

UNIT IV DISEASES OF HONEY BEE

BACTERIAL DISEASES

American foulbrood disease (AFB)

Beekeepers in temperate and sub-tropical regions around the world generally regard American foulbrood (AFB) as possibly the most destructive microbial disease affecting bee brood. The disease did not originate in, nor is it confined to, the Americas. It is widely distributed wherever colonies of *Apis mellifera* are kept. In tropical Asia, where sunlight is abundant and temperatures are relatively high throughout the year, the disease seldom causes severe damage the beekeeping operations. The disease is contagious and the pathogenic bacterium can remain dormant for as much as and more than 50 years. Therefore, beekeepers and extension specialists throughout Asia should be acquainted with the symptoms of this disease and know how to cope with it should the need arise.

Cause

American foulbrood disease is caused by a spore-forming bacterium, *Paenibacillus larvae*, which only affects bee brood; adult bees are safe from infection. At the initial stage of colony infection, only a few dead older larvae or pupae will be observed. Subsequently, if remedial action is not taken, the disease will spread within the colony and can quickly spread to other colonies in the apiary as a result of robbing, drifting workers, or contamination caused by the beekeeper's hive manipulations. In the same way the pathogen agent can spread to other apiaries. Natural transfer mainly takes place within a radius of 1 km around the apiary. Often spores enter the bee colonies via foreign honey. Commercially available honey may be highly contaminated; therefore, special attention should be paid near honey processing enterprises and waste disposal sites.

Symptoms

At the initial stage of AFB infection, isolated capped cells from which brood has not emerged can be seen on the comb. The caps of these deadbrood cells are usually darker than the caps of healthy cells, sunken, and often punctured. On the other hand the caps of healthy brood cells are slightly protruding and fully closed. As the disease spreads within the colony, a scattered, irregular pattern of sealed and unsealed brood cells (see Plate 1) can be easily distinguished from the normal, compact pattern of healthy brood cells observed in healthy colonies. The bee brood affected by AFB is usually at the stage of older sealed larvae or young pupae, upright in the cells. Often therefore, a protruding tongue can be found with the rest of the body already decayed. At first the dead brood is dull white in colour, but it gradually changes to light brown, coffee brown, and finally dark brown or almost black. The consistency of the decaying brood is soft. Once the dead brood have dried into scales, the test cannot be used. The dry brood lies flat on the lower side of the cell wall, adhering closely to it – in contrast to sacbrood. This scale is usually black or dark brown and brittle. Often, a fine, threadlike proboscis or tongue of the dead pupa can be seen protruding from the scale, angling toward the upper cell wall. The pathogen bacteria may be identified using

Plate 1

Irregular pattern of sealed brood with sunken and punctured caps, typifying American foulbrood infestation.

4 Honey bee diseases and pests: a practical guide a microscopic preparation or, more frequently, by cultivation on selective culture media. The Columbia slant culture has proved to be most effective for this purpose. The result is controlled by biochemical or serological tests and more often by means of the Polymerase Chain Reaction (PCR). As PCR is very sensitive its suitability is restricted regarding the direct evidence in comb samples (see OIE Manual of Diagnostics, 2004). Commercially available 'AFB diagnosing kits' are based on serological evidence of the pathogen agent. In general, they are appropriate for field use. But if there are clinically indifferent cases, misinterpretations may occur. The examination of samples from stored food of sealed brood combs has become important in diagnosing AFB, although it is not effective in detecting evidence of an outbreak of AFB. However, it is suitable for population screenings in apiaries and in determining the pathogen pressure in the individual colonies. The diagnostic reliability of the samples from the food wreath depends on the quality of sample extraction. If samples are taken from newly gathered food or from other areas than the sealed brood combs, wrong diagnoses might be made resulting in false negative results.

Control

In several countries, where apiculture includes large commercial operations, frequent, efficient

inspection services are particularly advanced and a 'search and destroy' strategy may be adopted in an attempt to minimize damage to apiaries caused by this serious honey bee disease. The procedure involves hive inspections by qualified apiary inspectors. The entire honeybee population that is infected by American foulbrood is killed and hive materials belonging to the colony, are disinfected or destroyed by burning. The bees are usually killed by poisonous gas such as the burning of sulphur powder. All the dead bees, the frames, the supers, the honey and the contaminated equipment are thrown into a 1m x 1m x 1m hole in the ground. Kerosene is poured over the pile and set alight. When all the material has been completely burned, the hole is carefully filled in, to prevent worker bees belonging to healthy colonies from robbing any remaining contaminated honey. Although the above-mentioned method has proven effective, the practice of burning AFB infected colonies and equipment is costly, especially taking into account the high cost of beekeeping equipment. The destruction of brood combs and food combs is absolutely necessary as, apart from the bees, they are the main carriers of spores. Dry combs, without brood, can be preserved if an examination of wax samples in the laboratory does not reveal *Paenibacillus* spores. In which case the dry combs must also be destroyed. Old hives should be burned. Well conserved hives, however, should be disinfected. The inner part of a hive, once carefully cleaned, can quickly be singed out with the flame of a gas burner. The wooden surface should look slightly brownish. When this is not possible, e.g. if the hive is made from plastic, they should be cleaned and brushed with 3 to 5 percent sodium hydroxide. Before using other substances for disinfection you should make sure that no residues remain that could be dangerous to bees or the consumer of the processed honey. The killing of the bees can be avoided if the BOX 1

Stretch test

A simple way of determining whether AFB caused the death of the brood is the 'stretch test' (see Plate 2). A small stick, match or toothpick is inserted into the body of the decayed larva and then gently and slowly, withdrawn. If the disease is present, the dead larva will adhere to the tip of the stick, stretching for up to 2.5 cm before breaking and snapping back in a somewhat elastic way. This symptom called 'ropiness', typifies American foulbrood disease, but it can be observed in decaying brood only.

Plate 2

Stretch test for American foulbrood disease. n Irregular pattern of sealed brood with sunken and punctured caps, typifying American Foulbrood infestation. W. RITTER Chapter 2 - Microbial diseases*

5 artificial swarm method is applied. A traditional method is to keep the bee colony in a dark environment for several days. The bees are pushed into a decontaminated hive with new combs, the bee entrance is closed and they are placed in a dark preferably quite cool room. Within two days, the bees have used up the contaminated food. The colonies can then be placed either at their former stand or within a distance of at least 3 km away. If the bees are kept in the dark for three days they forget their old stand and can be placed anywhere.

On the third day, however, some food shortage may occur. Therefore, the colonies should be fed.

The direct artificial swarm method is less complicated. First, a clean, decontaminated hive is prepared. Instead of combs it contains three to six wooden bars, depending on the colony's strength, provided with a wax strip as a starter for further comb construction. Using a queen excluder fixed at the entrance or above the bottom of the hive should prevent disappearance of the queen. The prepared hive is placed at the colony's old stand subject to sanitation. Now the bees are pushed or brushed into the empty hive. Three days later, the combs that have been partially constructed by the bees are removed again and burned. Combs with midribs later replace these. Now sanitation is finished. The combs and the hive of the old colony are burned or decontaminated. In some countries, beekeepers who destroy their AFB-infected colonies receive compensation, either directly from the government or from beekeepers' organizations. Chemotherapeutic methods of controlling AFB involve the administration of antibiotics or sodium sulfathiazole, in various formulations, fed mixed with powdered sugar or sugar syrup. Antibiotics and sulfonamides prevent multiplication of the agent, though it will not kill the spores. Therefore, multiplication may begin again shortly after treatment, which is why treatment must be repeated in shorter and shorter intervals. Over time the inner part of the hive, the food and honey become increasingly contaminated by spores. Stopping treatment without simultaneous disinfection leads irrevocably to a relapse. However, detectable residues remain even after a period of time has elapsed between treatment and honey extraction.

European foulbrood disease (EFB)

As with American foulbrood disease, the name of this bacterial bee brood disease is inappropriate.

The range of distribution of European foulbrood disease is not confined to Europe alone and the disease is found in all continents where *Apis mellifera* colonies are kept. Reports from India indicate that *A. cerana* colonies are also subject to EFB infection. The damage inflicted on honey bee colonies by the disease is variable. EFB is generally considered less virulent than AFB; although greater losses in commercial colonies have been recorded in some areas resulting from EFB.

Cause

The pathogenic bacterium of EFB is *Melissococcus pluton*. It is lanceolate in shape and occurs singly, in chains of varying lengths, or in clusters. The bacterium is Gram-positive and does not form spores. While many strains of *M. pluton* are known, all are closely related.

