INTRODUCTION, SIGNIFICANCE, HISTORY AND SCOPE

Introduction:

Entomology is a branch of zoology that deals with the study of insects. The term derived from the Greek word Entomon=insects and logos= study.

• With over one million different species inhabiting the earth, insects make up more than 80% of all described animal species and form a major component of the earth's biodiversity.

• The industrial entomology refers to the commercial rearing and industrial utilization of insects and their products.

• Usually insects are considered harmful to man but hardly 1 percent of insect species fall in the pest category.

• Benefits of insects in maintaining economy outweigh the injury inflicted.

Significance and scope

There are about 1 million named insect species.

- It has taken about 300 years for scientists to describe them.
- Estimates of actual species richness vary from less than 5 million to as many as 80 million.
- Because of their diversity, their world-wide distribution, their ecological importance, and their impact on other life-form, the insects are placed indeed in a class of distinction.
- They have different roles: as plant consumers and herbivores, food source for other organisms, scavengers and detritivores (feeding on decomposing organic matter), predators and parasites feeding on other insects and keeping balance in nature.
- They also directly affect human welfare by competing with us for food (damaging crops) and transmitting diseases.
- Hence, insects affect us in different ways.
- Some are beneficial while some are harmful.

Detrimental effects: Less than 1 % of the known insect species are regarded as pests.

1. Destruction or spoilage of food (both fresh and stored) and crop (including forests).
2. Damage to goods-leather, paper, textile (by beetle, cockroaches, silverfish or moths), timber (by termites and different types of borers).
3. Transmits disease in plants, animals and human beings.
4. Possess venoms and cause allergies.
5. Some insects are a nuisance to our well being-house flies, ants, mosquitoes.
6. Require use of pesticides and other poisons, which often harm other animals.

Beneficial effects

Most of the insects are beneficial or have an indirect influence

1. **Pollination:** Insect-mediated pollination is an essential step in reproduction for the majority of the world's flowering 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. It is estimated that 80% of the commercial food crops are pollinated by honey bees.

2. **Bio control:** Some parasitic and predatory insects are excellent bio-control agents for controlling other injurious insects. Example *Encarsia formosa* is an excellent bio-control agent for white flies on tomatoes and potatoes.

3. **Insect product:** Honey, wax (from *Apis mellifera*), silk (from *Bombyx mori*), shellac (from *Laccifer lacca*) and cochineal dyes, i.e. red dye widely used in cosmetics, medicinal and food product (derived from scale insects, *Dactylopius coccus*).

4. **Nutrient recycling:** Insects feed on dead and decaying plants, animals and animal excreta and help in recycling the nutrients. Some insects burrow into soils and improve the soil structure and texture. Examples are dung feeders and termites.

5. **Source of food:** Over 500 species of insects are used as food by humans-usually crickets, grasshoppers, beetles, wasps, butterfly larvae, bugs etc.

6. **Scientific study:** Insects are very important materials for research and study, like genetic study in *Dorsophila melanogaster*.

7. **Miscellaneous:** Some insects are used for medicinal purpose, decoration, hobby, and pets.

Apiculture or bee keeping

Apiculture or Beekeeping (derived from **Latin word**, 'Apis' meaning 'bees') is an art and science of rearing and managing honey bees in a box called "beehive" for production of honey and other products like beeswax, propolis, bee venom etc.

Beekeeping/ Apiculture is an industry, which provides valuable honey, beeswax and pollination services of honey bees.

The cultivation of bees on a commercial scale for the production of honey.

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

In the animal kingdom honey bees belong to:

Phylum-Arthropoda
Class- Insecta
Order-Hymenoptera
Superfamily-Apoidea
Family-Apidae
Genus: Apis
Species: dorsata, laboriosa, florea, cerena, mellifera

Significance

- Honey is very important product of honey bees. It is used as food; 200 g of honey is as nourishing as 1.135 kg of milk or 1.658 kg of cream cheese or 340 g of meat or 8 orange or 10 eggs.

- Honey has many medicinal values. It is used as laxative, as blood purifier, as preventive against cold, cough and fever and curative for sore eyes, sore throat, tongue ulcer, and burns and sugar substitute for diabetic and allergic patient.

- Honey can be used as a beauty and face pack. Applying honey mixed with almond oil on the face help to tone the skin and improve complexion.

- Honey can be used to enhance flavor of other foods.

- Wax is another important bee product. It is used for preparing comb foundation of artificial hives. It is used in furniture and floor polishes, in the manufacture of electrical insulators. Refined wax is used in the preparation of cosmetics, ointment, plaster and surgical dressing and making candle.

- Honey bee's pollination activates are worth 143 times than the value of honey and wax they produce. Bee pollination results yield increase over 50% in some crops.

- About 1/3 of our total diet comes directly or indirectly from insect pollinated crops.

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

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

Ten excellent reasons for beekeeping

1. **Pollination:** Bees pollinate flowering plants and thereby maintain the ecosystem. Bees pollinate cultivated crops.

2. **Honey:** People everywhere know and like honey, a valuable food and income source.

3. **Beeswax and other products:** Beeswax, propolis, pollen and royal jelly. These products have many uses, and can be used to create income.

4. **Few resources are needed:** Beekeeping is feasible even for people with minimal resources. Bees are obtained from the wild. Equipment can be made locally. Bees do not need the beekeeper to feed them.

5. **Land ownership not essential:** Hives can be placed anywhere convenient, and so beekeeping does not use up valuable land. Bees collect nectar and pollen wherever they can find it, so wild, cultivated and wasteland areas all have value for beekeeping.

6. **Nectar and pollen are otherwise not harvested:** Nectar and pollen are not used by other livestock: only bees harvest harvest these resources, resources, so there is no competition competition with other crops. Without bees these valuable resources could not be harvested.

7. **Different sectors and trades benefit from a strong beekeeping industry:** Other local traders benefit by making hives and equipment, and from using and selling the products.

