Laboratory Manual: Applied Entomology and Pest Management (ZOO506)

Virtual University

Virtual University of Pakistan

Content

Practical No: 1
Field visits for collection of different developmental stages of insects belonging to different orders

Basic collecting can be done by simply catching insects with your hands or a net and putting them into some type of jar. But, for more serious collecting, additional equipment is needed. Collecting supplies are somewhat dependent on the groups of insects being searched for and the time of day they are collected. Supplies needed for day collecting can be quite different than those used for night collecting. The same idea applies to collecting terrestrial insects versus aquatic insects, or flying insects versus soil dwelling insects. Indeed, it is difficult, if not impossible to collect all types of insects by an individual on a single collecting outing. It would also be impractical to carry the many supplies for all collecting methods by a single person. Many collectors only collect those insects in groups they work with, so they can handle the material collected in an efficient manner.

In our museum, we collect a wide variety of insects using many different methods and traps. I have given a list of many of the collecting supplies and traps used by museum personnel and students below. There are additional traps and supplies, and different methods used by other collectors around the world, but this should serve as a starting point anyway. There is some overlap between supplies used for both day and night collecting; therefore those supplies are included in the same list below. Supplies for collecting aquatic insects are given after the list of terrestrial insect collecting supplies. Following the collecting supply lists, a list of different types of traps used for the collection of insects is given. Some of the supplies are more basic than others, if not necessary; however, the individual can best decide what is most useful to her or him. Not everything below is linked to a page, because it is fairly obvious what some of the supplies are for.

Collecting supplies for Terrestrial Insects

1. Collecting bag or other container
2. Insect nets
3. Collecting jars (killing jars/alcohol vials)
4. Envelopes
5. Forceps

6. Beat sheet
7. Aspirator
8. Sifter/pan (for leaf litter)
9. Bait
10. Hatchet, knife, small garden shovel or other tools
11. Permanent ink pen and label paper
12. Log book
13. GPS unit/maps
14. Camera (digital or film)
15. Sunscreen
16. Repellant

Methods of Insect Collection

- Berlese funnels. These are devices to drive insects and other arthropods out of samples of leaf litter.
- Hand netting.
- Light traps.
- Yellow pan traps.
- Pitfall traps
- Malaise traps
- Flight interception traps (also called Barrier traps)
- Lindgren funnel traps
- Bait traps (various types)
- Japanese beetle traps
- Blacklight traps
- Pan traps

1. Collecting equipment Regardless of the type of insects being sought all collectors should have a good collecting bag.
2. A photographic accessory bag with a flat, rigid bottom and a variety of compartments is ideal. However, some entomologists use fishing jackets. Six meter wide malaise traps at Keep River.

3. Collecting Methods and Equipment with equipment placed in the many pockets with which these are fitted.
4. Collectors seeking flying insects will require a net or nets whereas wingless forms may require no more than a small camel-hair water color brush and a couple of pairs of forceps. The camel hair brush can be wetted with spit, water, fixative or alcohol in order to pick up very small delicate specimens; a pair of blunt tipped or stork billed, featherweight forceps to handle larger but still fragile species, and a heavier pair with fine (but not sharp) curved ends for the more robust forms.
5. For insects to be pinned or dry-mounted, killing bottles are required while tubes or vials of fixative will be sufficient for the others.
6. Adult specimens to be taken home alive will require small, round boxes with clear plastic bases, 50 x 25 mm glass specimen tubes or glass jars, which can be lined around the inside with blotting paper.
7. Plastic bags will be required for immature stages with their food plant or host material. No collecting bag should be without a notebook and 2H pencils. If the notebook cannot be cut up for labels, paper should be carried.
8. Tissues are needed for inserting in, or cleaning, killing bottles. 5 Other equipment found in collectors bags may include an aspirator or pooter , a x10 hand lens, a sharp, strong bladed penknife (useful when collecting scale insects), a trowel for digging, a stout screwdriver or chisel for lifting bark from tree trunks, a bale hook for rolling logs, a small tomahawk, a flexible wire saw, scissors for cutting labels, plastic bags of different sizes with closures (e.g. Ziplock bags), and paper triangles or envelopes for holding certain types of specimens such as dragonflies and butterflies.
9. If specimens are to be pinned in the field, pins, entomological forceps and a relaxing box or field pinning box will be required. Some collectors carry a small plant press for specimens of host plants and leaf mines.
10. Mined leaves for rearing should be kept in separate small glass jars or plastic bags. Galls from which insects have been taken or reared should always be kept, although it is often difficult to know if the insect was the gall inducer or a later inhabitant. Collecting techniques.

