lac culture. The areas for lac cultivation can be broadly classified into three categories :(a) Regular lac cultivation areas – at present, only 20-25% of the total available trees are being utilized, (b) Moderate lac cultivation areas – around 10-15% available trees are being utilized, and (c) Lac host trees are available but due to lack of knowledge and awareness, none of the trees are utilized for lac cultivation. Thus, on an average, only 15% of the available lac host trees owned by farmers are being utilized for lac cultivation presently. There are vast untapped areas, which are ecologically favourable for lac production in the country. These areas possess the potential lac host plants which if exploited properly in scientific and systematic manner is liable to enhance the lac production. Enhancing the exploitation of the idle or unexploited lac host plants in favorable lac growing areas can also enhance the lac production.

Indian Lac Research Institute (ICAR), Namkum, Ranchi established in 1924 is actively engaged in addressing the objective of enhancing lac productivity and production through transfer and adoption of proven technologies by interfacing research, development and extension. The Institute has developed various technologies and cultivation packages. By implementing and adopting the scientific method of cultivation, proper host plant management, integrated pest management, enhancing exploitation of unexploited host plants, and cultivation through 'Joint Forest Management' programme, the lac production can be enhanced in future. While enhancing production quality needs equal emphasis to meet the National and International demand. The quality of lac suffers due to following reasons like untimely harvesting, lack of appropriate storage, primary processing soon after harvesting and lack of appropriate processing machines for quality and recovery. These problems may be addressed by adopting recommended technologies developed by the Institute.

BIOLOGICAL METHODS

The successful control of a pest species by means of another living organism that is encouraged and disseminated by man is called the biological control. In such a programme the natural enemies are introduced, encouraged, multiplied by artificial means and disseminated by man with his own efforts instead of leaving it to nature and thus differs from natural control.

Biological control: May be defined as the destruction, regulation or suppression of undesirable insects, other animals or plants by introduction, encouragement, or artificial increase of their natural enemies.

Natural enemies of the insects are:

1. Predaceous and parasitic insects
2. Predatory vertebrates.
3. Nematode parasites
4. Bacterial diseases.
5. Parasitic fungi
6. Virus diseases
7. Protozoan diseases.

The use of chemicals in pest control has caused not only the rapid development of resistance in insects and mites to such chemicals but sometimes resulted in subsequent outbreaks of pests due to destruction of their natural enemies. The recent synthetic chemicals are also hazardous to human and wild life. These factors have been responsible for evoking considerable interest in the adoption of biological control.

Techniques / Methods in Biological Control:

1. Conservation: It refers to non use of those pest control measures that destroy natural enemies. It can be achieved by use of selective insecticides which do not kill natural enemies, avoidance of those cultural practices which are harmful for natural enemies, preservation of inactive stages of natural enemies.

2. Introduction: Suitable natural enemies can be obtained from the other part of country or world and introduced in new locality for the control of pests. Nearly 40 percent of the introduced natural enemies have established in the introduced countries and provided partial to complete control of important insect pests in the world.

3. Augmentation: It includes all activities designed to increase numbers or effect of existing natural enemies. It results in temporary suppression of the pest rather than permanent lowering of the general equilibrium position as in introduction. The periodic releases may be either inoculative or in-undative.

I. Inoculative release: This type of release may be made as infrequently as once a year or season to re-establish a species of natural enemies.

II. Inundative release: It involves mass culture and release of natural enemies to suppress the pest population directly periodically as in the case of conventional insecticides.

Properties of insect categories subsisting on animals:

Properties	**True parasites**	**Parasitoids**	**Predators**
Size	Smaller than host	Same size as host	Larger than host.
Feeders on host	Both larvae and adults feed	Only larvae, adults free living & vegetarians	Both larvae and adults feed.
No. of host needed for maturity	One	One	More than one
Injury to host	Feed without killing	Paralyze to oviposit & kills	Kill to devour
Activity	Functions at low host density, so	Function at low host density, so efficient	Function at higher host density.

	efficient		
Host specificity	Great	Great	Not so great
Suitability for biological control	Not suited	Best suited	Suited
Examples	Mosquitoes, lice, bed bugs etc.	Parasitic wasps, tachnid flies, *Trichogramma*	Mantids, lady bird beetles, spiders etc.

Characteristics of ideal parasites/Predator:

1) Adaptability: should be adapted in varied environmental condition and survive all habitats of pests. **2) Specific:** Should be monophagous

3) Fast multiplication: Short life cycle, high fecundity and high female**:** male ratio.

4) High host searching capacity 5) Easy rearing & **mass multiplication** in laboratory

6) Disperse quickly in locality **7)** Should be **free from hyperparasites**

8) Should not harmful to other beneficial species **9)** Should be **small and tiny**

10) Should not feed on plant species **11)** Should **withstand refrigeration**.

Natural enemies used in Biological control:

I) Insects:a) Predaceous insects: i) The predatory beetle (The Vedalia beetle) Rodolia cardinalis (Muls) for the control of the cottony cushion scale *Icerya purchasi*

ii) *Chrysoperla carnea* on aphids, jassids, whitefly etc.

iii) *Cryptolaemus montrouzieri* on mealy bugs

iv) *Sticolotis modagasa* on sugarcane scales

b) Parasitic insects:

1. *Trichogramma australicum***:** Egg parasite of shoot borer of sugarcane.

2. *Trichogramma minutum***:** Egg parasite of shoot borer of paddy.

3. *Trichogramma chilonis***:** Egg parasite of cotton bollworms and stem borer of sugarcane

*4. Copidosoma koehleri***:** Egg, Larval parasite of potato tuberworm.

*5. (Epipyrops) Epiricania melanoleuea***:** Nymphal and adult parasite of sugarcane pyrilla.

*6. Chelonus blackbumi***:** Egg larval parasite of bollworms and potato tuber moth.

I) Primary parasite: A parasite attacks the plant pest is called as primary parasite.

II) Secondary parasite: The insects which parasitizes the primary parasite of a plant pest is called secondary parasite.

III) Tertiary parasite: A parasite that attacks a secondary parasite is called a tertiary parasite.

IV) Hyperparasites: All parasites that are parasite upon other parasites are collectively called hyperparasites.