8. **Beekeeping encourages ecological awareness:** Beekeepers have a financial reason to conserve the environment: ensuring that flowers are available and bees are protected.

Major honey bee species:

Exotic and indigenous species

• Honeybees are social insects and live in colonies. Their main source of nutrition is flower nectar and pollen.

Bee species

There are five important species of honey bees as follows.
Apis dorsata: The rock bee Apidae.
Apis cerana indica: The Indian hive bee Apidae.
Apis florea : The little bee Apidae.
Apis mellifera: The European or Italian bee Apidae.
Melipona irridipennis: Danner bee, Meliporidae stingless bee.

Apis dorsata:-

1. They construct single comb in open (About 6ft long and 3ft deep)
2. They shift the place of the colony often.
3. Rock bees are ferocious and difficult to rear.
4. They produce about 36 Kg honey /comb/year.
5. The bees are the largest among the bee described.

Apis florea

1. They also construct comb in open of the size of palm in branches of bushes, hedges, buildings, caves, empty cases etc.
2. They produce about 1/2Kg honey/year/hive.
3. They are not rearable as they frequently change their palce.
4. The size of the bees is smallest among 4 Apis Sp. Described. (smaller than Indian bee).
5. They distributed only in plains and not in hills above 450M.

Apis cerana indica (Indian bee/Asian bee)

1. They make multiple parallel combs on trees and cavities in darkness.
2. The bees are larger than Apis florae but smaller than Apis mellifera.
3. They produce about 5Kg of honey/year/hive.
4. They are more prone to swarming and absconding.
5. They are native of India/Asia

Apis mellifera (Italian bee or European bee)

1. They also make multiple parallel combs in cavities in darkness.
2. They are larger than Indian bees but smaller than Rock bees.
3. They have been imported from European countries. (Italy)
4. They yield on an average 35Kg/hive/year.
5. They are less prone to swarming and absconding.

Morphological specialties mouth parts, legs and others

Morphology of honeybees

The honeybee is an insect and has a body divided into three parts: head, thorax, and abdomen.

Head

- The head contains the eyes, mouth parts, antennae, hypopharyngeal gland, and salivary gland.
- Eye: The honeybee honeybee has two flat oval compound compound eyes at the side of head and three simple eyes (ocelli) located in a triangular pattern between the compound eyes.
- The compound eyes can detect the shape and colour of objects, but not light intensity, and are used for distant sight. The simple eyes detect light intensity and are used for near sight.
- Bees can distinguish different colours but are red blind and can perceive ultraviolet rays.

Antenna

- The head contains a pair of antennae which are used to detect smells, for touching, and to help balance the body during walking and fighting.
- The head contains a pair of antennae which are used to detect smells, for touching, and to help balance the body during walking and fighting.
- Head Bears a pair of geniculate antennae.

Hypopharyngeal glands

- Worker bees have a pair of hypopharyngeal glands on the head which secrete the food called royal jelly.
- Hypopharyngeal Hypopharyngeal glands are large and active during the period in the worker bee's life when they are feeding royal jelly and then dry and inactive.

Salivary glands

- Worker bees have salivary glands in their mouth connected with the glossa ('tongue'). They produce saliva containing enzymes which is mixed with the food called 'bee bread' that worker bees prepare by grinding honey and pollen in the mouth. The enzymes help in food digestion.

Mouth

- The mouth is composed of the proboscis, mandibles, labrum, and labium.
- Two mandibles are attached to ventro-lateral part of head capsule. Mandibles differ in shape in three castes. Workers use mandibles for grasping and scrapping pollen from anthers, feeding of pollen and in manipulation of wax scales during comb building.

- Mouth parts of worker bees are modified for sucking and lapping. Tongue or proboscis (formed by medium labium and two lateral maxillae) is used for ingesting ingesting liquids liquids. Labium has long median glossa and spoon shaped lobe (flabellum) at the end.
- The proboscis is a flexible tube used to suck up liquids (nectar, water, honey) into the mouth. It is a temporary structure formed from the glossa, paraglossa, and galea and is folded behind the head when not in use.
- Inside the head there are long coiled strings of small lobes known as hypopharyngeal glands which secrete glandular food known as royal jelly that is fed to queen and young larvae.
- The glossa is composed of an array of hairs that form a tube at the centre and a sponge-like structure at the end. The spongy hairs absorb the liquid which is sucked upward through the tube. The glossa functions as a tongue and can 'taste'. The sucking capacity of a honeybee depends upon the length of its proboscis.
- Apis cerana has a shorter proboscis (3.5–4 mm) and smaller nectar collection capacity; Apis mellifera has a longer proboscis (6.5 mm) and greater collection capacity.
- The sickle-shaped mandibles mandibles are like paired 'teeth', 'teeth', one on each side of the mouth. They are used to collect pollen and propolis, to soften and manipulate wax by chewing, to clean other bees, and to bite workers from other colonies or pests.
- The labium is formed from two fused secondary maxillae and is equivalent to the floor of the mouth; it assists in chewing.
- The labrum is equivalent to the upper lip and supports the sucking process.

B. Thorax

The thorax is divided into three parts. It has three pairs of segmented legs and two pairs of wings.

1. Legs

• The three pairs of legs have different functions. The forelegs hold antennae cleaner or pollen comb, the middle legs are used to clean the thorax, and the hind legs have a pollen basket for collection and carrying of pollen.

2. Wings

• The two pairs of wings are mounted on the dorsal (rear) segments of the thorax. The front (fore) wings are larger than the back (hind) wings. The pairs are connected by hamuli (hooked structures) which enables flight.

C. Abdomen

- First abdominal segment is united with the metathorax and forms anatomically a part of thorax known as propodeum.
- Bee larva has 10 abdominal segments but in adult workers abdomen appears 6 segmented; segments 8-10 are reduced in size and first segment (propodeum) is transferred to thorax during pupal stage.