11. The wet-finger method is a useful technique for collecting small, delicate insects. An open container of alcohol or fixative is held in one hand with the index finger free and positioned so it can be bent to dip into the alcohol.
12. When wishing to collect a specimen the tip of the finger is dipped into the liquid, withdrawn and moved to touch and pick up the specimen, which is then transferred directly to the liquid by once again dipping the finger into the container.
13. Larger specimens, other than moths and butterflies, can be picked up with fingers. There is no limit to the development of special techniques. For example, a recent book details a method of collecting katydids using a pair of extendable barbecue tongs fitted with tea strainers. Some hard to reach specimens have been collected by shooting them down with chloroform from a syringe fitted with a fine needle.

Practical No: 2
Identification and classification of collected specimens

The identification of insect species is largely a process of patient observation - simply paying attention to key elements will help you determine what is what? An insect key is a tool used to determine the species of a given insect. Typically, insect keys are designed as dichotomous, or paired, couplets. The process continues until the user reaches a final couplet that identifies the insect.

Studying specimens

While a good quality l0x lens will reveal a surprising amount of detail, a binocular stereomicroscope is recommended for anyone wishing to study insects. An appropriate binocular microscope should provide magnifications from 10 to 120 times, with a good lamp giving a cool, bright light. Lamps with twin fiber-optic extension arms ("light boxes") are excellent for entomological use. A compound microscope will be required for examining micro slides with magnifications of 100 to 200 times or more and preferably having phase or interference-contrast capabilities so that weakly sclerotized material can be examined in detail without the need for staining. More critical detail can be obtained with scanning electron microscopes which produce three dimensional images magnified by over 1,000 times (see below). Holding specimens under a microscope so they may be viewed from any angle without difficulty is an important consideration. Pinned specimens are difficult to position correctly but a simple device can be made from a small jar lid about 50 mm in diameter filled with a domed column of plasticize. Specimens are pinned into the top of the dome at any angle and will remain there safely even when moved about during examination. The head of the pin can be embedded in the plasticine when examining the undersides of the specimens. For specimens in liquid preservative thick layer of clean white sand or chromatographer's glass beads (50 to 80 meshes) are placed on the bottom of the examination dish. The specimen may be placed at any angle or position by distribution of the sand or beads. The specimen must always be totally submerged in its liquid preservative or distortions in the image will result. To observe extremely small liquid-preserved specimens, or parts of specimens, under a compound microscope in the correct orientation, build a fixed stack of firmly stuck together coverslips, adjacent to the center of a micro slide, to the height of the specimen and smear the top with petroleum jelly. The stack should slope very

slightly towards the center of the slide. The specimen is placed in a drop of aqueous medium or glycerol in the center of the slide and an elongate coverslip (cut to size if necessary) placed with one end on the petroleum jelly and the other touching the medium. By carefully moving the elongate coverslip the specimen can be oriented to any required position. A camera lucida attachment may be used for drawing specimens under the microscope. These are generally supplied by the microscope manufacturers in special designs for each type of microscope.

Practical No: 3
Field visits and report writing of insect fauna of different crops

Students will go for field visit to **report** observations on **insects** or plant pathogens.

Practical No: 4
Field visits for survey of different control strategies being practiced for control of insect pests

Collection, identification and mode of damage of insect pests of various crops, fruits, vegetables, stored grains and household; insecticide formulations and their uses The Field of Entomology deals with the protection of crop, stored grains, fruit trees and ornamental plants from the attack of insect pests. Besides the insects produce highly useful products such as silk, honey etc, so the field of Entomology is directly related with Sericulture and Apiculture industries.