II) Predatory vertebrates:

BIRDS: The useful birds which destroy pests of crops and are often seen following the plough and they pickup grubs and other insects that get exposed. The useful birds include starling king-crow and myna. Ducks are employed for controls of striped bug in rice crop each bird accounting for about 500 bugs in a day.

Fishes: Destroy large number of mosquito larvae.

Frogs: destroy paddy stem borer, etc.

Toad & wall lizard - live almost exclusively on insects such as termites, crickets, grasshoppers, bugs, defoliating beetles attracted to light at night.

Snakes: feed on rats.

BIOLOGICAL CONTROL OF WEEDS

One of the well known examples on the use of insects in the biological control of weeds was the fight against cacti in Australia. The prickly pear, *Opuntia inermis* got accidentally introduced into that country by about 1840. The cactus spread so rapidly that in the course of next thirty years about 20 to 25 million hectares of arable land were rendered useless. The weed was attempted to be eradicated through the use of mechanical cutters, rollers, poisonous chemicals but without success. So in 1925, the moth borer, *Cactoblastis cactorum* was introduced and the plants were killed by damaging them into papery structures.

Incase of Lantana, the Lantana seed fly *Agromyza lantinae* controlled lantana. *Zygogramma bicolorata* a predaceous beetle is effective on *Parthenium historophorus*. Leaf eating weevils, *Neochetina* spp. feed on water hyacinth.

Advantages of Biological Control:

1) The complete control over a large area is possible.

2) The co-operative efforts of the farmers of a locality are not necessary. 3) Though initial cost in procuring the biological agents and initiating the project may be high, in the long run it becomes cheaper as the recurring expenditure will be very little later.

4) The biological agent will survive as long as the pest is prevalent and therefore the control affected may last over a long period.

5) When successfully established the biological agent can perpetuate itself and therefore after a few years of field release there may not be any necessity to propagate it further.

6) No pest resistance problem.

Definition of predator:

An organism that lives by preying on other organisms.

One that victimizes, plunders, or destroys, especially for one's own gain.

List of Predators:

Beetles (Class Insecta, Order Coleoptera): Soldier Beetles,Ground Beetles,Tiger Beetles,Lady Beetles

Flies (Class Insecta, Order Diptera): Robber Flies,Gall and Predatory Midges,Syrphid , Hover or Flower Flies

Lacewings and Mantidflies:(Class Insecta, Order Neuroptera)

Green lacewings Brown lacewings Mantidflies

Wasps (Class Insecta, Order Hymenoptera): Yellow Jackets, Hornets, Common Wasps

Bugs (Class Insecta, Order Hemiptera: Bigeyed Bugs,Pirate Bugs,Stink Bugs,Assassin Bugs

Thrips (Class Insecta, Order Thysanoptera): Predatory Thrips

Arachnids (Class Arachnida): Predatory mites,Spiders

PARASITOIDS Hymenoptera: Trichogrammatidae

*Trichogramma chilonis*Ishii Parasitised egg cards, *Trichogramma japonicum, Trichogramma achaeae Trichogramma pretiosum, Trichogramma embryophagum Trichogramma brassicae*

Goniozus nephantidis (Muesebeck), Hymenoptera: Bethylidae ,*Chelonus blackburnii* Hymenoptera: Braconidae, copodosoma cohhillari

Order : Hymenoptera

This order is especially rich in families having entomophagous insects. The insects from this order have 2 pairs of membranous wings, front wings being invariably larger then hind wings; mouth parts are chewing and lapping or biting type some insects having ovipositor mdified into stinge. Most of the parasitic species utilized in biological control belong to this order.

Important Entomophagous families : (Suborder - Apocrita)

Family : Ichneumonidae – Adults vary comsiderably in size, form and colouration. The commonest colours are black and bright yellowish brown with reddish or yellowish spots or bands. The wings have well developed stigma. Antannae are long, filiform not elbowed and are constantly vibrating. Throchanrets ae two segmented. The larva has a distinct head and nine pairs of spiracles but no legs. They comprise 20 % of all parasitic insects , and therefore of great economic value.

Examples : 1. ***Isotima javensis*** – parasitic on sugarcane top shoot borer , ***Scirpophaga novella*** and rice stem borer ***Scirpophaga incertulas***, 2**.** ***Xanthopimpla punctata*** – on chilo partellus and 3. ***Cosmomeriella colleris*** – on white grub ***Leucopholis Lepidoptera.***

Family: Braconidae These are small but stout bodied and over 15 mm in length. Their abdomen is about as long as the head and thoraxcombined. These are parasitising larvae of Lepidoptera, Coleoptera , Diptera, Homoptera (aphids). These insects are closely related in structureand habits to to Ichneumonidae but are readily separated by the absence of vein in the fore wings.

Examples: 1**.** ***Apanteles flavipes*** - on larvae of Chilo partellus, Scirphophaga nivella, Sesamia inferens and Tryporyza incertula , **2.** ***Bracon greeni*** **3. Rhogas aligarhensis** - both on larvae of Earias sp**.** **4. Chelonus blackburni** - an egg-larval parasitoid of cotton bollworms **5. Bracon hebetor** -on rice moth in storage and Lepidoptera larvae in field. **5. Bracon brevicornis** - on coconut black headed caterpillar **6.Bracon kirkpatricki** - on cotton bollworms**, 7.Apanteles glomeratus** – on cabbage butterfly (pieris sp) and **8. Cotesia plutellae** - on larvae of diamond black moth

Family: Chalcididae - These are fair sized chalcids about 2-7 mm in length with hind femora greatly swollen and toothed. These are parasitic on Coleoptora, Lepidoptera, Diptera and Neuroptera. **Examples** : ***Brachymeria nephantidis*** – parasitic on larvae of black headed caterpiiller of coconut.

Family: Pteromalidae - These are minute black metallic green or bronze coloured insects attacking wide variety of hosts. They have large but short thorax and subtriangular gaster.

Examples: 1. ***Hebrocytus cerealella*** - the female of this stem bore parasitoid penetrates its ovipositor into the seed containing larvae of Angoumois grain moth, Sitotroga cerealella and secretes a viscous fluid which form a tube through which it sucks the body fluid of injured larvae. ***2. Cardiagaster secundus*** – parasitize sugarcane white fly, Aleurolobous barodensis.