- Abdomen bears sting, wax glands (on sternites 4 to 7) and scent glands (on last two terga) and genitalia in addition to other viscera.
- In workers egg laying apparatus (ovipositor) is modified into sting.
- Queen uses ovipositor for egg laying and for stinging rival queen.

Honey bee castes

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

Duties of a queen

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

a) Prevent swarming and absconding of colonies.
b) Prevent development of ovary in workers.
c) Colony cohesion is maintained.

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

Duties of a drone

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

Duties of a worker

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

a) First three weeks- house hold duty.
b) Rest of the life- out door duty.

House hold duty includes

a. Build comb with wax secretion from wax glands.
b. Feed the young larvae with royal jelly secreted from hypopharyngeal gland.
c. Feed older larvae with bee-bread (pollen+ honey)
d. Feeding and attending queen.
e. Feeding drones.
f. Cleaning, ventilating and cooling the hive.
g. Guarding the hive.
h. Evaporating nectar and storing honey.

Outdoor duties

1. Collecting nectar, pollen, propolis and water.
2. Ripening honey in honey stomach.

Sex differentiation in bees

Bee behaviour

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

Steps involving in swarming

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

Supersedure:

When a old queen is unable to lay sufficient eggs, she will be replaced or superseded by supersedure queen. Or when she runs out of spermathezoa in her supermatheca, and lays many unfertilized eggs from which only drones emerge.

In this case, one or 2 queen cells are constructed in the middle of the comb and not at the bottom. At a given time both new and old queens are seen simultaneously. Later the old queen disappears.

Emergency queen

In the event of death of the queen the eggs (less than 2½ days old) in worker cells are selected and the cell extended like a queen cell. It is fed with abundant royal jelly and covered into queen. In this case many queen cells are built in the middle of the comb. The first queen

which comes out of the emergency queen cells kills other stages of queen inside the cells and then go for mating. After mating they lay fertile eggs.

Laying workers

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

Colony odour:

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

Hive temperature maintenance: Brought about by fanning of wings in hot weather to reduce temperature. In cold weather they sit on the brood and prevent heat loss.

Division of labour: Each and every caste of bees have their own role to play as described earlier.

Queen controls colony with her queen's substance Guarding the hive:- The workers perform this duty by sitting at hive entrance and preventing and stinging intrudes.

Royal fidelity or Blossom faithfulness

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

Communication in bees

Bees communicate using various phenomones, including the queen's substance, vasanov gland secretion, alarm pheromone emitted from sting and secretion of tarsal gland. In addition the bees also communicate by performing certain dances.

When scout bees return to the box after foraging they communicate to the other forages present in the box about the direction and distance of the food source from the hive by performing dances. The important types of dances are noticed.

1. Round dance is used to indicate a short distance (Less than 50m in case of A. mellifera). The bee runs in circles, first in one direction and then in opposite direction, (clockwise and anticlockwise).

2. Tail wagging dance or Wag-tail dance. This is used to indicate long distance. (more than 50m in case of A. mellifera). Here the bee makes two half circles in opposite directions with a

straight run in between. During the straight run, the bee shakes (wags) its abdomen from side to side, the number of wags per unit time inversely proportional to the distance of the food (more the wags, less the distance.). The direction of food source is conveyed by the angle that the dancing bee makes between its straight run and top of the hive which is the same as between the direction of the food and direction of the sun. The bees, can know the position of the sun even if it is cloudy

APIARY MANAGEMENT

Pre-requisites to start beekeeping
a. Knowledge/Training on beekeeping
b. Knowledge on local bee flora
c. Sufficient on local bee flora
d. If necessary practice migratory beekeeping

Apiary site requirements
a. The site should be dry without dampness. High RH will affect bee flight and ripening of nectar.
b. Water - Natural source/Artificial provision
c. Wind breaks - Trees serve as wind belts in cool areas
d. Shade - Hives can be kept under shade of trees. Artificial structures can also be constructed
e. Bee pasturage/Florage - Plants that yield pollen/nectar to bees are called bee pasturage/florage

General apiary management practices
i. Hive inspection
- Opening the hive atleast twice a week and inspecting for following details.
- Presence of queen
- Presence of eggs and brood
- Honey and pollen storage
- Hive record to be maintained for each hive
- Presence of bee enemies like wax moth, mite, disease

ii. Expanding brood net
- Done by providing comb foundation sheet in empty frame during honey flow period.

iii. Sugar syrup feeding
- Sugar dissolved in water at 1:1 dilution
- Used to feed bees during dearth period

iv. Supering (Addition of frames in super chamber)
- This is done when brood chamber is filled with bees on all frames are covered
- Comb foundation sheet or constructed comb provided in super chamber

v. Honey extraction
- Bee escape board
- Kept between brood and super chamber
- Bees bushed away using brush
- Cells uncapped using uncapping knife

- Honey extracted using honey extractor
- Combs replaced in hive for reuse

vi. Swarm management
- Remove brood frames from strong colony and provide to weak
- Pinch off the queen cells during inspection
- Divide strong colonies into 2 or 3 - Trap and hive primary swarm

vii. Uniting bee colonies
- Done by Newspaper method
- Bring colonies side by side by moving 30 cm/day
- Remove queen from week colony
- Keep a newspaper on top of brood chamber of queen
- Right colony
- Make holes on the paper
- Keep queenless colony on top
- Close hive entrance (the smell of bees will mix)
- Unite bees to the brood chamber and make it one colony

SEASONAL MANAGEMENT

- Pollen and nectar available only during certain period
  Honey flow season (surplus food source) x Dearth period (Scarcity of food)
- Extremes in climate like summer, winter and monsoon - Need specific management tactics

Honey flow season management (Coincides with spring)
- Provide more space for honey storage by giving CFS or built combs
- Confine queen to brood chamber using queen excluder

Prevent swarming - As explained
- Prior to honey flow - Provide sugar syrup and build sufficient population
- Divide strong colonies into 2-3 new colonies - if colony multiplication need
- Queen rearing technique may be followed to produce new queens for new colonies