Practical No: 5
Museum visits

Students will visit the Museum to study the **insect collections.**

Applied Entomology

Practical No: 6

Collection, identification and mode of damage of insect pests of various crops, Fruits Vegetables, Stored grains and household

Major insect pests of stored foods, two major groups of insects harbor the mostly economically important post-harvest insect pests:

Coleoptera (beetles) and Lepidoptera (moths and butterflies)

Several Coleopteran and Lepidopteran species attack crops both in the field and in store. Crop damage by Lepidoptera is only done by the larvae. Several lepidopteran larvae entangle the feeding media through silky secretion which turns products into entwined lumps. In the case of Coleoptera, both larvae and adults often feed on the crop and the two stages are responsible for the damage. Post-harvest insect pests may be primary, i.e. able to attack intact grains such as the genus Sitophilus, while others are secondary pests, attacking already damaged grains or grain products such as the genus Tribolium. The following is a list of the most common postharvest and storage pests, their biology, distribution and common host plants.

Coleoptera: The order Coleopteran is the largest order of insects and contains the most common and important stored product pests. Adults have their forewings modified as hard elytra. Beetles inhabit a wide variety of habitats and can be found almost everywhere. Those associated with stored products exhibit different behavioral types; some are primary and secondary pests feeding directly on the product, others are general scavengers, fungus feeders, wood borers or predators of other insects. Arvae lack the presence of prolegs (abdominal legs) and only possess true legs on the three thoracic segments. Larvae of a few species may also lack true legs, e.g. Sitophilus spp. Curculionidae (Snout Beetles). This is a large group of beetles that contains some of the most serious crop and stored grain pests. Members of this family are characterized by the form of the snout (rostrum) which is elongated in most species. This family contains the most destructive stored grains pests in the world: The Rice Weevil, Maize Weevil and Granary Weevil.

The first two species are major primary pests that have a virtually cosmopolitan distribution throughout the warmer parts of the world. The rice weevil mainly attacks rice and wheat in stores, while it is a serious primary pest of stored maize. However, both species are able to develop on all cereals, dried cassava and other processed food products. The two species are

morphologically identical. In Europe, the two species are replaced by the granary weevil, S. granarius, which is wingless and can be distinguished by the sculpturing on the prothorax and elytera.

Lepidoptera derived from Ancient Greek (lepís “scale” + pterón “wing”) is an order of insects that includes butterflies and moths (both are called lepidopterans). About 180,000 species of the Lepidoptera are described, in 126 families and 46 superfamilies, 10% of the total described species of living organisms. It is one of the most widespread and widely recognizable insect orders in the world. The Lepidoptera show many variations of the basic body structure that have evolved to gain advantages in lifestyle and distribution. Recent estimates suggest the order may have more species than earlier thought, and is among the four most speciose orders, along with the Hymenoptera, Diptera, and Coleoptera.

Lepidopteran species are characterized by more than three derived features. The most apparent is the presence of scales that cover the bodies, wings, and a proboscis. The scales are modified, flattened "hairs", and give butterflies and moths their wide variety of colors and patterns. Almost all species have some form of membranous wings, except for a few that have reduced wings or are wingless. Mating and the laying of eggs are carried out by adults, normally near or on host plants for the larvae. Like most other insects, butterflies and moths are holometabolous, meaning they undergo complete metamorphosis. The larvae are commonly called caterpillars, and are completely different from their adult moth or butterfly forms, having a cylindrical body with a well-developed head, mandible mouth parts, and three pairs of thoracic legs and from none up to five pairs of prolegs. As they grow, these larvae change in appearance, going through a series of stages called instars. Once fully matured, the larva develops into a pupa. A few butterflies and many moth species spin a silk case or cocoon prior to pupating, while others do not, instead going underground. A butterfly pupa, called a chrysalis, has a hard skin, usually with no cocoon. Once the pupa has completed its metamorphosis, a sexually mature adult emerges.

The Lepidoptera have, over millions of years, evolved a wide range of wing patterns and coloration ranging from drab moths akin to the related order Trichoptera, to the brightly colored and complex-patterned butterflies. Accordingly, this is the most recognized and popular of insect orders with many people involved in the observation, study, collection, rearing of, and commerce in these insects. A person who collects or studies this order is referred to as a lepidopterist.