Family: ***Encyrtidae*** - They are 1-2 mm in length and can usually be recognized by the broad convex mesopleura. Mid tibial spur is enlarged. Marginal vein short and it is shorter than submarginal vein. These are parasitising egg, larva and pupa of Lepidoptera, Hemiptera and Homoptera.

Examples: 1.***Copidosoma koehleri-*** an egg-larval parasitoid of potato tuber moth, ***Phthorimaea operculella, 2. Ooencyrtus sp***. - an egg parasite of fruit sucking moth and anar caterpillar

Family: Eulophidae - These are rather small insects of about 1-3 mm in length. . They have 4 segmented tarsi; many have a brilliant metallic coloring and males of many species have pectinate antennae.

Cotesia (=Apanteles) glomerata **(Hymenoptera: Braconidae)**

Cotesia glomerata was introduced to North America in 1883 for the control of the imported cabbageworm on cole crops and has become a major mortality factor of cabbageworm.

Cotesia adults are small (about 7 mm), dark wasps and resemble flying ants or tiny flies. They have two pairs of wings, the hindwings being smaller than the forewings, and chewing-lapping mouth parts. The antennae are about 1.5 mm long, and curved (not elbowed) upward. The abdomen of the female narrows to a downward curving extension called the ovipositor with which she lays eggs. The pupae are in an irregular mass of yellow silken cocoons attached to the host larva or to plant leaves.

Pests Attacked: The imported cabbageworm and its relative *Pieris brassicae*.

Adults mate and the females lay eggs, in most cases, immediately after emerging from their cocoons. Eggs are deposited into larvae (preferably first instar) of caterpillars--about 20-60 per larva--soon after mating. A female lays about 150-200 eggs during her life. *Cotesia* larvae emerge after about 15-20 days and spin their cocoons on or near the host which dies when the wasps emerge. The life cycle, from egg to adult, is approximately 22-30 days, depending on the temperature.

Bracon: ***Bracon*** is a genus of wasps in the Braconidae, a family of parasitoid wasps. There are several hundred described species but there are thousands still undescribed.[1] The genus is cosmopolitan, distributed throughout the world, with most of the described species occurring in the Palearctic ecozone.

These wasps are mostly ectoparasitoids, with the larvae developing on the outside of the body of the host. Recorded hosts include the larvae of many species of lepidopterans, beetles, flies, hymenopterans, and true bugs. They are idiobionts, halting the development of the host when they lay eggs on its body. Some *Bracon* wasps are specific to one host species, and some are known to utilize many different hosts.The eggs of the wasp can be very hardy. In one report, *Bracon* wasps oviposited on tortrix moth larvae, which then entered privet seeds and were consumed by birds along with the fruit. The wasp eggs were later excreted and the larvae emerged.This large genus has been divided into several subgenera, some of which are further divided into species-groups.A DNA analysis showed that the genus is paraphyletic, that its subgenera and other defined groups are not all valid on a molecular basis, and that revising it into informal groups would be more practical. Other authors still divide the genus into subgenera using morphological characters to make identification easier

Most of the thousands of species that fit into this genus have not yet been described, but even the number of named species is unclear, with estimates ranging from 500 to 1000.

Species include:*Bracon hebetorBracon acrobasidisBracon agathymiBracon americanus,Bracon analcidisBracon angelesiusBracon apicatusBracon argutatorBracon bembeciaeBracon brachyurusBracon brevicornisBracon canadensis,Bracon caulicolaBracon cephiBracon cinctusBracon connecticutorum,Bracon hebetorBracon helianthiBracon hemimenaeBracon hobomok*, *Bracon kirkpatricki*.

Scientific name: *Epiricania melanoleuca***Order:** Lepidoptera **Family:** Epipyropidae

Epiricania melanoleuca is a moth in the family Epipyropidae. It was described by Thomas Bainbrigge Fletcher in 1939. It is found in India, where its larvae are external parasitoids of the sugarcane planthopper. It has been used in biological pest control against this pest. The adult *E. melanoleuca* is a small, dark grey, moth with short, broad wings giving it a triangular outline. The male has a whitish margin to both pairs of wings, while the female has slatey-grey forewings and dark grey hindwings. The wingspan is 10 to 13 mm (0.4 to 0.5 in) in females, and slightly less in males. The antennae are bipectinate (have comb-like lateral processes on both sides).The larvae are at first campodeiform, having a long flattened body, legs and antennae, but the later instars are fleshy and ellipsoidal; they are concealed by the white waxy filaments they secrete. The pupa is concealed in an oval, white, silken cocoon.

Epiricania melanoleuca is native to India, occurring in the drier parts of the sugarcane-growing area. It also occurs in Pakistan and Bangladesh, and has been introduced into Sri Lanka

The larvae of *E. melanoleuca* are parasitoids on the sugarcane planthopper (*Pyrilla perpusilla*). The moth's eggs are laid on the surface of the leaves on which the planthopper and its larvae are feeding. Fecundity of the female moth is in the range 400 to 800. On hatching, the moth larvae attach themselves with their prolegs to the edge of a leaf and hold themselves erect, questing for a suitable host. When one is found, they attach themselves to the planthopper larvae with hooked claws, pierce the cuticle with their mouthparts and suck out the hemolymph. When the moth larvae are fully grown, after four or five moults, they can be seen as conspicuous, white bulges on the surface of the host. They then detach from their hosts, which dies at around this time, and pupate on the surface of a leaf near the ground

Epiricania melanoleuca can be used in biological pest control. When it has been introduced to areas of India where it does not naturally occur, the incidence of the sugarcane planthopper has been reduced. The moth can be bred in the laboratory, and eggs can be transferred on leaves, or cocoons can be collected from fields and transferred. In a research study in Orissa, peak planthopper activity was observed in September. A parasite/pest ratio of 1:64 in late August was converted into a ratio of 1:0.25 in late October, indicating control of the pest. As well as the natural suppression of the pest, there is a considerable saving to be made by reducing the use of insecticides on the sugarcane crop

Examples: 1. ***Tetrastichus israeli*** - pupal parasite of black headed caterpillar**, 2.** ***T. pyrillae*** - an egg parasitoid of pyrilla, **3.** ***Trichospilus pupivora***- attack pupae of black headed caterpillar and **4.** ***Aphelinus mali*** - attack wooly apple aphids, ***Erisoma lanigera***

Family: *Trichogrammatidae* - This is one of the most important hymenopterous parasitoid for the purpose of biological control. It contains very minute insect of about 0.3 to l mm in length and recognized by three segmented tarsi. They have broad front wings which have microscopic hairs on them usually being arranged in rows and short head that is some what concave behind. These insects are egg parasitoids of a large number of insects especially those belonging to Lepidoptera.**Examples:** Trichogramma chilonis, T. australicum, T. japonicum, T brasiliensis are important parasitiods of sugarcane stem borers, paddy stem borers, cotton bollworms, etc.