Summer management
- Bees have to survive intense heat and dearth period
- Provide sufficient shade (under trees or artificial structure)
- To increase RH and reduce heat
- Sprinkle water twice a day on gunny bag or rice straw put on hive
- Increase ventilation by introducing a splinter between brood and super chamber
- Provide sugar syrup, pollen supplement/substitute and water

Winter management

- Maintain strong and disease free colonies
- Provide new queen to the hives
- Winter packing in cooler areas (Hilly areas)

Management during dearth period

- Remove empty combs (and store in air tight container)
- Use dummy division board to confine bees to small area
- Unite weak colonies
- Provide sugar syrup, pollen supplement/substitute

Rainy season/monsoon management

- Avoid dampness in apiary site. Provide proper drainage
- In rain when bees are confined to the hive, provide sugar syrup feeding

BEE PASTURAGE/BEE FORAGE

Plants that yield pollen and nectar are collectively called bee pasturage or bee forage.

Plants which are good source of nectar

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

Plants which are good source of pollen

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

Plants which are good source of Pollen and Nectar

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

FORAGING

Refers to collection of nectar and pollen by bees.

Nectar foragers

- Collect nectar from flowers using lapping torigue
- Passes the nectar to hive bees
- Hive bees repeatedly pass the nectar between preoral cavity and tongue - to ripen honey
- Later drops into cell

Pollen foragers

- Collects pollen by passing flower to flower. Pollen sticking to body removed
- Using pollen comb - Packed using pollen press into corbicula
- A single bee carries 10-30 mg pollen (25% of bee's wt)
- Dislodge by middle log into cell - Mix with honey and store

Floral fidelity

A bee visits same species of plant for pollen/nectar collection until exhausted. Bees travel 2-3 km distance to collect pollen/nectar.

BEE PRODUCTS - THEIR PROPERTIES AND USES

1. Honey
2. Bees Wax
3. Royal Jelly
4. Bee Venom
5. Propolis
6. Pollen

1. Honey

- A sweet, viscous fluid
- Produced by honey bees
- Collected as nectar from nectaries at base of flower
- Also collected from extra floral nectaries (nectar secreted by parts other than flowers)
- Collected also from fruit juice, cane juice

Collection and ripening of honey

- Bee draws nectar by its tongue (proboscis)
- Regurgitated by field bees
- Collected by hive bees
- Deposited in cells in comb
- Nectar contains 20-40% sucrose
- Invertase converts sucrose into dextrose (glucose) and levulose (fructose)
- Invertase is present in nectar itself and in saliva of honey
- Ripening of honey is by action of enzyme and by evaporation of water by fanning of wings

Composition of fully ripened honey	**Per cent (Approx.)**
Lrvulose	41.0
Dextrose	35.0
Sucrose	1.9
Dextrins	1.5
Minerals	2.0
Water	17.0
Undetermined (Enzymes, Vitamins, Pigments, etc.)	1.6

Pigments

Carotene, Chlorophyll, Xanthophyll

Minerals include

Potassium, Calcium, Phosphorus, Sodium, Magnesium, Manganese, Copper, Sulphur, Silica, Iron.

Vitamins

Vit B1 (Thiamine), B2 (Riboflavin), Nicolinic acid, Vit.K, Folic acid, Ascorbic acid, Pantothenic acid.

Physical properties of honey

1. Honey is hygroscopic. If exposed to air it absorbs moisture
2. Honey is a viscous fluid. Heating of honey reduces viscosity
3. Specific gravity of pure honey is 1.35 - 1.44 gms/cc
4. Refractive index of honey - Helps to find moisture content measured using refractometer

Purity test for honey

1. Measure specific gravity of honey using hydrometer
2. If the specific gravity is between 1.25-1.44 it is pure honey

Aroma and flavour of honey

1. Acquired from the nectar of the flower
2. Lost if heated or exposed to air for long time

Colour of honey

1. Depends on the nectar of flower (plant species)
2. Darker honey has stronger flower
3. Lighter honey has more pleasant smell

Fermentation of honey

- Honey containing high moisture can ferment
- Sugar tolerant yeast present in honey cause fermentation
- Fermentation more at 11-21oC
- Fermentation lends to formation of alcohol and carbondioxide
- Alcohol later converted into acetic acid
- Fermented honey sour in taste due to acidity
- Heating honey to 64oC for 30 min destroys yeast and prevents fermentation

Crystallization or granulation of honey

- This is a natural property of honey (particularly at low temperature)
- Dextrose present in honey granulates and suffers down
- Levulose and water remain top - More prone to fermentation
- High ratio of Levulose/Dextose (L/D)

- Less granulation - High ratio of Dextrose/Water (D/W)
- More granulation

Moriculture: Cultivation of Mulberry Plants

Introduction

Silk is Nature's gift to mankind and a commercial fiber of animal origin other than wool. Being an eco-friendly, biodegradable and self-sustaining material; silk has assumed special relevance in present age. Promotion of sericulture can help in ecosystem development as well as high economic returns.

Sericulture is practiced in India and India is the 5th largest producer of silk in the World. It has been identified as employment oriented industry. All the sections of sericulture industry, viz. mulberry cultivation, silkworm seed production, silkworm rearing, reeling and weaving of silk and collection of byproducts and its processing provide a large scale employment, thereby a source of livelihood for the rural and tribal people. Sericulture industry is rated as the second largest employer in India.

Owing to this peculiar nature, the Indian planners have identified sericulture as one of the best-suited occupations for ideal growth and development of rural India. Mulberry sericulture has been traditional occupation in Karnataka, Tamil Nadu, A.P. and Kashmir; Tasar one, in M.P., Chota Nagpur Division and Orissa; Muga one, in Assam, Nagaland, Tripura and Eri one in Assam and West Bengal. North-eastern part of India is the only region in the world where all four varieties of silk are produced.