Symptoms

Honey bee larvae killed by EFB are younger than those killed by AFB. Generally speaking, the diseased larvae die when they are four to five days old, or in the coiled stage. The colour of the larva changes as it decays from shiny white to pale yellow and then to brown. When dry, the scales of larvae killed by EFB, in contrast to AFB scales, do not adhere to the cell walls and can be removed with ease. The texture of the scales is rubbery rather than brittle, as with AFB. A sour odour can be detected from the decayed larvae. The clinical picture and the odour can vary depending on the kind of other bacteria involved (*Bacillus alvei*, *Streptococcus faecalis*, *Achromobacter eurydice*). Another symptom that is characteristic of EFB is that most of the affected larvae die before their cells are capped. The sick larvae appear somewhat displaced in the cells (see Plate 3).

Plate 3

Larvae in coiled stage, killed by European foulbrood disease. W. RITTER

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When a scattered pattern of sealed and unsealed brood is observed in a diseased colony, this is normally an indication that the colony has reached a serious stage of infection and may be significantly weakened. However, this is the case with all brood diseases. EFB is transferred in the same way as AFB. *Melissococcus pluton* as a permanent form, does not form spores but capsules which are less resistant than the spores of *P. larvae*.

The detection of *M. pluton* is normally carried out microbiologically. Selective culture media (OIE, 2004; Bailey and Ball, 1991) are most appropriate.

For further verification biochemical tests or the PCR can be applied. The gene technological test is very sensitive and is therefore less suitable for the detection of *M. pluton* in suspicious brood. A single-use test set is commercially available based on a serological proof like the AFB test set (see OIE Manual of Diagnostics, 2004).

Control

The choice of an EFB control method depends on the strength of the infection, i.e. how many brood cells and combs are infested. If the infection is weak, it is often sufficient to stimulate the hygiene behaviour of the bees. Either they are placed at a good foraging site or they are fed with honey or sugar water. An even better result is achieved if the individual combs are sprayed with a thinned honey solution. If the infestation is stronger it makes sense to reduce the number of pathogens in the colony by removing the most infested brood combs. Empty combs or healthy brood combs then replace these. Since the bees' hygiene behaviour is also genetically determined, replacement of the queen is also possible. Requeening can strengthen the colony by giving it a better egg-laying queen, thus increasing its resistance to the disease and interrupting the ongoing brood cycle giving the house bees enough time to remove infected larvae from the hive. In serious cases, the same methods can be used as for AFB. Sometimes chemotherapeutic measures such as antibiotics are called for, however, their application, always risks the danger of residues.

2.2 FUNGAL DISEASE

Chalkbrood disease (*Ascosphaerosis*)

In Asia, chalkbrood is rarely considered to be a serious honey bee disease, although in Japan the disease has been reported to cause problems to beekeepers. In temperate America and Europe, however, cases have occurred in which chalkbrood has caused serious damage to beekeeping; therefore, Asian beekeepers should be aware of this problem.

Cause

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

Symptoms

Initially, the dead larvae swell to the size of the cell and are covered with the whitish mycelia of the fungus. Subsequently, the dead larvae mummify, harden, shrink and appear chalklike. The colour of the dead larvae varies with the stage of growth of the mycelia: first white, then grey and finally, when the fruiting bodies are formed, black (see Plate 4). When infestation is heavy, much of the sealed brood dies and dries out within their cells. When such combs are shaken the mummified larvae make a rattling sound. In the laboratory the fungus can be identified by its morphology (see OIE Manual of Diagnostics, 2004).

Plate 4

Brood killed by chalkbrood: white and black mummies. W. RITTER Chapter 2 - Microbial diseases 7

Control

As with other brood diseases, the bees remove the infested brood with their hygiene behaviour (see European foulbrood), which is especially effective for white mummies. Though as soon as the fruit bodies of *A. apis* have developed, cleaning honey bees spread the spores within the colony by this behaviour. During the white mummy stage the fungus continues to develop at the hive bottom. If the mummies are not removed quickly, the spores may enter the brood cells carried there by circulating air. The beekeeper can stimulate the hygiene behaviour of the bees by changing the broodrearing conditions. In this respect, it is most important to adapt the size of the hive to the strength of the bee colony. In this way the bees have a chance to inspect and clean the many brood cells. Therefore, in most cases, the method of stimulating hygiene behaviour, already described under European foulbrood control, is sufficient for chalkbrood control. The beekeeper should ensure that the colony has a strong worker population, and that the hive is well ventilated and free from accumulated moisture. At early stages of chalkbrood infection, adding young adult workers and hatching brood, combined with sugar-syrup feeding, often proves to be helpful. Currently there is no known successful chemical control against chalkbrood. It means that chemical treatment shows a little effect to control chalkbrood. In most cases, commercialised substances only show a positive effect because they are sprayed, or fed with sugar water as described above.

2.3 VIRAL DISEASES

Over the past years at least 18 virus types and strains have been recorded as disease pathogens of adult bees and bee brood, nearly all are RNA viruses. Laboratory examination for virus diseases is difficult, calling for sophisticated equipment and procedures, since particles of the virus are too small to be observed with ordinary light microscopes. However, they can rarely be differentiated with an electron microscope. Apart from serological methods, most of the known viruses can now be identified by genetic technologies (PCR). The damage caused to colonies by viral infection varies considerably according to a number of factors, which include the type and strain of virus involved, the strength of the colony, weather conditions, the season and food availability. Basically, bees are well-protected against infection with their chitin body shell and gut coating. Parasitic mites sucking the blood of the bees, however, can penetrate this protection. Therefore, increased infestation by parasites is often accompanied by increased virus infection. Little known viruses such as Acute Paralysis Bee Virus (APBV), and Deformed Wing Virus (DWV) may become increasingly destructive in the future. As not much is known about the life cycle and pathogenicity of most virus diseases, there are only a few ways to control them. Therefore, reflecting this situation, only the most widespread sacbrood is described.

Sacbrood disease

Sacbrood disease (caused by *Morator aetotulas*) is perhaps the most common viral disease of honey bees. In Asia, at least two major types have been recorded. Sacbrood disease that affects the common honey bee *Apis mellifera* and the sacbrood disease of the Asian hive bee *A. cerana*.

A new type of sacbrood virus has recently been reported in Asian colonies of *A. cerana*. It is highly probable that the virus is native to the continent and that it has been with the Asian hive bees over the long period of its evolution. Since its first discovery in Thailand in 1981, it has been found in association with *A. cerana* in India,

Plate 5

Honey bee larvae killed by sacbrood disease. W.RITTER **8** *Honey bee diseases and pests: a practical guide*
Pakistan, Nepal, and perhaps all other countries in Asia within the honey bee's range of distribution. Several reports indicate that nurse bees are the vectors of the disease. Larvae are infected via brood-food gland secretions of worker bees.

Symptoms

Field inspection to determine whether the pathogenic virus has infected a colony can be easily carried out following symptomology. Diseased larvae fail to pupate after four days; they remain stretched out on their backs within their cells (distinct from the mostly twisted position of larvae affected by European foulbrood). The anterior section of the larva, consisting of its head and thorax, is the first part of its body to change colour, changing from white to pale yellow and finally to dark brown and black (see Plate 5). On removing the larvae from their cell the inspector can easily observe that their skin is quite tough and that its contents are watery; the infected larva thus has the appearance of a small, watery sac. Dead larvae remaining within their cells eventually dry out to flat scales that adhere loosely to the cell floor.

Control

No chemotherapeutic agent is effective in preventing or controlling sacbrood disease. Colonies often recover from the infection without the beekeeper's intervention, particularly if the infection is not new to the geographic area. This mainly depends on the hygiene behaviour of the bees, which may be stimulated as with other brood diseases (see European foulbrood). Since the disease usually occurs when the colony is under stress (shortage of food, food-storage space, unfavourable climatic conditions such as damp during the rainy or cold season, unhygienic hive interior, poor queen, infestation with other diseases, etc.), the beekeeper should deal with severe cases by requeening the colony, removing infected brood combs and taking other management measures to restore colony strength, such as providing food and adding worker population. If there is an extremely strong infestation it may be convenient to apply the artificial swarm method as for American foulbrood.

2.4 PROTOZOAN DISEASE

Nosema disease (*Nosemosis*)

Nosema disease is generally regarded as one of the most destructive diseases of adult bees, affecting workers, queens and drones alike. Seriously affected worker bees are unable to fly and may crawl about at the hive entrance or stand trembling on top of the frames. The bees appear to age physiologically: their life-span is much shortened and their hypopharyngeal glands deteriorate, the result is a rapid dwindling of colony strength. Other important effects are abnormally high rates of winter losses and queen supersedures.

In climates with pronounced long periods of flight restrictions, i.e. no flight opportunities even for a day, the infection easily reaches a severe stage that visibly affects the strength of the colony. Less obvious infection levels in other climates often go undetected.

The damage caused by Nosema disease should not be judged by its effect on individual colonies alone as collectively it can cause great losses in apiary productivity.