Family: Elasmidae - These insects have laterally compressed, triangular body and have mostly branched antennae **Examples:** Elasmus nephantidis -parasitise advanced instar larvae of black headed caterpillar of coconut.

Family: Mymaridae - These are also called fairy flies. They are very tiny insects mostly less than a millimeter in length, black or yellow in colour having fringed wings. Hind wings are linear and base forms a stalk, ovipositor arising from tip of gaster. **Examples**: Anagyrus empoescae - parasitic on jassids.

Family: Scelionidae - These are very small insects which are parasitic on the eggs of Orthoptera, Dictyoptera, Hemiptera, etc. Examples: 1. Telenomus beneficiens - parasitises eggs of top shoot borer of sugarcane and paddy stem borer, 2. Telenomus remus - attacks eggs of tobacco leaf eating caterpillar (Spodoptera sp.)

Family: Platygasteridae - These are minute shining black insects with reduced wing venation. Several species exhibit phenomenon of polyembryony with as many as 18 young ones developing from a single egg.**examples**: Platygaster oryzae - parasitic on rice gall fly.

Family: Bethylidae - These are ant like small to medium sized dark Coloured insects parasitic on the larvae of Lepidoptera and Coleoptera. they have 11-13 segmented antennae, 7-8 segmented gaster, hind wings are with anal lobe**.Examples**: *Perisierola nephantidis* - parasitic on black headed caterpillar of coconut.

Family: Vespidae - This includes social wasps which are predating on larvae of Diptera and Lepidoptora There are two spurs at the end or each middle tibia, These are severe stingers. Examples: Vespa orientalis

Family: Scolidae- These are large, hairy and usually black with a yellow hand or bands on the abdomen. These are parasitic on the grub of Scarabacid bectles. The females of these insects burrow in to the ground to locate the larvae of Scarabaeids; when they find a grub, they stings it and paralyze and then construct a cell around grub. **Examples**: Scolia manilae - successfully employed to control the beetle Anomala orientalis in Hawaii, and Scolia flavifrons attacks the grub of rhinoceros beetle.

Order: Diptera:This order includes the insects which possess single pair of membranous wings with hind pair modified into halteres. Mouth parts suctorial form proboscis, mandibles rarely present, labium forms a pair of fleshy lobes. Prothorax and metathorax are small and fused with mesothorax.

Important Entomophagous families Suborder: Brachycera

Family: Asilidae - The insects from this family are commonly called robber flies. These flies have top of the head hollowed out between the eyes and face, more or less beared and they have a stout thorax, with long strong legs. Most of them are elongate with abdomen tapering but some are stout bodied and very hairy, and strongly resemble bumble bees. The adults are predaceous and attack a variety of insects including wasps. bees, dragonflies, grasshoppers and other flies. Examples: Indian species, Allocotosia auranta and Philodicus femoralis

Suborder : Cyclorrhapha

Family: Syrphidae- These insects are called hover flies as they rapidly vibrate the wings in air. These are moderate to large sized flies having brightly coloured markings on body. They resemble various bees or wasps, und some look much like honey bees. These flies can be recognized by the spurious vein between radius and media. Examples: Syrphus unipunctus - on aphids (larvae are predacious on aphids)

Family: Tachinidae - In these flies, both the hypopleural and pteropleural bristles are developed and post scutellum is prominent. The ventral sclerites of abdomen are usually overlapped by terga and abdomen generally have a number of very large bristles in addition to smaller ones. The larvae of these flies are parasitic on insects.

Examples: 1. Actia monticol -parasitic on the larvae of Spodoptera litura,

2. Sturmiopsis inferens- parasitic on larvae of Sesamia inferens,

3. Podomyia setosa - parasitic on larvae of Achaea janata

. Other entomophagous families

Pipunculidae (big headed flies), Conopidae (thick headed flies) and Cryptochaetidae.

Order: Lepidoptera : This order includes very familiar insects like moths and butterflies. In these insects, body and wings are clothed with broad scales. Mandibles are absent and their maxillae form proboscis which remains coiled below the head.

Family: Epipyropidae - The larvae of the moths from this family are ectoparasites of plant hoppers which feed on dorsal surface of the abdomen of nymphs and adults of plant hoppers under the wings.Example: Epiricania melanoleuca- The larvae of the mothsparasities nymphus adults of sugarcane Pyrilla.Adults of the parasite are small black coloured moths very active and

possess bipectinate antennae.Male are very active and yellow coloured which in later instars are white in colour.

Order: Dictyoptera: **Family: mantidae**-both nymphs and adults of these insects are predacious.nymphs fees on aphids and leaf hopers and adults feed on catwerpillar ,grasshopper .mantids are about 40-75 mm long and their prothorax and fore coxae especially long and the froe legs so modified tha they can graspe small insects between the piny tibia and femora.

Ex. *Mantis religiosa*

order:hemiptera :suborder:heteroptera:in these insect,either both wings are similar in texture or fore wings are half thin and half thick(hemelytra),and mouth part piercing and sucking type.maxillae and mandibles are modified to stylets.

Family:reduviidae-(eg.assassin bugs). These bugs are usuallu blackish or brownish in colour, the head elongated with part behind the eyes neck like, beak is short and three segemented. The most species are predacious on other insects but few are blood sucking and frequently bite man. Ex.1.harpactor costalis-predacious on red cotton bug,2.rhinocoris fascipes-predacious on the larvae *of Helicoverpa armigera and Spodoptera litura*.