Central and State level Government Silk Departments are actively engaged in addressing the objective of promotion of sericulture in traditional as well as non-traditional regions. With the launching of massive developmental schemes, it is expected to gain an accelerated tempo of sericultural activities in the country, paving way for doubling the employment opportunities in phased manner, and thereby, it may set to bring a soothing touch to the burning problem of acute unemployment in rural India and thus can check the rural migration to urban areas to a certain extent.

Sericulture is an agro-based cottage industry involving interdependent rural, semi-urban and urban-based activities in which estimated participation of women is about 60%. Thus, in contrast to any other agro-based profession the role of women in sericulture industry is dominating which will be helpful for improving the status of women in family enterprises. In the light of women welfare through Sericulture industry, the Central Silk Board, a statutory organization, under the Ministry of Textiles, Government of India has established a special component of assistance to Women and NGO's' into the National Sericulture Project.

There are four major research centres for Sericulture in India:

1. Central Sericulture Research and Training Institute, Behrampur (Orissa).
2. Central Sericulture Research and Training Institute, Mysore (Karnataka).

3. Central Tasar Research and Training Institute, Ranchi (Jharkhand).
4. Central Silk Technological Research Institute, Bangalore (Karnataka).

Sericulture and its components:
Commercial rearing of silk producing silkworm is called sericulture. It is an agro-based industry comprising three main components:
i) cultivation of food plants of the worms
ii) rearing of silk worms
iii) reeling and spinning of silk

The first two are agricultural and the last one is an industrial component. There are four varieties of silkworms in India, accordingly sericulture is classified into Mulberry Culture, Tasar Culture, Muga Culture and Eri Culture

Mulberry Cultivation (Moriculture):
Cultivation of mulberry plants is called moriculture. There are over 20 species of mulberry, of which four are common: Morus alba, M. indica, M. serrata and M latifolia. Mulberry is propagated either by seeds, root- grafts or stem cuttings, the last one being most common. Cuttings, 22-23 cm long with 3-4 buds each and pencil thick, are obtained from mature stem. These are planted directly in the field or first in nurseries to be transplanted later. After the plants have grown, pruning is carried out routinely which serves two purposes, induction of growth and sprouting of new shoots.

Harvesting of leaves for feeding larva is done in three ways: leaf picking, branch cutting and top shoot harvesting. In leaf picking, individual leaves are handpicked. In branch cutting method, entire branch with leaves are cut and offered to 3rd instar larva. In top shoot harvesting, the tops of shoots are clipped and given to the 4th & 5th instars. The yield and quality of leaf depend upon the agronomic practices for cultivation of mulberry trees, namely irrigation, application of fertilizers etc. It is estimated that 20,000 to 25,000 kg of leaves can be harvested per hectare per year under optimum conditions. It has also been estimated that to rear one box of 20,000 eggs, 600-650 kg of leaves are required for spring rearing and 500-550 kg for autumn rearing in Japan. In India, to rear 20,000 eggs the quantity of leaves required is about 350-400 kg.

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 55o 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.

Cares:

Silkworms must be reared with utmost care since they are susceptible to diseases. Therefore, to prevent diseases, good sanitation methods and hygienic rearing techniques must be followed. The appliances and the rearing room should be thoroughly cleaned and disinfected with 2-4% formaldehyde solution. Room temperature should be maintained around 25^0C.

Taxonomy of silkworm:

Silk producing insects are commonly referred to as serigenous insects. Silkworm is a common name for the silk-producing caterpillar larvae of silk moths. Silk moths belong to Phylum - Artropoda, Class - Insecta, Order - Lepidoptera, Super family - Bombycoidea. Bombycoidea comprises eight families of which only Bombycidae and Saturnidae are the two important families the members of which produce natural silk. There are several species of silkworm that are used in commercial silk production.

These are:

(i) Mulberry silk worm

- Bombyx mori (Bombycidae)
- Bombyx mandarina (Bombycidae)

(ii) Tasar silk worm

- Antheraea mylitta (Saturnidae)
- Antheraea pernyi (Saturnidae)
- Antheraea yamamai (Saturnidae)
- Antheraea paphia (Saturnidae)
- Antheraea royeli(Saturnidae)

(iii) Muga Silkworm

- Antheraea assama (Saturnidae)

(iv) Eri silk worm

- Philosamia ricini (Saturnidae)

Rearing of Mulberry Silkworm:
Procurement of quality seeds:

The most important step in silkworm rearing is the procurement of quality seeds free from diseases. Seeds are obtained from grainages, which are the centers for production of disease free seeds of pure and hybrid races in large quantities. These centers purchase cocoons from the certified seed cocoon producers. These cocoons are placed in well-ventilated rooms with proper temperature (23-25o C) and humidity (70-80 %), and emergence of moth is allowed. Grainage rooms may be kept dark, and light may be supplied suddenly on the expected day of emergence to bring uniform emergence. Emerging moths are sexed and used for breeding purposes to produce seed eggs. Three hours of mating secures maximum fertilized eggs. The females are then made to lay eggs on paper sheets or cardboard coated with a gummy substance. Egg sheets are disinfected with 2% formalin, and then washed with water to remove traces of formalin and then dried up in shades. The eggs are transported in the form of egg sheet. However, it is easy to transport loose eggs. To loosen the eggs, the sheets are soaked in water. The loose eggs are washed in salt solution of 1.06-1.10 specific gravity to separate out unfertilized eggs and dead eggs floating on surface. Prior to the final washing, the eggs are disinfected with 2% formalin solution. Eggs are dried, weighed to the required standard and packed in small flat boxes with muslin covers and dispatched to buyers.

Brushing:
The process of transferring the silkworm to rearing trays is called brushing. Suitable time for brushing is about 10.00 am. Eggs at the blue egg stage are kept in black boxes on the days prior to hatching. The next day they are exposed to diffused light so that the larvae hatch uniformly in response to photicstimuli. About 90% hatching can be obtained in one day by this method. In case of eggs prepared on egg cards, the cards with the newly hatched worms are placed in the rearing trays or boxes and tender mulberry leaves are chopped into pieces and sprinkled over egg cards. In case of loose eggs a net with small holes is spread over the box containing the hatched larvae and mulberry leaves cut into small pieces are scattered over the net. Worms start crawling over the leaves on the net; the net with worms is transferred to rearing tray.