Cause

The disease is caused by the protozoan *Nosema apis*, whose 5 to 7 mm spores infest the bees, are absorbed with the food and germinate in the midgut. After penetration into the gut wall the cells multiply forming new spores that infect new gut cells or can be defecated. The nutrition of the bees is impaired, particularly protein metabolism.

Symptoms

Unfortunately, there is no reliable field diagnostic symptom enabling a diseased worker bee to be identified without killing it, nor can the beekeeper recognize an infected queen. However, in severe cases of infection, it is sometimes possible to separate healthy from diseased bees, the abdomen of an infected worker often being swollen and shiny in appearance. On dissection, the individual

Plate 6

Nosema apis spores (magnification factor 400 x). W.RITTER Chapter 2 - Microbial diseases 9

circular constrictions in the alimentary canals of uninfected bees are clearly visible, while the constrictions cannot be seen clearly in diseased bees. Easy separation, after killing, of first abdominal segments with intestines attached, which shows white if strongly infected, versus a normal transparent, darker grey/ochre colour if there is no or only a low infection.

The most reliable method of detecting *Nosema* disease involves laboratory procedures using a microscope for diagnosis. A simple diagnostic method used for adult workers is to use a sample of 20 suspected workers. The bees are killed, and their abdomens are removed and ground in water (2 to 3 ml per sample). A drop of the suspension of pulverized bee abdomens is then viewed under a microscope. If the disease is present, reasonably large individual bacilliform spores with bright, queen's egg-laying capacity fluorescent edges (see Plate 6) will be observed. In the visual field of the microscope, at a 400 fold magnification, up to 20 spores indicate a weak, 20 to 100 a medium and 100 and more a severe infestation. In productive beekeeping, a healthy queen with a good egg-laying capability is always required, and *Nosema* disease in queens is therefore critical. The queen's egg laying ability can be reduced possibly inducing her supersedure. She may also become the major cause of spreading the disease within the colony. On the other hand, beekeepers are naturally reluctant to destroy queens in the uncertain possibility that they are infected. The microscopic inspection of her faeces makes it possible to verify the presence or absence of the disease in the queen. Placed alone in a Petri dish, the queen will defecate in about an hour, the faeces appearing as colourless drops of clear liquid. This liquid can be examined under the microscope for the presence of spores, without further preparation (see OIE Manual of Diagnostics, 2004).

Control

Nosema can best be controlled by keeping colonies as strong as possible and removing possible causes of stress. Colonies and apiaries should receive adequate ventilation and protection from the cold and from humidity. The bees should have the possibility of foraging regularly in order to defecate. This prevents spreading of the spores within the colony. Beekeepers should also ensure that their colonies and queens come from disease-free stock. Hive equipment that is suspected of being contaminated by *Nosema apis* spores should be thoroughly decontaminated, preferably by heat and fumigation.

The best prevention is to change the combs once every two years. During normal wax processing the *Nosema* spores are killed. The only effective chemotherapeutic method currently available for treating *Nosema* is to feed the colony with fumagillin (25 mg active ingredient per litre of sugar syrup), preferably at a time when the colony is likely to encounter stress conditions, such as during a long winter or rainy season. Fumagillin can repress and prevent infection in bee packages, in queens in mating nuclei and in wintering colonies. The active ingredient of fumagillin is an antibiotic. It is of the utmost importance that no medication be administered to colonies when there is a chance of contaminating the honey crop. BOX 2

Heat treatment and fumigation

Heat treatment

Infected equipment is maintained at 49°C (120°F) for 24-hours, ensuring that hot air passes through all stacked combs during the entire period of treatment. The temperature must however be carefully regulated, because heat at levels higher than that specified will melt wax.

Fumigation

A pad of cotton or other absorbent material, soaked with 80 percent acetic acid, is placed over the top-bars of the comb in each hive. The hive bodies are stacked together, the entrance is closed, all cracks are sealed, and the stacks are placed in an open shed for about a week. After this period, the hives are opened and the pads of acetic acid are removed. The combs must then be allowed to air for 48 hours to rid them of acetic acid residue so that they can be used again. The spores in the food cannot be killed. Therefore, the food combs have to be centrifuged before decontamination. The food should not be used anymore for bees.

UNIT 111

DISEASES OF SILK WORM

1. GRASSERIE:

Causative agent: Bombyx mori Nuclear Polyhedrosis Virus

Occurrence: The disease prevails all through the year but its severity is more during Summer and Rainy seasons.

Source of infection: Silkworm gets infected when it feed on contaminated mulberry leaves. The milky white fluid released by the grasserie larvae, contaminated silkworm rearing house and appliances are the sources of infection.

Predisposing factors: High temperature, low humidity and poor quality mulberry leaves.

Symptoms:

- The skin of infected larvae becomes shining before moult and fails to moult.
- Inter segmental swelling appears and the colour of the body becomes yellowish.
- The infected larvae move restlessly in the rearing bed/ along the rim of the trays.
- Infected larval body ruptures easily and turbid white haemolymph oozes out.

Management:

- Practice thorough disinfection of rearing house, its surroundings and appliances with any recommended disinfectant.
- Conduct an optional disinfection with 0.3% slaked lime solution when high incidence of disease noticed in the previous crop.
- Practice personal and rearing hygiene.
- Collect the diseased larvae and ensure its proper disposal.
- Maintain optimum temperature and humidity in the rearing house.
- Feed quality mulberry leaf and avoid overcrowding.
- Apply recommended bed disinfectant as per schedule and quantity.
- Feed Amruth as per schedule to control grasserie disease.

2. FLACHERIE:

Causative agent: Bombyx mori Infectious flacherie virus/Bombyx mori Densonucleosis virus or different pathogenic bacteria viz., Streptococcus sp./Staphylococcus sp./Bacillus thuringiensis/Serratia marscesence individually or in combination of bacteria and viruses.

Occurrence: The disease is common during Summer and Rainy seasons.

Source Infection: Silkworm gets infected by eating contaminated mulberry leaf. Dead diseased silkworm, its faecal matter, gut juice, body fluid are the sources of pathogen contamination. The infection can also takes place through injuries/cuts/wounds.

Predisposing factors:Fluctuation in temperature, high humidity and poor quality of leaves.

Symptoms:

- The larvae become soft and flaccid.
- The growth of infected larvae retarded, becomes inactive and vomit gut juice. The faeces become soft with high moisture content. Sometimes chain type excreta and rectal protrusion also observed.
- Larval head and thorax become translucent.
- When infected with Bacillus thuringiensis symptoms of toxicity such as paralysis and sudden death are observed. After death, larvae turn black in color and gives foul smell.
- Some times, the dead larvae turn red when infected with Serratia sp.

Management:

- Disinfect the rearing house, its surroundings and equipments with recommended disinfectant mentioned above.
- Pick up diseased larvae and dispose them by burning.
- Provide good quality leaf grown under good Sunlight and recommended inputs. Do not provide over matured/over stored /dirty leaf to the silkworms
- Avoid starvation, overcrowding and accumulation of faeces in the rearing bed.
- Rear silkworms under optimum temperature and humidity.
- Avoid injury to the larvae.
- Apply recommended bed disinfectant as per schedule and quantity.
- Feed Amruth as per schedule to control flacherie disease.

3. MUSCARDINE:

Causative agent : Among fungal diseases, White Muscardine is common. The disease is caused by *Beauveria bassiana*.

Occurrence: The disease is common during Rainy and winter seasons.

Source of Infection: The infection starts when conidia come in contact with silkworm body. Mummified silkworms / alternate hosts (most are lepidopteron pests), contaminated rearing house and appliances are sources of infection.

Predisposing factors : Low temperature with high humidity.

Symptoms:

- The larvae loose appetite and become inactive.
- Presence of moist specks on the skin.
- The larva vomits and turns flaccid.
- After death, larva gradually becomes hard followed by mummification due to growth of aerial mycelia and conidia over the body and body turns chalky white.

Management:

- Disinfect the rearing house, its surroundings and equipments with recommended disinfectant as mentioned above.
- Control mulberry pests in the mulberry garden.
- Pick up diseased larvae before mummification and dispose them by burning
- Avoid Low temperature and high humidity in the rearing house. If required use heater/stove to raise the temperature.
- Regulate bed humidity during rainy season by dusting slaked lime powder during moult.
- Apply bed disinfectant, Vijetha and Vijetha supplement/Ankush/any recommended bed disinfectant as per schedule and quantity.

4. PEBRINE:

Causative agent: *Nosema bombycis* / different strains of microsporidia.

Occurrence: Non-seasonal

Sources of Infection: Silkworm gets infected through eggs (Transovarian/Transovum transmission) or by eating contaminated mulberry leaf. Infected silkworms, faecal matter, contaminated rearing house and appliances and alternate hosts (mulberry pest) are the sources of infection.

Symptoms:

- Irregular hatching of silkworm eggs.
- Irregular size of the larval body and moulting.
- The infected larva loses its appetite and becomes inactive with wrinkled skin.
- Black pepper-like spots appear on the body of the infected worms.
- White postules appear on the silk gland when examined under microscope with presence of shining oval spores.