Butterflies and moths play an important role in the natural ecosystem as pollinators and as food in the food chain; conversely, their larvae are considered very problematic to vegetation in agriculture, as their main source of food is often live plant matter. In many species, the female may produce from 200 to 600 eggs, while in others; the number may approach 30,000 eggs in one day. The caterpillars hatching from these eggs can cause damage to large quantities of crops. Many moth and butterfly species are of economic interest by virtue of their role as pollinators, the silk they produce, or as pest species.

Table 6.1: Important insect pests of tropical stored grains or grain products

COLEOPTERA	*Anobiidae*	Lasioderma serricorne (F)
	Bostrichidae	Rhyzopertha dominica (F)
	Bruchidae	Prostephanus truncatus (Horn)
	Cucujidae	Acanthoscelides obtectus (Say)
	Curculionidae	Callosobruchus spp
	Dermestidae	Zabrotes subfasciatus Boheman
	Silvanidae	Cryptolestes spp
	Tenebrionidae	Sitophilus oryzae (L)
		S. Zeamais Motschulsky
		Trogoderma granarium Everts
		Dermestes spp
		Oryzuephilus surinamensis (L)
		Tribolium castaneum (Herbs)
LEPIDOPTERA	*Gelechiidae*	Sitotroga cerealella (Olivier)
	Pyralidae	Ephestia cautella (Walker)
		Plodia interpunctella (Hubner)
		Corcyra cephalonica (Stainton)