Preparation of feed bed and feeding

After brushing, the bed is prepared by collecting the worms and the mulberry leaves together by using a feather. The bed is spread uniformly using chopsticks. The first feeding is given after two hours of brushing. Feed bed is a layer of chopped leaves spread on a tray or over a large area. The first and second instar larvae are commonly known as chawki worms. For chawki worms, paraffin paper sheet is spread on the rearing tray. Chopped mulberry leaves are sprinkled on the sheet and hatched larvae are brushed on to the leaves. A second paraffin paper sheet is spread over the first bed. In between two sheets water soaked foam rubber strips are placed to maintain humidity.

The 4th and 5th instars are reared in wooden or bamboo trays by any of the three methods: viz., shelf-rearing, floor-rearing and shoot-rearing. In shelf rearing, the rearing trays are arranged one above the other in tiers on a rearing stand which can accommodate 10 -11 trays. This method provides enough space for rearing, but it is uneconomical as it requires large number of laborers to handle the trays. Chopped leaves are given as feed in this method. In floor rearing, fixed rearing sheets of 5-7x1-1.5m size are constructed out of wooden or bamboo strips in two tiers one meter apart. These sheets are used for rearing. Chopped leaves are given as feed. This method is economical than the first one because it does not involve much labour in handling of trays. Shoot-rearing is most economical of the three methods. The rearing sheet used is one meter wide and any length long in single tier and the larvae are offered fresh shoot or twigs bearing leaves. This method can be practiced both outdoors and indoors depending upon the weather.

Each age of the silk worms could be conveniently divided into seven stages. First feeding stage, sparse eating stage, moderate eating stage, active eating stage, premoulting stage, last feeding stage, moulting stage. The larvae have good appetite at first feeding stage and comparatively little appetite at sparse and moderate eating stages. They eat voraciously during active stage to last feeding stage after which they stop feeding.

Bed Cleaning:

Periodical removal of left over leaves and worms' excreta may be undertaken and is referred to as bed cleaning. It is necessary for proper growth and proper hygiene. Four methods are adopted: conventional method, husk method, net method, and combined husk and net method.

Spacing:

Provision of adequate space is of great importance for vigorous growth of silkworms. As the worms grow in size, the density in the rearing bed increases and conditions of over crowding are faced. Normally it is necessary to double or triple the space by the time of moult from one to other instar stage, with the result that from the first to third instar the rearing space increases eight fold. In 4th instar, it is necessary to increase the space by two to three times and in 5th instar again twice. Thus, the rearing space increases up to hundred folds from the time of brushing till the time of maturation of worms.

Mounting:

Transferring mature fifth instar larvae to mountages is called mounting. When larvae are fully mature, they become translucent, their body shrinks, and they stop feeding and start searching for suitable place to attach themselves for cocoon spinning and pupation. They are picked up and put on mountages. The worms attach themselves to the spirals of the mountages and start spinning the cocoon. By continuous movement of head, silk fluid is released in minute quantity which

hardens to form a long continuous filament. The silkworm at first lays the foundation for the cocoon structure by weaving a preliminary web providing the necessary foot hold for the larva to spin the compact shell of cocoon. Owing to characteristic movements of the head, the silk filament is deposited in a series of short waves forming the figure of eight. This way layers are built and added to form the compact cocoon shell. After the compact shell of the cocoon is formed, the shrinking larva wraps itself and detaches from the shell and becomes pupa or chrysalis. The spinning completes within 2-3 days in multi-voltine varieties and 3-4 days in uni- and bi-voltine.

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.

Stifling

The process of killing pupa inside cocoon is termed as stifling. Good-sized cocoon 8-10 days old are selected for further processing. Stifling is done by subjecting cocoon to hot water, steam, dry heat, sun exposure or fumigation.

Reeling

The process of removing the threads from killed cocoon is called reeling. The cocoons are cooked first in hot water at 95-97oC for 10-15 minutes to soften the adhesion of silk threads among themselves, loosening of the threads to separate freely, and to facilitate the unbinding of silk threads. This process is called cooking. Cooking enables the sericin protein to get softened and make unwinding easy without breaks. The cocoons are then reeled in hot water with the help of a suitable machine. Four or five free ends of the threads of cocoon are passed through eyelets and guides to twist into one thread and wound round a large wheel. The twisting is done with the help of croissure. The silk is transferred finally to spools, and silk obtained on the spool is called the Raw Silk or Reeled Silk. The Raw silk is further boiled, stretched and purified by acid or by

fermentation and is carefully washed again and again to bring the luster. Raw Silk or Reeled Silk is finished in the form of skein and book for trading.

The waste outer layer or damaged cocoons and threads are separated, teased and then the filaments are spun. This is called Spun Silk.

Several species of Antheraea are exploited for production of wild silk known as tasar silk. These are Antheraea mylitta, A. pernyi, A.yamamai, A.paphia and A.royeli. A. mylitta and A. paphia are reared in central and north eastern parts of India. Many regional strains known by different local names are also found. Three types of voltinism, namely Uni-, Bi- and Multi-voltine are found in A. mylitta and A. paphia. These are reared on trees of Terminalia tomentosa (Vern. Asan), Terminalia arjuna (Vern. Arjun), Shorea robusta (Vern. Saal) and Zizyphus jujuba (Vern. Ber). Rearing of A. pernyi and A. royeli has been introduced recently in Manipur. These are reared on Quercus or Oak. A. pernyi and A.yamamai are the tasar silk worms of China and Japan respectively. These species feed on Quercus or Oak trees and are normally bivoltine.

The tasar moths are fairly large insects. Females are larger and yellowish brown in colour, while males are smaller and brick red in colour. Both have prominent and colourful eye spots on their wings. The antennae of males are bushy, and abdomen is narrower in comparison to female.