Management:

- Disinfect the rearing house, surroundings and with recommended disinfectant as mentioned above.
- Conduct strict mother moth examination and surface disinfection of silkworm eggs to produce and rear disease free layings.
- Follow strict hygiene maintenance during rearing.
- Control mulberry pests in and around the mulberry garden.
- Apply recommended bed disinfectant, Vijetha/Ankush as per schedule and quantity.
- Monitor seed crops constantly to eliminate the microsporidian infection.

Disinfection of rearing house, its surroundings and appliances:

Select any recommended disinfectant for disinfection purpose. CSR&TI, Mysore has recommended the following disinfectants:

- 0.05% Asthra solution (Add 50g Asthra powder in 100 liters of water and stir thoroughly and keep for 2 hours for dissolution of the powder).
- 2.5 % Sanitech/Serichlor in 0.5% Slaked lime solution (To prepare 100 liters of solution, take 250g of activator in to a basin/bucket and add 2.5 liters of Sanitech/Serichlor solution. Keep it for 10 minutes. Add activated solution to the rest of water. To this solution, add 500 g slaked lime powder and mix thoroughly).
- 2% Bleaching powder in 0.3% slaked lime solution (To prepare 100 liters of solution, add little water to 2 kg bleaching powder and 300g slaked lime powder and make a paste. Add this paste to the rest of water and stir thoroughly. Keep for 10 minutes and use the supernatant).
- 0.3 % Slaked lime solution (optional disinfection if viral diseases noticed in previous crop - Add 300g of slaked lime to 100 liters of water and stir thoroughly. Keep for 10 minutes and use supernatant).

- The total requirement of disinfectant solution for disinfection is estimated based on the rearing house floor area (**Length × Breadth of floor**).
- The quantity of disinfectant solution required is 1.5 lt./sq. m or 140 ml/sq. ft. floor area of rearing house (height 3 m /10 ft.) + 10% of total quantity of disinfectant solution.
- Disinfect the rearing house, appliances and surroundings by spraying the solution with power sprayer. Two times disinfection recommended for each crop (once 3days before initiation of rearing and after completion of rearing).

UNIT IV

ECONOMIC IMPORTANCE OF HONEY

Honey has been used since prehistoric time. People were very much dependent upon honey as medicine and essential nutritive diet. Honey is prepared by honeybees that belong to genus *Apis*. Four species of honeybees are reported, *Apis dorsata*, *A. indica*, *A. florea* and *A. mellifera*.

"The culture of honeybees for the production of honey and bee wax is known as apiculture."

Honey is plant product of high nutritive value. It contains about 80% sugar. It is not a direct plant product because the nectar, pollen grains and cane sugar is collected by the bees in their crops where it gets mixed with saliva, containing certain enzymes and undergoes chemical changes due to enzyme action. At this stage cane sugar (sucrose) is converted into dextrose and levulose and some ingredients of bees also added to the mixture to reduce the water content. The whole mixture is then collected in the honey sac (crop) until it reaches the hive. As the honeybee reaches the hive this compound is regurgitated in the hive cell and is known as honey.

Chemical Composition of honey

Honey is very sweet in taste. It is a sugar rich compound having following ingredients :

- (1) Levulose - 38%
- (2) Dextrose - 21%
- (3) Maltose and other sugars - 9%
- (4) Enzymes and pigments - 2.3%
- (5) Ash - 10%
- (6) Water - 17%

Economic Importance of Honey

Honey is used by human beings as food and medicine.

1. Food value : 100 gm of honey provides as much nourishment as 6 litres of milk or 800 gm cream or 170 gm meat. 2.1 gm of honey provides 67 Kcal of energy. Sugar, minerals, vitamins and other vital elements of honey are easily absorbed by systems. Honey can be taken by healthy as well as sick persons at any time in any season. It is used in the preparation of candies, cakes and bread.

2. Medicinal value : Honey is mild laxative, antiseptic and sedative. It is generally used in Ayurvedic and Unani systems of medicines. Honey is quiet helpful in building up of the haemoglobin of blood and also used as preventive against fever, cough and cold. It is also used to treat ulcers of tongue and alimentary canal. Germs of typhoid are killed by honey within 48 hours.

UNIT 111

ECONOMIC IMPORTANCE OF SILK

The raw silk is used in the manufacture of woven materials and the knitted fabrics for the preparation of garments, parachutes, parachute cords, fishing lines sieve for flour mills, insulation coil for telephones and wireless receivers and tyres of racing cars. Fabrics for garments in various waves plain will, salt, stockings, dyed and printed ornamented fabrics for saris, jackets, shawls and wrappers are made out of this material.

Status of sericulture industry in India: At the root of the social, economic, cultural and political progress of India, there are 6.5 lacs villages where 75% of the population of the country lives. The real progress of our country is definitely on the development of these villages.

For the economic independence of the villages it is most important to check the flow of ingenious people from the villages towards cities so that the villages also may get a chance for advancement and progress. Even today the main source of earning livelihood in villages is agriculture and agriculture based industry on which 70% of the population depends.

Majority of the village population even today lives below poverty line. It is believed that small scale and cottage industries are only in small and under developed counties but this assumption is only partially correct because in developed countries like USA, Germany, France, Britain, Russia, Switzerland and Denmark cottage industries occupy a special importance in their economy.

In such countries where there is dearth of capital but ample labour power, small scale and cottage industries also have great importance. When we discuss the economic policy of India, one doubt always, haunts our mind, whether on the strength of small and cottage industries only would it be possible for us to face the challenges in the international economic competition.

Gandhi's economic philosophy provides solution to this doubt that small cottage industries and modern and large industrial units have to be free from mutual competition, then only all round development of the nation can be possible.

A. In business:

1. Sericulture is a small scale, agro based cottage industry.
2. In India, the sericulture is carried out in 27500 villages.
3. It provides self employment.

B. As source of Employment:

1. In different states of India more than 4 million people are employed in sericulture.
2. Thus, sericulture jobs and is a source of income.

C. Clothing:

1. Sericulture substitutes the cotton textile industry.
2. Fine delicate clothes are prepared from silk threads.
3. Silk threads are also exported. India gets large foreign exchange by silk exports.

D. Importance of silk:

There are many other uses of silk:

1. Silk is used in the preparation of garments.
2. Silk is used in the preparation of parachute cords.
3. Preparation of fishing line and elastic webs.
4. In preparation of race tyres of cars and two wheelers.
5. In insulation coils for telephone and wireless receivers.

METHODS OF BEE KEEPING

It can be studied under two heads

Traditional method:

Fixed comb hives

A fixed comb hive is a hive in which the combs cannot be removed or manipulated for management or harvesting without permanently damaging the comb. Almost any hollow structure can be used for this purpose, such as a log gum, skep, wooden box, or a clay pot or tube. Fixed comb hives are no longer in common use in industrialized countries, and are illegal in places that require movable combs to inspect for problems such as varroa and American foulbrood. In many developing countries fixed comb hives are widely used and, because they can be made from any locally available material, are very inexpensive.

Beekeeping using fixed comb hives is an essential part of the livelihoods of many communities in poor countries. The charity Bees for Development recognizes that local skills to manage bees in fixed comb hives¹²⁴¹ are widespread in Africa, Asia, and South America. Internal size of fixed comb hives range from 32.7 liters (2000 cubic inches) typical of the clay tube hives used in Egypt to 282 liters (17209 cubic inches) for the Perone hive. Straw skeps, bee gums, and unframed box hives are unlawful in most US states, as the comb and brood cannot be inspected for diseases. However, skeps are still used for collecting swarms by hobbyists in the UK, before moving them into standard hives. Quinby used box hives to produce so much honey that he saturated the New York market in the 1860s. His writings contain excellent advice for management of bees in fixed comb hives.