Other entomophagouss families:gerridae,anthocoridae,miridae,lygaeidaepentatomidae,notonectidae,belostomatidae and nepidae.

Order: NEUROPTERA

These are soft body insect with long antennaewings paired,membranous which are disposed roof like over the boddy. Veins in thee wings form a fie net work. Mouth parts in adults are bting but in larvae may be biting orr suctorial.

Suborder:planipennia-the insects from this family are called common lace wings. Most of them are greenish in colour with golden or copper coloured eyes. They have elongated filiform antennae which are longer than fore wings. Wings are of equal size,hind paires narrow at base,lacy with veins bifurcated at margin. Larvae have often long or hooked hairs on the body and mouth parts are suctorial.eggs are stalked.larva is yellowish or greenish with red chocolat or black margins and spindle shaped tapering almost as mch toward the head and tail provided with sickle shaped mandible they have long and hooked haires on the body. Empodium trumpet shaped.Family:chrysopidae(green lace wing)Ex.1.chrysoperla scelestes and s.carnea-predator on aphiods, leaf hoffer, psyllids, scale insect, mealy bugs, thrives, mites etc.

Family:hemerobiidae(brown lace wings)-these insect resemble common lace wings(chrysopidae) but they are brownish instead of green. They have moniliform antennae. The wings are oval, fore wings with rs arising as atleas two branches. Larvae are fusiform and smooth without tubercles of any kind and body haires are short and simple mouth parts are rather

stut and only slightly curved. Adult and larvae of these lace wings feed on aphids and other homoptera and mites.Ex.an adult of hemerobius stigma could eat 13,000 to 15,000 aphids and lava about 3,000 aphids.

Other entomophagous families:mantispidae, myrmeleontidae(antlion) and ascalaphidae

ORDER:COLEOPTERA

This order includes the insect which are having very hard body and hard fore wings; hind wings are membranous or may be absent. Prothorax in these insect is large and mobile, mouth parts biting and chewing type both in adult and larvae.

Suborder-polyphaga

Family: coccinellidae(lady bird beetles)-these beetles are oval, convex and often brightly coloured insect. The commonest species are red, brown or tan usually with black spots. They have three distict tarsal segments. The larvaeare soft bodied, elongated somewhat flattened and covered with minute tubercles or spines. They are usually spotted or banded wit bright colour. The larvae and adults of these beetles are predating on aphids, coccids, mealy bugs, white flies, psyllids and mites.Ex.1.*Rodolia Cardinalis* (vedalia beetle)-collected from Australia andintoduced to califonia in 1888 for the control of the citrus scale, icerya purchase, 2. Menochilussexmaculata-a cmmon indian species feeding on aphids, mealy bugs, sugarcane white flies, 3.*Cryptolaemus Montrouzieri*-can be used succefully for the control of grapes vine mealy bugs,4. *Coccinella Septempunctata*-feedon aphids and various species of coccids.

Other entomophagous families: carabidae(ground beetles), staphylinidae(rove beetle) lampyridae(glow worm or fire flies), cantharidae (soldier beetles) feed on mealy bugs, aphid,etc. cleridae(checkered beetles-larvae and adults feed on bark boring coleopteran, meloidae(blister beetles grub feeding on eggs of grass hoppers, histeridae(steel beetles)

Order:strepsiptera

This order includes small endoparasitic insects whose adult males are free living. Males are winged, fore wings club like and hind wings fan shaped. Females of parasitic species usually lack eyes, antennae and legs, body segmentation is very indistinct, and head and thorax are fused. Various species of orthoptera, hemiptera, homoptera, hymenoptera and thysanura serve as hosts of strepsiptera.

Family: myrmecolacidae-paracitic on female of orthoptera.

Halictophagidae-paracitic on homoptera and family tridactylidae on orthoptera

Other entomophagouys families- callipharyxenidae, stylopidae

Order:odonata

This order includes exclusively entomophagous insects called dradon flies and damsel flies. These insects have biting mouth parts and two equal or sub equal pairs of elongated, membranous wings, each wing with a complex reticulation of small cross veins and usually conspicuous stigma. Compound eyes are very large and prominent,antennae very short and filiform. Abdomen is elongate, slender. Nymphs are aquatic. Adults of these insects are generalized predator usually feeding on almost any suitable sized insects. They capture their prey in flight or while it is resting using their forwardely directed legs to hold and transfer it to mouth. The nymphs are aquatic feeding on aquatic insects.

Mass multiplication and field release of parasitoids

Different species of Trichogramma used in India:

a) *Trichogramma brasiliensis Trichogramma japonicum Trichogramma exiguum*

b) *Trichogramma chilonis Trichogramma bactrae Trichogramma T eldanae*

1. Take a wooden box of dimension 45 x 30 x 15 cm. and it should be cleaned property.
2. The sorghurn or wheat grains should be heat sterilized in oven at 100 degree Celsius for 30 minutes.
3. The sorghum or wheat grains should be sprayed with 0.1% formalin. This treatment helps to prevent the growth of moulds as well as increase the grain moisture to optimum (15 to 16%) which was lost due to heat sterilization.
4. The required quantity of sorghum or wheat grains should be milled to make 3 to 5 pieces of each grain by using grinding mill.
5. The following material should be filled in wooden boxes -
   i) Crushed wheat or jowar grains = 2.5 kg
   ii) Crushed groundnut = 25 gm (to apply protein and fats)
   iii) Protein - x or agar-agar = 2 gm (to increase fecundity)
   iv) Sulphur powder = 1 to 1.5 gm (to control mites)
   v) Streptocyclin @ 0.5 gm per 5 lit (to control bacterial infestation)
   vi) *Corcyra cephalonica* eggs = 0.5 cc (9000 to 10000 eggs)
6. All filled material should be mixed properly and cover the box with lid and keep it in iron racks for 40 to 45 days. After that *Corcyra cephalonica* moths will emerge out.
7. Emerged Corecyra Cephalonica moths should be collected daily by two method:-
   i. Vacuum cleaner method ii.Test tube method