Rearing of Tasar Silkworm

Cultivation of food plants is generally avoided, as tasar silkworms are wild in nature and need to be reared outdoors. However, modern sericulturists prefer to cultivate the food plants for better supervision. Cultivation is done with seeds or saplings being raised in nurseries. Saplings are transplanted to fields 20-25 feet apart. Agronomic practices are carried on regularly. Pruning is done regularly to maintain better foliage growth.

It is the bi-voltine variety of tasar worm that is used for commercial purpose. The cocoons of bi-voltine variety harvested in November/December go into diapause at pupal stage and moths generally emerge in May/June of following year. The rearing of worms from eggs produced in May/June is completed by June/July. This is the summer crop. These cocoons do not undergo diapause. The moths emerge in 15-20 days, and the layings prepared out of this crop are used for rearing the second crop during September/October. The summer crop is seed crop for second crop which is commercial crop. The rearers usually keep the necessary quantity of seed cocoons from the previous year crop for preparation of egg laying. Emergence is usually in the evening. The males are active and copulate with the females soon after emergence. After copulation the females are decoupled and kept in bamboo baskets for about 48 hours to lay eggs. A single female lays about 150-200 eggs in 2 days. The eggs are oval and dorso-ventrally flattened. Eggs are soaked in 2% formalin, washed with water, dried and allowed to hatch. Life cycle of tasar worm consists of adult, egg, larva and pupal stages.

The larvae hatch out in ten days. The hatching larvae are kept in cups made up of leaves and the cups are uniformly distributed over the host trees. These larvae crawl in search of food. The larval period lasts for 30-35 days in summer, which may prolong in winter. The larvae pass through four moults and 5 instar stages. The hatched 1st instar larvae are brown and change to green colour at second instar. There are a number of tubercles on the body, which carry the setae. The final instars are green in colour with violet tubercles distributed over the body. A prominent brown and yellowish lateral line is visible on either side of the body. The tubercles are violet. The dorsal tubercle carries brick red dorsal spots, and lateral tubercles carry mirror like shining lateral spots.

The larvae feed voraciously on leaves and defoliate trees. In Antheraea, cocoon formation takes about in two days. It follows gut purging, initiated by ecdysone production in which larva expels gut contents by a series of waves of contraction passing along the abdomen from front to back. Subsequently, the larva enters an active wandering phase, which ends when it finds a suitable site in which to pupate. The first phase of cocoon formation is the construction of a scaffold of silk threads between leaves of food plant and the production of stalk or peduncle which attaches the cocoon to the leaf petiole /tree twig. Subsequent behavior consists of a series of cycles in which the larva weaves loops of silk by figure-of-eight movements of the head to construct one end of the cocoon and then turns through 180o to form the other end. After a period of about 14 hours, by which time a complete layer of silk has been produced, the insect turns from one end of the cocoon to the other at much shorter intervals, and at the same time, it coats the inside of cocoon with a liquid from the anus containing crystals of Calcium Oxalate produced by the Malpighian tubules. The hydration of silk by secretion promotes cross-linking and tanning of the silk protein sericin, and the wall of cocoon becomes stiff and yellowish- brown. This period of impregnation lasts for an hour. After this more silk is added to the inside of the cocoon. The rearers then harvest the cocoons. In addition to systemic rearing, the cocoons are collected in forests by the tribes and forest men, as the tasar worms thrive naturally in wild.

Post Cocoon Processing

Cocoon are first soaked in 5% Soda (Na2CO3) solutions for 18 hours and then subjected to steam cooking in pressure chambers for 2½ hours to bring about the stifling of cocoon. After 24 hours, the stifled cocoons are washed in 0.5% formalin for 15-20 minutes followed by washing with water. Water is then squeezed out, and cocoons are reeled on reeling machine.

The waste outer layer, damaged cocoons and peduncles are teased, and then silk thread is spun on earthen mutka. The spun silk is commonly known as katia matka.

Muga Silkworm

Muga is an Assamese word which indicates the golden brown (amber) colour of the cocoon. The Muga silk worm, Antheraea assama is mainly confined to the Brahmaputra valley of Assam and foothills of East Garo hills of Meghalaya. Its distribution in the wild state, however, extends from western Himalaya to Nagaland, Cachar district of Assam and south Tripura. However, commercial exploitation is restricted only to north eastern India. The Muga silk worm is multivoltne and passes through four moults and five instar stages. Generally 4-5 crops are raised in a year. Muga silkworm is a polyphagous insect. It feeds on the leaves of several kinds of trees, but Machilus bombycine (Vern. som) and Litsaea polyantha (Vern. soalu) are the two principal host food plants of muga silkworm. The host plants are cultivated through propagation by seeds or vegetatively by air layering. The plants are trained and pruned regularly.

Like other Lepidopterans, muga silkworm is a holometabolous insect passing through a complete metamorphosis from egg (Koni) to adult (Chakari) stage through two intermediate stages of larva (Polu) and Pupa (Leta). The entire life cycle lasts for about 50 days in summer and 120 days in winter. The wings and body of the male moth are copper brown to dark brown, while those of female, yellowish to brown. Both pair of wings bears eye spots. Besides colouration, the male moth can be distinguished from the female by its slightly smaller size, slender abdomen, bushy antennae and sharply curved forewing tips.