MODERN METHODS OF BEE KEEPING:

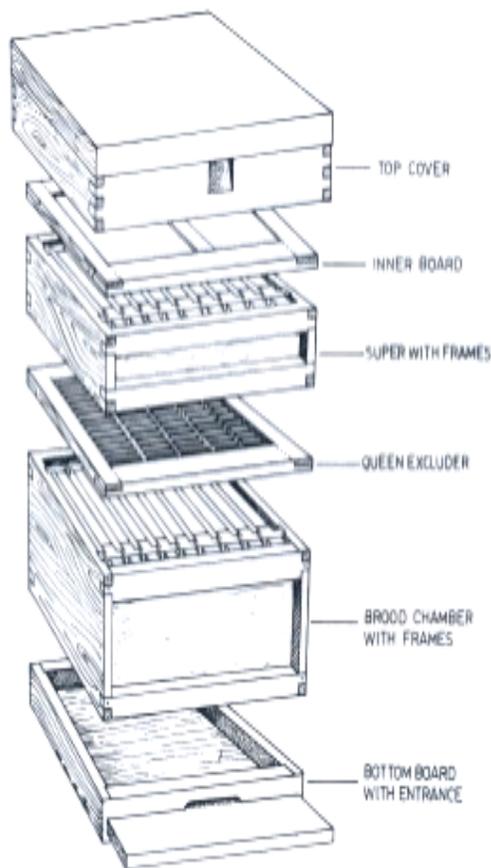
BEE HIVES

- In modern apiculture several types of hives are used. The hive is a wooden structure, consisting of several parts.
- Primitive and rustic hives like hallowed logs and wood, baskets, claypots and clay cavities fixed in the walls of mud houses have been in use for keeping bees in India till about the close of 19th century.
- The hive developed on the principle of bee space by L. Langstroth (USA) revolutionized the whole concept of bee keeping from 1851 onwards. In India beginning was made to keep the bees in movable frame hives in 1880's after the widespread adoption of Langstroth hive in west. These movable frames which could be taken out of the hive, observed and replaced by shifting them suitably.

TYPE OF HIVES

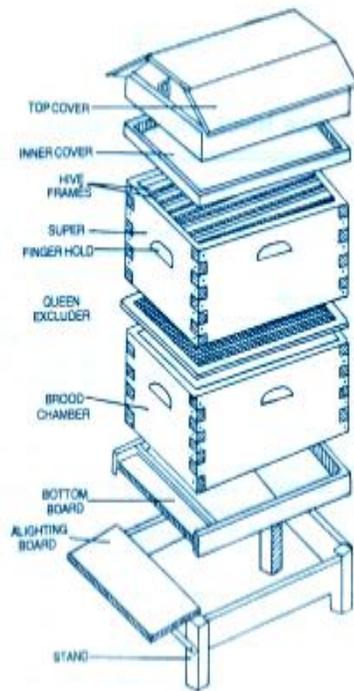
- The standard Langstroth hives made of light strong wood is now in use in most of the country for *A. mellifera*.
- The hives suited for *A. c. indica* (i) Newton's hive, (ii) ISI meshy used – 10 frames, (iii) Jeolikote villager – 7 frames.

ISI HIVE (A Type)



| | |
|---------------------------------|----------------------|
| Bottom board | -861 x 356 x 50 mm |
| Brood chamber length | - 286 x 356 x 174 mm |
| Super length | - 286 x 356 x 94 mm |
| Top cover length | - 328 x 398 x 115 mm |
| Brood frame(Length x breadth) – | 230 x 165 mm |
| Super frame | -230 x 85 m |
| Dummy board | - 230 x 165 mm |
| Top bar length | - 260 mm |
| Bottom bar length | - 210 mm |

Langstroth frame hive showing different parts



Langstroth hive

In modern beekeeping, a **Langstroth hive** is any vertically modular bee hive that accepts frames that are locally referred to as "Langstroth" frames. The actual dimensions of so-called Langstroth frames differ by region or manufacturer. These modern Langstroth hives have little in common with Rev LL Langstroth's bee hive that was originally patented in 1852 and manufactured until approximately 1920.

Historically, a "Langstroth hive" is the hive that was designed by Rev LL Langstroth in 1852. The historical Langstroth hive had a portico entrance, integrated floor and non-removable brood box, a single removable honey box (using the same frame size as the brood box) that sat inside an outer box that extended from the brood box, and a hinged roof. LL Langstroth's famous book on beekeeping went through several editions until about 1900, but in all of them the hive that is illustrated is the same as the original design. The original Langstroth frame dimensions is no longer in use.

Similar designs is the standard beehive used in many parts of the world for beekeeping. The advantage of this hive is that the bees build honeycomb into frames, which can be moved with ease. The frames are designed to prevent bees from attaching honeycombs where they would either connect adjacent frames, or

connect frames to the walls of the hive. The movable frames allow the beekeeper to manage the bees in a way which was formerly impossible.

Other inventors, notably François Huber in 1789, had designed hives with frames (the so-called *leaf* or book hive), but Langstroth's hive was a practical movable frame hive, which overcame the tendency of the bees to fill empty spaces with comb and to cement smaller spaces together with propolis. In contrast to August von Berlepsch's frame-movable side-opened hive (May 1852, Germany), Langstroth's hive was top-opened, as was the Bevan top-bar hive (1848, UK). These combined adaptations led to the Langstroth hive design being preferred by beekeepers over all others, and his hive is used throughout the world.

Design

The Langstroth bee hive is made up from top to bottom of:

- telescoping cover or migratory cover
- inner cover
- one or more hive bodies or honey supers made of wood, polystyrene, or other plastic
 - (optional) queen excluder between brood box and honey supers
 - eight to ten frames, made of wood or plastic, per hive body or honey super
 - (optional) foundation made of wax and wires or plastic
- bottom board, with optional entrance reducer

Outer cover

This is a wooden or polystyrene cover that fits on the top of the hive. In higher latitudes (further north in the Northern Hemisphere; further south in the Southern Hemisphere), a cover which telescopes down around the inner cover and an inch or so down over the top super, called a telescoping cover, is usually used. Many commercial beekeepers use what is known as a migratory cover, a solid cover which does not extend beyond the sides of a hive body.

Inner cover

The inner cover provides a barrier between the telescoping cover and the bees. In more temperate climates, a plastic foil may be used as an inner cover. Plastic foil should not be used to winter bees under, as trapped condensation would cause the hive to become wet, and bees can be lost due to freezing when temperatures fall during the night. In areas with a hot summer, a solid inner cover with a communication hole provides dead-air space for insulation against both heat and cold. This prevents the bees from gluing the top cover to the top bars of the super under it. When an inner cover is used, the top cover is more easily removed from the hive. Notches in the frame of the solid inner cover and telescoping cover can serve as an upper entrance for the bees. A communication hole in the middle allows bees to reach emergency food placed above by the beekeeper if it becomes required. Granulated sugar can be poured onto the inner cover near the hole, and the bees will be able to access it during even the coldest of days.

Hive body and hive super

Hive bodies and hive supers are four-sided boxes with standardized inside dimensions. There are generally four different sizes. Outside box dimensions vary depending on the type of material used. Polystyrene boxes have much larger outside dimensions than boxes made out of wood. Deep and medium hive bodies are provided to serve as the brood chamber, the part of the hive where the queen lays eggs and the bees care for the larvae. Medium, shallow and comb honey supers are used for honey stores and to harvest the honey. The inside width is 14-11/16 inches (373 mm) and the inside length is 18-5/16 inches (465 mm). The frames rest on a rabbeted side along both ends of each box.

The deep hive body is normally used only for brood, as it becomes too heavy to handle manually if it becomes filled with honey. Commercial operations usually use one- or two-deep hive bodies for brood, and

additional shallow hive components for honey supers. Some hobbyists prefer to standardize on all mediums. Shallow supers are not ideal for the brood chamber of the hive because the bees need to form a single compact sphere during the cold winter months – a sphere that can expand and contract without being divided by a horizontal plane in the middle caused by the gaps between combs in multiple hive bodies.

The hive body or hive super holds 8 to 10 frames that are standardized in length. The frames hold the foundation and the honeycomb that is built on it.

Hive equipment manufacturers will often produce bodies and supers that vary from other manufacturers though the differences are generally 1/8th of an inch or less. The following table includes interior dimensions and volumes for the 5, 8, and 10 frame shallow, medium, and deep bodies/supers.

Specialty parts

The **Cloake board**, also known as the "bottom-without-a-bottom", is a specialty piece of hive equipment that is installed between two hive bodies of the brood nest. It allows the beekeeper to insert a sliding metal or wood panel, which will split the hive into two parts without having to lift the hive boxes, the objective being to split a single hive into two independent hives.

The **queen excluder** is a mesh grid, usually made of wire or plastic, sized such that worker bees can pass through, but queens (generally) cannot. When used, it is generally placed between the hive body and the honey supers. The purpose of the queen excluder is to keep the queen from laying eggs in the honey supers, which can lead to darker honey and can also complicate extraction. Many beekeepers reject the use of queen excluders, however, claiming that they create a barrier for workers and result in lower levels of honey collection and storage.

A **feeder** is most often used to feed granulated sugar or sugar syrup at times of the year when no, or not enough, nectar flow is available from natural sources to meet the hive's needs. There are various styles. Division board feeders have a shape similar to that of the frame, and hang inside the hive body in the same manner as a frame. Entrance feeders are wedged into the hive entrance on the bottom board with an inverted container of feed. Hive-top feeders have the same footprint as the hive body and are placed on top of the hive, but underneath the telescoping cover. Other hive-top feeders consist of an inverted container with small holes in the lid, which are placed either directly on top of the frames, or on top of the hole in the inner cover.