8. Kept the collected *Corcyra cephalonica* moths in tin for egg laying and previously laid eggs should be cleaned by two method:-i) Sieving method ii. Paper tapping method
9. Store the eggs in refrigerator at 5 degree Celsius, b) Preparation of Trichocard:

1) Take a Trichocard of size 17.5 x 14 cm
2) Fill up the information on Trichocard.
3) Spread paste gum uniformly on Trichocard.
4) The *Corcyra cephalonica* eggs are glued on the card by tapping uniformly on the gum coat.
5) The egg card should expose to UV rays for 20 minutes for kilting embryo.
6) The egg card is placed in plastic jar.
7) Introduce the parasitized egg card in such container or expose these egg cards to adult females of Trichogramma for 24 hours.
8) Close the container with cloth and rubber bands conveniently.
9) The adult female parasitoids emerge from the parasitized blackened egg cards and parasitise the eggs of *Corcyra cephalonica* after mating.
10) The parasitoids complete its life cycle within 8 to 10 days.
11) The parasitoids eggs of *Corcyra cephalonica* start changing from creamy white to blackish due to accumulation of urate granules after 4 days of parasitization. Such parasitized egg cards could be stored for about 30 days at 5 degree Celsius temperature in refrigerator.

C) Field release: For field release of Trichogramma in standing crop, select the spot in field at 3-4 meters distance. Cut Trichocard along segment markings and staple the Trichocaris segmetns (i.e. Trichobit) on lower surface of plant leaves. Care should be taken to avoid rubbing touching of surface of parasitized eggs to leaves for preventing the destruction of eggs.

(D) *Chelonus blackburni* Cameron:cotton bolloworm cause severe losses (40%) in yield of seed cotton.chelonus blackburni is a highly potent egg-larval parasitoid of the bolloworms. Methods of mass multiplication of the parasitoid is given below:

Material:1.rearing unit of *Corcyra cephalonica* stain. Which includes wooden boxes, crushed grains of orghum, egg cards,gum Arabic, corcyara eggs,etc2.rearing unit of potato tuber moth,which includes potato tubers, plastic baskets,sterilized soil, puncturing brush, egg-sheet of PTM, etc.3.breeding glass jars, muslin cloth, rubber bands, scissor, wide mouth plastic jars, etc.4.nucleus culture of *C.blackburni* adults.

Laboratory host1.rice moth,Corcyra cephalonica st.2. potato tuber moth, phthorimaea operculella z.Target pest:Pink bollworm, *pectinophora gossypiella* s.

1. spotted bolloworm, earias spp.
2. Potato tuber moth,phthorimaea operculella z.

Method of mass rearing of *C.blackburni*

C.blackburni is an exotic internal solitary egg-larval parasitoid and is uniparental in nature.one adult parasitpid parasitizes 70-100 eggs and on corcyara culture, it completes the life cycle within 30-35 days. Whereas on potato tuber moth culture,life cycle of the parasitoid is complete in 26 days. Following steps are involved in mass rearing of *C. blackburni* on *C.cephalonica* culture.

1. Obtain Corcyra eggs from the rearing units as described earlier and glue oone cc eggs cards sparsely. For this purpose, use only freshly laid or 0-24 hrs old eggs of the host.

2. put this egg card in breeding glass jar and released the freshly emerged adult parasitoids C.blackburni on Corcyra egg card with the help of aspirator. During parasitization, adult parasitoids may be provided wih 50% honey sssolttion on wax paper or in cotton wicks. About 100 adult parasitoids can be used to parasitize 0.25 cc of C.cephalonica egs with the embryo in the host eggs.

3. after exposure of 24 hrs, the eggs card which is kept for parasitization iss removed and another egg card can be placed placed for parasitization.

4.put 2.5 kg crushed grains of sorghum already treated with 0.1% formalin solution in each Corcyra rearing wooden boxes, or sufficient quantity of crushed grains in glass jar, where in the grain layer should be 2.5 cm thickness.

4. place the convenient sized pieces of parasitized egg cards on the layer of the crushed grain with the proportion of 0.5 cc eggs per 2.5 kg grains. Cover the top o0f wooden box with it lid or jar with muslin cloth and rubber band.the parasitized larva hatched out and the larvae already parasitized in its egg stage start feeding on broken grains and remain developed in it.

5. After a period of 1 month, the parasitoid complete its life cycle and adult emergence start , which can be collected with aspirator and used for further multiplication.beside this,after about 25 days of parasitization of eggs, the pupae of the parasitoid which are silvery white in colour may be collected from larval grain webbing. Such pupae, as per requirement, could be stored for 17 days at 10 degree celcius temperature.

In case of mass culturing of C. blackburni on PTM, follow same procedure as given for C. koehleri parasitoid. Here egg shets of PTM may be exposed to adults of C. blackburni and the parasitized egg sheet after 24hrs. of exposure, may be established In to plastic basket with the punctured potato tubers already placed on a soil layer. The silvery white earten pupae of the parasitoid could be collected by sieving the soil or collect emerging adults with aspirator.

FIELD UTILIZATION OF C. BLACKBURNI

Potato:The adult parasitoid could directly be released in the field crops or even in stored potatoes(Arni) as descriebed for earlier parasitoid. Release of 60,000 adults/ha (i.e 15,000 adults/week/release and such 4 releases in the ffield crop). In case of stored potatoes, release 2 adults/kg tubers.

Cotton: release 2 lakh adults/ha with total 6 releases starting after 60 days of planting.

Precautions:-1.Do not keep the height of broken grains more than 2.5 cm in the rearing jar/box, otherwise parasitoid emergence may be affected.

2. plan flowering shrubs along the field margin to provide food to parasitoids in off season.

3. Avoid use of pesticides before and after 15 days of release or follow staggered spray technique and release the parasitoid on alternate untreated strips.

(E) *Chrysoperla Carnae* STEPHENS

Green lace wings (aphid lion), chrysoperla spp. Is a potent preadator of many sucking pests. The mass production technique of the predator is given below:

1.corcyra cephalonica rearing unit for the egg production.2. nucleas culture of chrysoperla spp.

3. rearing trays, plastic jars. 4. slotted iron angel racks, working tables 5. weighing balance.