Rearing of Muga Silkworm

The seed cocoons intended for preparation of eggs are obtained from commercial rearers or from Government grainages. These are then laid in a single layer in trays to facilitate the emergence of moths. Emergence starts from dusk and continues till morning. Male moth is smaller in size has slender abdomen and bushy antennae. The emerging adults are allowed to mate and in the coupled state itself the pair is tied with a piece of cotton thread to 1.5-2 feet long stick made of dried straw which is known as Kharika. After overnight mating, the couples separate in the morning and if they do not decouple naturally they are made to do so by heat of fire lighted some distance away. The female moth lays about 150-250 eggs on Kharika. During summer, the worms hatch out in the morning in about 8 days. The Kharikas with the hatched worms are hanged on the host plants. The larvae immediately crawl and start feeding. When the leaves are exhausted, the larvae crawl down and are collected on triangular bamboo sieves with long handles (Chaloni), which are again hanged on a fresh tree. A band of straw with a little sand or ash is tied around the tree trunk 1-1.2 m above the ground to prevent the worms from crawling down the ground. The larvae feed voraciously, pass through 4 moults and reach the mature stage. In the final stage, larvae become greenish blue with prominent tubercles. Larval period lasts for 30-35 days. The ripe worms come down the trees searching for a suitable place for spinning of cocoon. They are then collected by rearers and put in baskets containing mango twigs and leaves, which are set as cocoonages (Jali) for the spinning of cocoons. The jalies are then hung and left undisturbed in separate rooms or at some shady place till cocoons are formed. Spinning takes about 2-3 days in summer and 7 days in winter. Muga cocoon is golden or light brown, 4-6 cm long and 2-3 cm broad with a rudimentary peduncle without ring.

Post Cocoon Processing

The muga cocoon is compact and leathery in structure. The length of continuous silk filament ranges from 350-450 meters with 4 to 5 breaks.

Stifling

Immediately after removal from the mountages, cocoons are spread on bamboo mats in sun during hot hours of the day that partially kills the chrysalis. These are then subjected to heating in oven that kills the chrysalis completely, and the cocoons are stifled.

Degumming

It is the process by which gummy substance is softened and compact filaments are released for reeling. Cocoons are boiled in mild alkaline solutions for about 15-20 minutes.

Reeling

Almost entire reeling is done with a primitive machine called Bhir. The cocoons are kept in basin with warm water. Reeling requires two persons: one person releases the filaments from cocoons while the other twists the filament into one thread and wind it on Bhir. Two persons can reel around 100g raw silk per day on an average. Only 40-45% silk filament is reeled and rest is rejected as waste.

The other reeling machines include different types of Charkha: Chaudhary, Trivedi, Bharali, CMERS, Golden Muga, RMRS-I, RMRS II, RMRS III, Ambar Charkha. Reeling with these machines is economical, as it requires only one person. Standard wild silk thread is made up from 8 cocoons and averages 32/34 deniers. The typical finished fabrics are Rajah, Shartaug, Tussah, and Pongee etc.

Eri Silkworm:

The silk produced by Philosamia ricini is called Eri silk. The distribution of Eri silk worm is confined to Assam and bordering districts of West Bengal. The Eri silkworm is multivoltine and reared indoors 5-6 times a year. Optimum conditions required are 24-28oC temperature and 85-90% humidity. Adult moths emerge from morning to mid day; males emerge earlier than the females. After an hour of emergence mating occurs and continues till evening. Males are then separated. Both male and female have brown (chocolate), black or green coloured wings with white crescent markings and woolly white abdomen. The male is smaller than female and bear bushy antennae and narrow abdomen.

Eri worms are polyphagous having primary as well as secondary food plants (hosts). Primary food plants are Ricinus communis (Vern. Castor) and Heteropenax fragrans (Vern. Kasseru). Castor plants are of two varieties; the green leaved and violet leaved. Both are equally suitable

for feeding the Eri silkworms. These plants are grown by seed sowing. Kasseru grows wild but may be cultivated as regular plantations on embankments around homestead land. It is grown by seed sowing and also vegetatively by stem cuttings. The secondary food plants are Manihot utilissima (Vern. Tapioca), Evodia flaxinifola (Vern. Payam), Plumeria acutifolia (Vern. Plum) and Carica papaya (Vern. Papaya).

Rearing of Eri Silkwom:

Disease free seed cocoons are obtained from Grainages or Agencies and reared fully indoors. Healthy cocoons are spread on bamboo trays in cool dark room. On hatching, active males are separated from passive females and are then allowed to mate in quiet dark room. Fertilized females are then tied to 'kharikas' by passing a thread around the shoulder joint of the right wings. Kharikas are then suspended from a string. Eggs are laid within 25 hours on Kharika are normally selected for rearing. The eggs are white, oval and covered with a gummy substance, which makes them adhere to one another. The eggs are disinfected with 2% formalin solution and then washed thoroughly with water. Eggs are incubated at 26o C, the colour changes to blue on the day prior to hatching. Hatching takes place in the morning after ten days of incubation. The newly hatched larvae are yellow with black segments. These larvae are brushed to rearing trays over which few tender leaves are spread, and crowding is avoided. As the worms advance in age, older leaves can be given as feed at four hour interval for four to five times.

Bed cleaning is carried out at regular interval in the same way as for the Mulberry silkworm. The growing worms undergo four moults and have five instar stages. Total larval period lasts for 30-35 days. The 5th instar mature larvae stop feeding and start searching for a proper place to spin the cocoon. At this stage, the mature worms are picked up and transferred to mountages (Chandrikes). In wild, cocoons are spun between folds of leaves. The spinning is completed in 2-3 days. The cocoons are open mouthed, white or brick red, 5 cm long in case of female and 4.6 cm in male, tapering at one end and flat rounded at open end, flossy and without a peduncle. The silk filaments are not continuous.

Post Cocoon Processing

Stifling is done by spreading and exposing the cocoons to sun for 1-2 days. For degumming, cocoons are tied in a cloth sac and dipped in boiling soda solution. After sufficient boiling, the cocoons are taken out, washed with water several times to remove soda, squeezed to remove water and then spread on mats to dry. Being open mouthed, the thread of the cocoons is discontinuous. So, the thread can only be spun and not reeled. Traditionally spinning is done in wet condition on takli and in semi dried condition on a charkha. Improved spinning machines like N.R. Das type charkha and Chaudhury type charkha are also available for spinning of silk from Eri cocoons.

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:-

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.

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.

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

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.

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-

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.

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

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.