An **"escape board"** is placed between the brood boxes and the supers to clear the supers of most of the bees. The escape board lets bees exit the supers into other areas of the hive, but makes it difficult for the bees to re-enter the supers. There are several different designs.

UNIT I11

SERICULTURE REARING METHODS

1. Rearing of chawki worms :

Chawki rearing has a great influence on the cocoon crop production. Chawki worms must be reared under good hygienic conditions and feeding them with quality mulberry leaf rich in nutrients and moisture content. Young worms are more resistant to high temperature, feed actively and grow vigorously. It also helps in improved survival rate and cocoon characters. The amount of ingestion and digestion is increased with rise in relative humidity during young stage.

Rearing schedule for chawki worms

| Factor | Instar | |
|--------|-----------------------|-----------------------|
| | 1 st stage | 2 nd stage |
| | | |

| | | |
|----------------------------|----------|-----------|
| Temperature °C | 27-28 | 27-28 |
| Humidity (RH%) | 85-90 | 85-90 |
| Leaf quality/100 dfls | 3-3.5 kg | 8.5-10 kg |
| Bed area/100 dfls (sq.ft.) | 4.4-7.5 | 17.5-52.5 |
| Bed cleaning | -- | Twice |

Surface Disinfection: Before incubation of seed, the eggs should be surface sterilized with 2% formalin for 5 minutes and washed with water. Dry them in shade.

Brushing of silkworm eggs:

At the time of brushing, the mulberry leaf is cut to 0.5 sq.cm and sprinkled over the hatched worms.

After half an hour the worms are tapped on the rearing bed in the tray.

The size of the bed for 25 dfls should be 25 sq.cm.

Methods of young age rearing: Different methods of young age rearing are in practice. The most common methods are box and stand rearing.

Box rearing:

Wooden trays of 4' x 3' x 2' and 4" depth are used.

Trays during feeding period are arranged one above the other upto a convenient height. It can increase the temperature/humidity in the rearing bed.

Keep the trays in criss-cross condition for 30 minutes before feeding to allow fresh air.

30 minutes before feeding and during moulting period, the paraffin or polythene sheets are removed.

Minimum space is requirement.

Stand rearing: Stand rearing is done when optimum temperature and more rearing humidity are available in the rearing room. In this method more rearing space is needed.

Cover rearing method: During the first two instars, the rearing bed of young larvae is covered with polythene sheets both at the bottom and top with four sides wrapped. The size of plastic film is 116 cm x 86 cm (depends on the size of tray), thickness 0.03-0.4 mm. The polythene should be punched and the size of the hole should be 0.15-0.2 mm and distance between the holes should be 1.5-2 cm. The polythene sheet should be transparent.

Feeding/Nutrient requirement for chawki rearing :

Chawki worms should be fed with succulent mulberry leaves rich in nutrients and moisture content viz., water content (80%), protein (27%) and carbohydrates (11%).

Separate chawki garden with superior mulberry variety like KNG or Ichinose are maintained by providing irrigation and inputs such as FYM and chemical fertilizers in the recommended dose (FYM : 40 MT; N:P:K:300:150:150)

Select first glossy leaf from the top of branch for 1st feeding at the time of brushing and with the advancement in larval age the first 3-4 tender leaves can be used.

Leaf harvest must be done in the morning and evening.

Preserve the mulberry leaves in a cool place covered with wet gunny cloth.

In dry season, sprinkle water over leaves and preserve them under wet gunny cloth.

Chopped leaves should be fed to worms for uniform growth.

Three feeding schedule viz., 6 am, 2 pm and 10 pm should be followed.

Stop feeding when above 90% worms settle for moult and resume when 95% worms comes out of moult.

30 minutes before feeding, the paraffin or polythene are removed and after feeding the rearing beds are again covered with polythene sheets.

The size of the leaf fed should be 1.5 sq.cm. in first stage and increased to 3 sq.cm. as worms advance in age.

Size of the leaf should be reduced when worms start settling for moult.

Bed cleaning : Only two cleanings are recommended during second stage and no cleaning in first stage. Cleaning nets are applied on the bed, chopped leaf is fed to worms. Worms crawl through the

net. After two hours, worms are transferred to another tray. If cleaning nets are not available, the topmost layer with worms must be taken with a feather.

Spacing : Overcrowding of the silkworms in the early stage leads to sizing and poor growth. Regulate the spacing for the healthy growth of the silkworms. There should be uniform distribution of the larvae in the bed.

Use of bed disinfectant : Dusting of bed disinfectants is important to avoid secondary contamination. The quantity and schedule of dusting of different bed disinfectants for 100 dfls is given as under:

| Dosage | RKO | Vijetha | Resham Jyoti |
|-----------------------------|-------|---------|--------------|
| After 1 st moult | 60 g | 50 g | 50 g |
| After 2 nd moult | 120 g | 100 g | 100 g |

Proper care during moult:

Ensure good aeration and dry conditions in rearing bed during moult.

Remove the polythene during moult period.

Temperature/humidity should be kept 1°C less viz., 26°C and RH 65-70%.

Concept of chawki rearing : To raise a healthy stock of silkworms the system of chawki rearing must be quite effective:

Maintenance of optimum temperature/relative humidity.

Feeding of nutritious tender leaves.

Maintenance of absolute hygienic conditions.

For rearing chawki worms experienced persons are needed.

Distribution of chawki worms: Worms in the tray can be rolled along with punched paraffin/old news paper at the base and top. Ends are closed and stapled. Worms should be transported to the rearers house during morning hours and fed immediately with fresh leaves.

Advantages of cover rearing method :

- Humidity in the rearing bed is increased, with the result driage % of the leaf is reduced.
- Optimum conditions in the rearing beds is maintained during chawki rearing.
- Yield and cocoon characters are improved.
- Polythene sheets can be easily washed and disinfected and can be used for subsequent crops.
- Reduces the input cost.
- Minimum space is required

Advantages of chawki rearing :

- Ensures stable rearing and quality cocoon crop.
- Healthy and disease free worms.
- Uniform and vigorous worms with a minimal loss of larval population.
- Reduction in rearing expenditure and saves labour.

Precautions while Adoption/Usage

Cover rearing method :

- During high humid conditions, applying of polythene should be

avoided.

- During moulting time the polythene sheets should be removed.
- Use of thicker gauge polythene sheet should be avoided.
- Drying should be avoided from sun.

Precautionary measures during the rearing of young larvae(Chawki):

- Before entering the rearing room, where chawki worms are reared, hands should be washed.
- Separate footwear should be used inside the rearing rooms.
- Silkworm litter should not be thrown in the rearing room.
- Rearing rooms should be kept clean and tidy.
- Avoid touching the worms.

LATE AGE SILKWORM REARING

- The third, fourth and fifth instar larvae are considered as late age worms. They are reared in bamboo trays. Newspapers are spread over the trays to absorb excess moisture in leaves and faecal pellets.
- The temperature and humidity requirement gradually comes down as the stage advances.
- Leaves of medium maturity (6th leaf onwards) are fed in the third and fourth age and coarse leaves are fed in the fifth age.
- Over matured and yellow leaves should be rejected, since they may induce disease outbreak.

Bed disinfectants

Apply bed disinfectants like TNAU Seridust, Resham Jyothi, Vijetha or Sajeevini @ 4 kgs/100 dfls.

| Stage (before feeding) | Bed disinfectant (Qty/100 dfls) (g) |
|-------------------------------|-------------------------------------|
| After 1st moult | 50 |
| After 2nd moult | 150 |
| After 3rd moult | 800 |
| After 4th moult | 1000 |
| On fourth day of final instar | 2000 |
| Total | 4000 |

Moulting

- Remove the paraffin papers
- Evenly spread the larvae in the rearing bed 6-8 h before settling for moult.
- Provide air circulation to avoid excess humidity inside the room.
- Provide charcoal stove/heaters to raise the room temperature during winter.
- Apply lime powder at 60 minutes before resumption of feeding daily during rainy/winter seasons to reduce the dampness in bamboo trays.

Mounting

- Apply Sampoorna @ 20 ml (dissolved in 4 l of water) per 100 dfls over the leaves for early and uniform spinning of cocoons.
- After attaining full growth in the final instar, the worms cease to feed and are ready to spin.
- Such worms are slightly translucent and raise their heads to find a place for spinning.
- These worms have to be picked up and transferred to a mountage for spinning cocoons.
- Mounting of worms should not be delayed as the ripened worms will waste silk.
- About 800-900 worms per m² are to be kept on a mountage. For 100 dfls, about 30 to 40 chandrakis are required.
- Mountages should be kept under shade in well ventilated place.

Care during spinning

- Quality of silk depends on the care taken at the time of spinning.
- Mature worms are sensitive to temperature, humidity, light, etc., at the time of spinning.
- The ripe worm requires space equal in area to square of the length of its body for spinning.
- Proper spacing avoids wastage of silk for forming preliminary web and avoids double cocoons.
- To prevent staining of cocoons, keep mountage in an inclined position so that the urine may drop to the ground.