6. scissor, brushes,cooton wol, forceps, tissue paper, bown paper, separators. 7.foam sheet, sponge, acrylic sheet. 8. fructose, protinex mixture, honey, yeast, castor pollen,etc.

BIOLOGY:The eggs of chrysoperla are stalked and green in colour. They are laid singly or in clusters. The eggs turn pale whitish and then black before hatching. Thr newly hatched larva is white in colour. It is tapering towards both the end and having two scissor like mouth part (mandible). The larvae undergo moult three times till maturity.cocoon are whitish and round. The adults are round in colour with transparent wings.Adults are laying the eggs 5^{th} day onword and peak egg laying period is 9 to 23 days after emergence and fecundity is 600-800eggs/female.

Duration of life cycle:Eggs 3-5 days Larvae 10-15 days,Cocoon 6-17 days,Adult 47 days (summer), 65 days (winter) Male 30-35 days Female 35-55 days, Total period 66-102 days

Mass Rearing Of Chrysoperla:

Rearing of chrysoperla sp. Requires 1 room 6*6m maintained at 27+\- 1 C, RH 70% and constant light of normal illumination levels emitted by florescent tube.

1.Confine 200 pairs of adults in oviposition cage, measuring 75*30*30cm. the sides of the cage are lined with smooth nylon wire mesh and the sliding top cover is fitted with black cloth for obtaining eggs. To prevent damage to the eggs the top is slided over a comb fitted on both the side of the cage. The sliding top cover is replaced on alternate days starting from 4^{th} days onwards. The oviposition cage is kept for 30 days and the dead adults are removed every alternate day.

2. the adults in oviposition cage are are fed on alternate days on cotton wool swabs soaked with drinking water, 50% honey solution and protinex mixture(equal quantity of protinex + fructose + powdered yeast dissolved in small quantity of water). Two swabs of each of the three liquid should be hanged in cage with the help of thread or thin iron wire.

3. one day old eggs are dislodged from black cloth top cover of oviposition cage by gently moving a piece of sponge.

4. since the larvae of chrysopids are cannibalistic, rear them individually in plastic louvers or in hexagonal cells. Place a foam sheet of convenient size in plastic rearing tray. Then put the paper separator having hexagonal cells on the foam. Sprinkle about 300-400 corcyra eggs in each cell. Introduce 3 days old 1-2 chrysopids eggs per cell. The top of separator should be covered with paper to avoid larval migration from one cell to another and it is again covered with a lid of the tray. The lid should be provided with center opening for aeration.

5. after hatching of larvae on 3rd day transfer these larvae into individual cubicle cells of plastic louvers(192 larvae/tray). Give first feeding of 1.5 ml eggs and second feeding of 2 ml eggs/100 larvae with 3-4 days gap. Total 4.25 ml corcyara eggs are required for rearing of 100 chrysopid.

6. the matured larvae pupate in round white cocoons, which may be collelcted after 24 hrs of formation by removing paper top. These cocoons are kept in oviposition cage/ jar for adult emergence.

FIELD UTILIZATION:Normally chrysopids released in field in its first instar larval stage against different sucking pests@ 15,000 larvae/ ha or 10-20 larvae/ fruit tree. Depending upon pest saturations, two releases at fortnightly interval are recommended for the control of following sucking pest and early instars lavae of lepidopteron pests.

Target pests: aphids, white flies, jassids, eggs and early stage of bolloworms and tobaccoleaf eating caterpillar.

Dose: chrysoperla @ 15,000 larvae/ ha and 2-3 releases at 15 days interval, 1-2 larvae/ plant or 10-20 larvae/ tree.

Method of release:

1.brod casting of larvae with saw dust in thick crop canopy.

2. dropping 1-2 larvae/ plant on leaves or 10-20 larvae/ tree placing corrugated paper strip on the plant or tree or also eggs mixed in saw dust are dropped in crop canopy.

Precautions:-

1.Rear to grub stage individually to avoid cannibalism.

2. release should be made in early morning hours to settle larvae on crop canopy.

3.avoid to release freshly laid eggs as they may be parasitized/ predated in the field.

Do not use pesticides in the field where the predators are released, otherwise use selective/ safer pesticides after or befor 10-15 days of release following strip or staggered spray method.

Mass production of *Goniozus nephantidis*

Goniozus nephantidis is the most widely used parasitoid of *Opisina arenosella*. It is a sturdy gregarious larval or prepupal ectoparasitoid. The female practices maternal care of eggs and larvae. The host larvae are parasitized and the parasitoid even feeds on host body fluid. The parasitoid is also capable of suppressing the population by merely stinging and aralyzing 1st – 2nd instar larvae. *G. nephantidis* is the most common and effective parasitoid of late instars caterpillars of *O. arenosella* in several parts of the country. The parasitoid is being mass multiplied and released in Karnataka, Kerala and several other states.

Production procedure

- The parasitoid is multiplied on *Corcyra cephalonica* larvae in diffused light. A pair of parasitoid is introduced in tube (7.5 x 2.5 cm).
- The adults are provided honey in the form of small droplets on wax coated paper. After a pre-oviposition period of six days one healthy last instar larva is provided in a vial.
- The larvae parasitized and containing eggs of *G. nephantidis* are removed regularly from the vials till the death of the female. Such larvae are kept in accordion type strips of paper in plastic boxes which are covered by muslin cloth.

- Considering the fecundity as 20-50, the female is capable of parasitizing 6-7 larvae in three oviposition spells each separated by 4-5 days.

The life cycle of the parasitoid is completed in 10-14 days (incubation 24-36 hrs, larval feeding 36-48 hrs, prepupal stage 48-60 hrs and cocoon period 48 to 56 hrs + resting adult inside the cocoon 108-128 hrs).

Mass Production Of *Cryptolaemus Montrouzieri*

The predatory beetles Cryptolaemus montrouzieri needs to be reared on the host species of mealy bugs like Planacocus citri, ferrisia virgate, Maxonellicoccus hirsutus under laboratory

conditions. Hence, the development of mealy bugs can be done on sprouted potatoes as well as on Red Pumpkins. However, rearing over red pumpkins is more practicable

a) Mass culturing of Mealy bug :

- Medium sized pumpkins with ridges and grooves with a stalk be selected for mass rearing.
- Clean the Pumpkins with 0.1% Bavistin solution and prior to that was them with distilled water Bavistin solution prepared as:- 1g/ lit. water i.e.0.1% to prevent its rotting during rearing process.
- The wounds if any they may be plugged by paraffin wax to prevent the infection.
- Keep such red Pumpkin in the plastic trays introduce the ovisacs of mealy bugs on Pumpkins.
- After 2 days such Pumpkins be kept into wooden cages provided with the sliding glass at the front end and wire guage and cloth on other sides.
- These cages are then placed on working tables/racks in the room.
- Mealybugs will develop in 30-40 days.