Maintenance of humidity

- Fluctuation of humidity causes abrupt thinning and thickening of silk filament.
- A relative humidity of 60-70% is ideal for spinning.
- Provide proper ventilation and straw mats below the mountage to quid excreta.
- Provide even and moderate lighting. Improper lighting (bright light or dark shadow) causes crowding of larvae to shaded area leading to double cocoons.
- Remove dead worms and non-spinners on the 2nd day of spinning.
- To protect the silkworm from predatory ants, apply malathion 5% dust/lakshman rekha at the base of mountage stand.

Harvesting

- The silk worms complete spinning in 2 to 3 days but the cocoons should not be harvested at this time as the worms inside are still in the prepupal stage.
- Harvesting should be done on the fifth day (7th day for bivoltine hybrids) when pupae are fully formed and hard.
- Do not harvest when the pupa is in amber colour.
- Dead and diseased worms on the mountages should be removed before harvest.
- Marketing of cocoons should be done on the sixth day (8th day for bivoltine hybrids).

Shoot rearing for late age worms

Silkworm larvae consume 85% of their food requirement during fifth instar. Fifty per cent of the labour input is utilized during the last seven days of rearing.

Rearing house

- Provide separate rearing house for shoot rearing in shady areas. Separate room should be provided for young age worm rearing, leaf storing and hall for late age worm rearing.

Shoot rearing rack

- A rearing rack of 1.2m x 11m size is sufficient to rear 50 dfls.
- Provide 15 cm border on all sides of the shelf to prevent the migration of the larvae.
- Arrange the shelves in three tier system with 50 cm space between the tiers.
- Fabricate the rack stand with wood, or steel and the rearing seat with wire mesh/bamboo mat.

Shoot harvesting

- Harvest the shoots at 1 m height from ground level at 60 to 70 days after pruning.
- Store the shoots vertically upwards in dark cooler room.
- Provide thin layer of water (3 cm) in one corner of storage room and place the cut of shoots in the water for moisture retention.

Feeding

- Provide a layer of newspaper in rearing shelf.
- Disinfect the bed, spread the shoot in perpendicular to width of the bed.
- Place top and bottom ends of the shoots alternatively to ensure equal mixing of different qualities of leaves.
- Transfer the third instar larvae to shoots immediately after moulting.
- Watch for feeding rate from 4th day of fourth instar. If 90% of larvae have not settled for moulting, provide one or two extra feedings.
- Provide 3 feedings during rainy/winter months and 4 feedings during summer rearing.

Spacing

- 18-36 m²/100 dfls.

Bed cleaning

- Bed cleaning is done once during second day of fifth instar following rope (or) net method.
- In rope method, spread 2 m length of rope (two numbers) at parallel row leaving 0.5m on other side.
- After 2 to 3 feedings, ends of the ropes are pulled to the centre to make it into a bundle.

- In net cleaning method, spread 1.5 cm² size net across the bed.
- After 2 or 3 feedings, the nets are lifted and the old bed is cleaned and disinfected.
- Transfer the net to newer shelf, spread the net over the shoots; larvae will migrate to lower layer.

Advantages

1. Labour saving upto 70% when compared on hour to hour basis with leaf feeding method.
2. Leaf saving upto 15-20%. Hence, leaf cocoon ratio is less by 2-3 kg and extra cocoon production.
3. Better cocoon characters and effective rate of rearing (ERR).
4. Better preservation of leaf quality both during storing and on the bed.
5. More organic matter production (upto 18 tonnes per ha per year).
6. Better hygienic conditions can be maintained.
7. Handling of silkworms minimised. Hence, contamination and spreading of disease reduced.
8. Bed cleaning only once after IV moult.
9. Worms and leaves are kept away from the litter. Hence, chances of secondary contamination are minimised.
10. Labour dependent risk is reduced.

Disadvantages

1. Required rearing room floor area is more (by 30%)
2. Bed refusals will not be available as a cattle feed.
3. Planting materials (cuttings) will not be available.

UNIT 111

STATUS OF SERICULTURE IN JAMMU AND KASHMIR

Silk industry has occupied a prime place in the industrial structure of the state. Its significance in the state can be understood in terms of position it occupied during different periods of history and the interest different rulers took in developing this industry, as they observed that this industry had very flourishing and prosperous future for the development of the state economy. During 15th century, during the reign of king Zain-ul-Abidin, Kashmir attained great progress in this industry. During Mughal period also, the industry flourished because they were the great lovers of silken cloths. The industry however passed through many ups and downs, during its long history, but the same could not dampen the enthusiasm of the rulers as from time to time steps were taken to promote the growth of the industry. Organizational changes on modern lines were undertaken in tune with the available factory inputs. Separation of processes was initiated and the quality of seed was improved to increase production. The combined effect of all these measures was that the employment in the industry increased along with the remuneration for those who are directly employed by the industry also witnessed an un-presidential rise. Thus the industry has witnessed

various changes in respect of performance, organization, diversification and modernization that have made the industry economically viable during the pre-1947 period. However, in the post 1947 period, changes in the structure of land ownership which affected the incentive structure in agriculture, introduction of new avenues of income and consequent improvement in the economic condition of the people, reduced the interest of farmers towards silk worm rearing. In addition, the state monopoly control which has once helped to organize the industry on modern lines became an obstacle in its development. Consequently during 1988-89, silk industry was demonopolised and mulberry tree was declared as farmer's property. Once the monopoly system was dispended with, there was a tremendous change in the overall transformation of sericulture development in the state. People started showing enormous interest to adopt this craft as a means of their livelihood. But the unfavorable conditions created in the valley, immediately after demonopolisation act was enforced, and the constraints such as non-availability of quality mulberry leaves, un-scientific rearing techniques, poor quality of seed, lack of proper supervision, competition from other crops and handicrafts, lack of proper extension activities and also the marketing, financial and other constraints again stood in the way of development of sericulture in the state. Cocoon which is an intermediate product/input in the production of silk has a direct bearing on the quantitative and qualitative variations in silk production. This can be proved by looking at the data pertaining to cocoon production and silk production during the last ten years. The production of cocoons has witnessed cyclical trends during the last three decades and no firm trend is traceable. These ups and downs in cocoon production are also visible in the production of silk in the Valley and also in respect of the performance of the industry as a whole. Unfortunately, no study has been made so far, in the state to analyse the relationship between cocoon production and silk production and to identify the factors responsible for poor performance of the industry, As per Government of Jammu & Kashmir the data of production is as under

| Year | Cocoon Production (MT) | Income generation (Lac Rs.) | Avg. Price for "A"grade dry cocoons (Rs./kg) | Cocoon Productivity (Kg/100Dff's) | Rearers (Nos.) |
|----------------|-----------------------------------|---|---|--|---------------------------|
| 2008-09 | 738 | 455.67 | 192.00 | 32.00 | 19700 |
| 2009-10 | 810 | 800.00 | 300.00 | 35.00 | 22800 |
| 2010-11 | 860 | 1100.00 | 410.00 | 35.00 | 25500 |
| 2011-12 | 917 | 963.00 | 350.00 | 37.00 | 27000 |
| 2012-13 | 901 | 1193.00 | 397.00 | 37.00 | 28000 |
| 2013-14 | 1022 | 2200.00 | 650.00 | 40.00 | 30000 |

UNIT IV

Tools of Apiculture

The Hive and Its Parts

Honeybees can live in hollow trees, wall voids in buildings, attics, or any other protected place. Several types of hives have been designed to manage honeybees. Old-fashioned hives were simple devices, such as plain boxes, short sections of hollow logs called gums, or straw baskets called skeps. These hive styles have many disadvantages and are rarely used now. Combs in them were usually irregular and braced together with bur comb. Individual combs could not be removed from the hive without damaging other pieces or even injuring or killing the queen. It was also difficult to inspect the hives for diseases and other problems.

Modern hives with *movable frames* allow easy inspection and honey removal. Hive design is efficacious for other management practices and for the bees. The inner dimensions of the hive and its parts are very precise. They are based on a dimension called the "bee space," which is about 5/16-inch wide or deep. Proper spacing is

important. If gaps are too wide, bees build brace comb and glue down movable frames. The modern hive consists of several parts.

A *hive stand* keeps the hive off the ground so it is less likely to rot, flood, or be attacked by termites. It can be as simple as a few bricks stacked under each hive corner, or it might be a wood frame with an alighting board. The alighting board allows heavily loaded field bees to land more easily before crawling into the hive.

The hive rests on the three rails of the *bottom board*. The open side is the hive entrance. This opening can be closed or narrowed with an entrance cleat when necessary. Reducing the entrance opening in the fall keeps out field mice looking for shelter. The standard *hive body* or *brood chamber* holds 10 frames of comb. Besides being the nursery, it is also pantry, kitchen, living room, dining room, bedroom, and workshop for the bees. If it becomes too crowded, the bees might begin rearing brood in the supers. If colonies get very large, provide extra hive bodies for the brood chamber.

A *queen excluder* is sometimes placed above the brood chamber to keep the queen in the brood chamber. Slots in the excluder are wide enough workers can go back and forth but too narrow for the queen to pass through. Beekeepers who produce extracted honey do not use excluders because they reduce the bees' efficiency. For comb honey and chunk honey production, the excluder assures that brood are not in the honey product.

Chambers above the brood chamber are called *supers*. They are the same size as the brood chamber and are used for storage of surplus honey. Deep supers are used by those who primarily produce extracted honey. Larger boxes require less handling but are heavy when full of honey. Shallow supers are easier to lift and convenient for harvesting small honey yields from a particular nectar source.

The inner cover is a flat piece with an oblong hole in the center. A bee escape can be put in the hole when needed. The hole provides ventilation and a place to puff smoke when opening the hive. The edges of the inner cover have railings on both faces. The railing on one side is higher than the other. The tall railing should be on the outside. If the tall rail is on the inside, the bees build wax between it and the tops of the frames. This buildup is a mess to clean.

The *top cover* is a waterproof lid that rests on the edges of the top super. Bees do not glue down the top cover, so it can be lifted from the hive without prying or jarring.

Frames are the inside parts that hold the comb. They consist of a top and bottom and two end bars. The wide part of an end bar is keeled on one edge. Place frames in the

hive so that the keeled edge of one frame abuts the flat edge of the next one. Frames help keep comb-building regular and allow easy inspection and honey removal. All frames are the same length, but there are different depths and styles.

Carefully put together unassembled frames. Fit the frame together so that the keel on the left end bar is toward you and the keel on the right end bar is away from you. If you rotate the frame, the keel is still toward you on the left side and away from you on the right. Use plenty of nails when fastening the frame together. Otherwise, it can pull apart when the comb is full of honey.

To ensure that the comb is regular, frames are fitted with thin sheets of embossed wax called *foundation*. Foundation for brood frames and extracted honey frames has embedded wires for extra strength. This prevents the comb from sagging when the wax gets soft during hot weather or from tearing apart during extraction.

Foundation can be purchased with wires in it, or wire can be embedded after the foundation is fitted into the frame. It is more convenient for the beginner to buy wired foundation for brood frames. Use unwired foundation in the honey frames if you are going to produce chunk honey. The size of foundation sheets varies with frame size. Bee supply catalogs specify the frame styles different foundation sheets fit.

Other Beekeeping Equipment

A *hive tool* is the most useful piece of beekeeping equipment. It can be used to pry up the inner cover, pry apart frames, scrape and clean hive parts, and do many other jobs.

Examining a hive is much easier when you use a *smoker*. It is used to puff smoke into the entrance before opening the hive and blow smoke over the frames after the hive is opened. Smoke causes the bees to gorge themselves with honey; then they are much gentler. Smoke must be used carefully. Too much can drive bees from the hive. They will be slow to settle down after the hive is closed again. Burlap, rotted wood, shavings, excelsior, cardboard, or cotton rags are good smoker fuels.

Even the most experienced beekeepers wear *veils* to protect their face and eyes. Wire veils keep bees farther away from the face than those made of cloth. Black veiling is generally easier to see through. Some beekeepers prefer to wear a bee suit. Whether or not a suit is used, a beekeeper's clothing should be light in color. Bees generally do not like dark colors and will attack dark objects.

Bee gloves protect the hands and arms from stings, but it is hard to do some jobs while wearing them. It is a good idea to wear gloves until you feel more comfortable working your bees.

A brush gently removes bees from frames. A leafy twig or bunch of grass can do the same job and gives you fewer tools to carry around.

A bee escape is used to clear bees out of supers. Place the escape in the center hole of the inner cover below the super to be cleared. Bees can pass through in only one direction. It usually takes about a day to get the bees out of a super.

Wire embedders are handy for wiring your own foundation. Various jigs for assembling frames and supers save time and assure square fitting. These can be purchased or made. Most beekeepers are creative with tools and make various gadgets to do special jobs.

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TYPES OF SILK

There are four types of natural silk which are commercially known and produced in the world. Among them mulberry silk is the most important and contributes as much as 90 per cent of world production, therefore, the term "silk" in general refers to the silk of the mulberry silkworm. Three other commercially important types fall into the category of non-mulberry silks namely: Eri silk; Tasar silk; and Muga silk.

There are also other types of non-mulberry silk, which are mostly wild and exploited in Africa and Asia, are Anaphe silk, Fagara silk, Coan silk, Mussel silk and Spider silk.

Bulk of the commercial silk produced in the world comes from this variety and often 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.

Mulberry silk contributes to around 90 percent of the world silk production.

Tasar silk

The tasar silkworms belong to the genus *Antheraea* and they are all wild silkworms. There are many varieties such as the Chinese tasar silkworm *Antheraea pernyi* Guerin which produces the largest quantity of non-mulberry silk in the world, the Indian tasar silkworm *Antheraea mylitta* Dury, next in importance, and the Japanese tasar silkworm *Antheraea yamamai* Querin which is peculiar to Japan and produces green silk thread.

The Chinese and Japanese tasar worms feed on oak leaves and other allied species. The Indian tasar worms feeds on leaves of *Terminalia* and several other minor host plants. The worms are either uni- or bivoltine and their cocoons like the mulberry silkworm cocoons can be reeled into raw silk.

Eri silk

These belong to either of two species namely *Samia ricini* and *Philosamia ricini*. *P. ricini* (also called as castor silkworm) is a domesticated one reared on castor oil plant leaves to produce a white or brick-red silk popularly known as Eri silk.

Since the filament of the cocoons spun by these worms is neither continuous nor uniform in thickness, the cocoons cannot be reeled and, therefore, the moths are allowed to emerge and the pierced cocoons are used for spinning to produce the Eri silk yarn.

Muga silk

The muga silkworms (*Antheraea assamensis*) also belong to the same genus as tasar worms, but produce an unusual golden-yellow silk thread which is very attractive and strong. These are found only in the state of Assam, India and feed on *Persea bombycina* and *Litsaea monopetala* leaves and those of other species.

The quantity of muga silk produced is quite small and is mostly used for the making of traditional dresses in the State of Assam (India) itself.

Anaphe silk

This silk of southern and central Africa is produced by silkworms of the genus *Anaphe*: *A. moloneyi* Druce, *A. panda* Boisduval, *A. reticulate* Walker, *A. ambrizia* Butler, *A. carteri* Walsingham, *A. venata* Butler and *A. infracta* Walsingham. They spin cocoons in communes, all enclosed by a thin layer of silk.

The tribal people collect them from the forest and spin the fluff into a raw silk that is soft and fairly lustrous. The silk obtained from *A. infracta* is known locally as "book", and those from *A. moloneyi* as "Trisnian-tsamia" and "koko" (Tt). The fabric is elastic and stronger than that of mulberry silk. *Anaphe* silk is used, for example, in velvet and plush.

Fagara silk

Fagara silk is obtained from the giant silk moth *Attacus atlas* L. and a few other related species or races inhabiting the Indo-Australian bio-geographic region, China and Sudan. They spin light-brown cocoons nearly 6 cm long with peduncles of varying lengths (2-10 cm).

Coan silk

The larvae of *Pachypasa atus* D., from the Mediterranean bio-geographic region (southern Italy, Greece, Romania, Turkey, etc.), feed primarily on trees such as pine, ash cypress, juniper and oak.

They spin white cocoons measuring about 8.9 cm x 7.6 cm. In ancient times, this silk was used to make the crimson-dyed apparel worn by the dignitaries of Rome; however, commercial production came to an end long ago because of the limited output and the emergence of superior varieties of silk.

Mussel silk

Whereas the non-mulberry silks previously described are of insect origin, mussel silk is obtained from a bivalve, *Pinna squamosa*, found in the shallow waters along the Italian and Dalmatian shores of the Adriatic. The strong brown filament, or byssus, is secreted by the mussel to anchor it to a rock or other surface. The byssus is combed and then spun into a silk popularly known as "fish wool". Its production is largely confined to Taranto, Italy.

Spider silk

Spider silk – another non-insect variety – is soft and fine, but also strong and elastic. The commercial production of this silk comes from certain Madagascan species, including *Nephila madagascarensis*, *Miranda aurentia* and *Epeira*. As the spinning tubes (spinne-rules) are in the fourth and fifth abdominal segments, about a dozen individuals are confined by their abdominal part to a frame from which the accumulated fibre is reeled out four or five times a month. Because of the high cost of production, spider silk is not used in the textile industry; however, durability and resistance to extreme temperature and humidity make it indispensable for cross hairs in optical instruments.