Biology of mealy bugs:500-300 eggs in ovisacs,Incubation period = 5 days,Nymphal period = 3 weeks,Nymph undergoes = 3 instars each 1 week,Adult period = 5-7 days,Total life cycle = 30-40 days

b) Mass production of *Cryptolaemus montrouzieri*

- When mealy bugs are 8-10 days old, a stock of 25 mated females are placed in rearing cages such that there are two beetles/pumpkins.
- Temperature maintained at 20-30^{o}.
- The released mated females feed over the stages of mealy bugs.
- Later on these females deposit their eggs over mealy bugs ovisacs.
- Deposited eggs are oval yellowish in colour.
- Remove ovipositing adults after 12 days.
- On hatching, larvae feed over the stages of mealy bugs.
- Display overlap strips to the front of the cages to accommodate pupating larvae of the predator.
- During this period maintain darkness.
- Collect the emerging beetles with aspirator and feed them with honey agar diet as well as mealy bugs ovisacs (eggs)

Life Cycle of *Cryptolaemus Montriuzieri*

Pre-oviposition period:7-12 days,Oviposition period39-63 days,Incubation Period 4-8 days Grub period 14 days with 4 instars-1st instar : 2-4 days,2nd instar : 3-5 days,3rd instar : 2-4 days,4th instar : 1-2 days,Prepupal period1-2 days , Pupal period7-11 days

- Collect the adult beetles and keep them in plastic jars with honey diet and mealy bug eggs.
- Pair the newly emerged male and female of the predator and confine them to the pelriplates or plastic jars with lid and use for future mass production.

INSECT POLLINATORS, WEED KILLERS AND SCAVENGERS

Pollination is transfer of pollen grain from anthers to the stigma of either same flower or of different flowers on same plant or different plants.

Self-pollinated plants -Need no agent for transfer of pollen.

Cross pollinated plants -Need wind, water, insects or other agents for transfer of pollen.

Insect Pollination:

- Result in uniform crop and in some cases in improvement of quality of fruit.
- Horticultural, crops, vegetables and fields crop like cotton and tobacco are pollinated by various insects.
- Flowers of insect pollinated crops show adaptations like:-

1) Bright attractive colours

2) Scented flowers

3) Showy large petals

4) Nectaries

5) Sticky stigma and sticky pollen.

Insect visit the flower for nectar, the pollens get dusted all over the body and is transferred to stigma of flower next visited. Thus cross pollination is brought about.

* Insect pollinators: Examples:-

Honeybees,	Bumble bees,	*Sarcophaga,*	Butterflies
Xylocopa ,	*Bombus* spp,	Beetles,	*Acherontia*
Andrena ,	*Syrphus*,	Black ants,	*Deilephila,*
Halictus,	*Bombylius,*	Thrips.	

- Wide use of broad spectrum .insecticide has caused decrease in wild pollinators hence practice of employing honeybees artificially for, pollination in fields is increasing.
- Carrots, Umbelliferous plants depend on wasps and flies.
  Tobacco: honeybees and Bumble bees.
- Fruit crops like apple, plum, blackberry, raspberry, strawberry, citrus, grapes, papaya, cherry, vegetables, like lady's finger, brinjal, tomato, cucurbits and field crops like cotton: alfalfa. clover depend on honeybees for pollination.
- In western countries honeybees are hired out in flowering seasons, such forced bee populations increase apple yield by 3 folds and alfalfa yield by 4 times. Cotton yields

increased 23 to 53 % due to honey bee pollination reported in Coimbatore district of Tamilnadu State.

- Bumble bees are generally fewer but useful to pollinate large flowers with long corollas and deep seated nectaries like cotton and lady's finger.

Dependence of plant on insect for pollination Ex. fig tree

Smyrna fig - produce only female flowers but fruit is fleshy, edible and sweet

Capri fig - produce plenty of pollen but non-edible fruits.

Capri fig is normal host for Aganotid wasp i.e.*Blastophaga psenes*. This wasp lays eggs in ovary of Capri fig flower. The eggs hatch and larvae grown in the ovaries. The males are wingless while female adults are winged. They copulate inside the flower and female flies away for oviposition. While it files, it carries pollen from Capri fig for oviposition it may visit a Smyrna fig flower but is unable to deposits eggs as a ovary is deep seated but it deposits pollen grain on Smyrna flower thus affecting fruit formation.

Hence, in fig plantations Capri and Smyrna figs are planted side by side and pollination done by wasps.

Pollination service:

Practice of renting bee colonies for pollination service started in U.S.A. in to 1910. Every year about a million of hives are hired for pollination in U.S.A.

Usually five colonies are maintained for two hectares. Number of colonies per unit area depend upon concentration of flowers, attractiveness, the presence and number of other pollinating insects and presence of competing crops in the vicinity. The colonies should be moved well before flowers have not lost their receptivity to fertilization. The interval between two colonies should about 90 m. as bee activity is concentrated within this radius.

SCAVENGERS

These are insects that feed upon dead and decaying plant and animal matter.

Advantages:

i) Remove dead and decaying bodies from earth surface.

ii) Decrease the health hazard due to this decomposing matters

iii) Clean filth form human habitations. .

iv) Convert the complex body materials to simpler ones making available for growing plants then easily

Important scavengers:

1) Coleopterans: Rove beetles, Darkling beetles. Skin beetles, Chafer beetles, Ptinid beetles, Jewel beetles, Carrion beetles, Water scavengers beetles

2) Dipterans: (Larvae serve as scavengers)

Dady-long-legs, Sand flies, Moth flies, Midges or gnats, fungus gnats, hover flies, Muscids.

3) Isopterans: Termites.