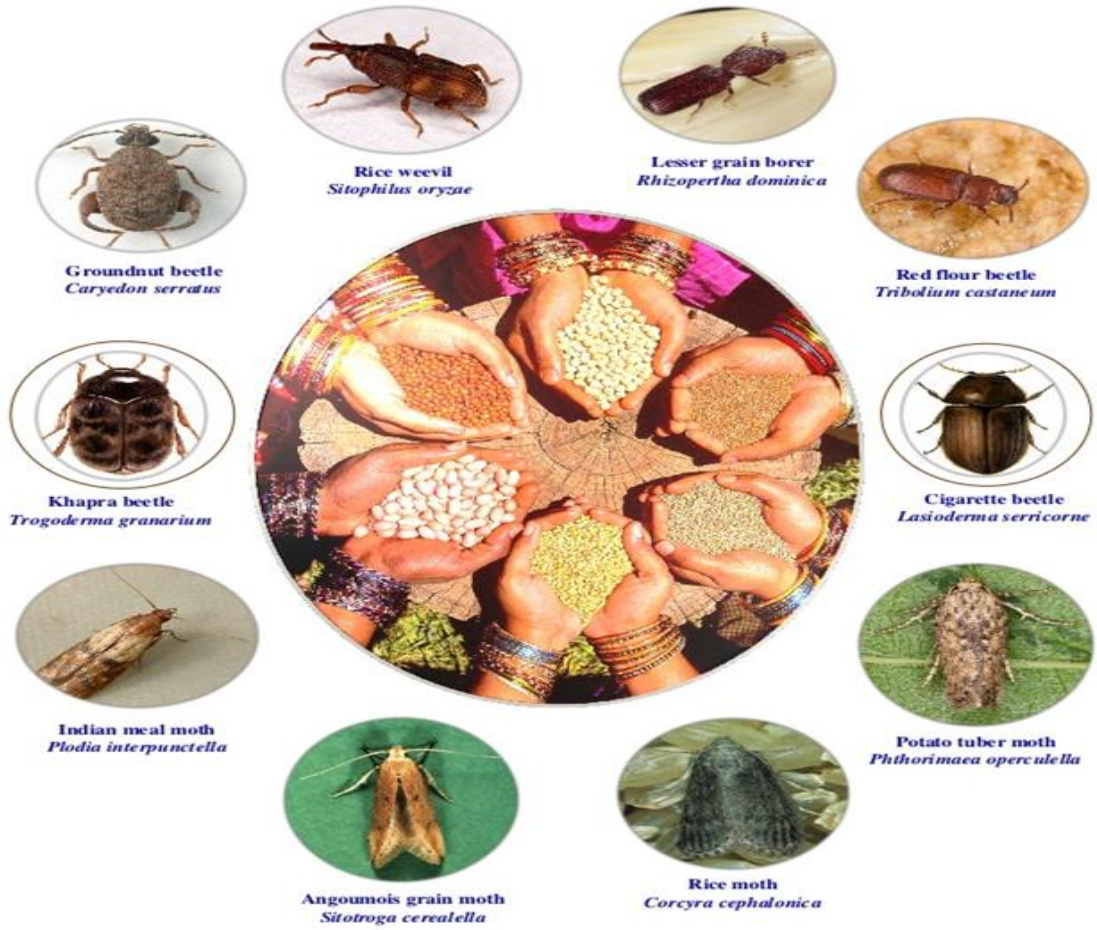

Fig 6.1: Storage grain insect pests

Insect pests of vegetables

- Aphids
- Caterpillars
- Cutworms
- Grasshoppers and locusts
- Thrips
- Weevils
- Whiteflies
- Mites

Aphids

Aphids are 1–3mm, soft-bodied insects that can be green, grey, or black. Most commonly seen in spring and autumn, aphids can be winged or wingless and are usually slow-moving. Aphids

cluster on the tips of the shoots, sucking the sap from the plant, which reduces plant vigor. Aphids can also spread viruses which can severely reduce yields and quality.

Fig 6.2: Aphids on broccoli

A number of natural enemies such as lacewings and ladybugs will give some biological control. If required, control with sprays such as garlic extract or horticultural oils and horticultural soaps. Sprays containing pyrethrum and piperonyl butoxide can also be used but crops cannot be picked for one day after its use.

Caterpillars

Caterpillars are usually the larval stages of moths or butterflies. They are normally hairless, with a long cylindrical body from 10–50mm long and range in color. Caterpillars may attack leaves, stems, flowers, fruits and roots.

Green caterpillars of the large cabbage white butterfly and the small diamond-back (cabbage) moth can severely damage the leaves of the Brassica family which includes broccoli, cabbage, kale and cauliflower. Cluster caterpillars, woolly bear caterpillars and looper caterpillars will attack the leaves of most vegetables.

Fig 6.3: The woolly bear caterpillar will eat just about anything that is green

The eggfruit caterpillar bores into aubergine and the native budworm will bore into the fruit of many vegetables, especially, capsicums, tomatoes and sweet corn. These fruit pests are hard to kill and early spraying is required to kill the caterpillars before they enter the fruits.

Other caterpillars attack the roots and stems. Potato moth caterpillars will 'mine' potato leaves and bore into potato tubers.

Cutworms

Cutworms hide in the soil by day and attack plants at night. They damage the stem of young seedlings at the base, causing the plant to collapse.

Fig 6.4: Cutworm caterpillar

Control with Bacillus thuringiensis, a biological insecticide which targets only caterpillars but needs to be sprayed every five days or after rain or overhead watering. Spinosad is a chemical of low toxicity which has a translaminar movement, which means the chemical moves into the leaf, making the active ingredient resistant to rain and sunlight once the spray has dried. Sprays

containing pyrethrum and piperonyl butoxide can also be used but crops cannot be picked for one day after spraying.

Grasshoppers and locusts

In some years, grasshoppers and locusts can appear in plagues in summer and are capable of destroying all plants.

Fig 6.5: Locust nymph

They are very hard to control as they are unlikely to eat baits until all the green vegetation is eaten. Use baits containing carbaryl.

Thrips

Thrips are 1–2mm long torpedo-shaped insects that can be yellow, green, grey, or black. Thrips suck the sap of leaves, fruit and flowers and these feeding results in white streaks on the plants.

Fig 6.6: Thrips feeding causes silvering on underside of a potato leaf

Some species are carriers of tomato spotted wilt virus. Control with garlic extract, horticultural soaps or sprays containing pyrethrum and piperonyl butoxide.

Weevils

A few species of weevils are pests, such as the garden and vegetable weevils.

At night the 10mm adults may attack stems and leaves of asparagus, beetroot, carrots, parsnips, peas, potatoes, rhubarb, silverbeet and spinach are also subject to attack. The 12mm larvae may bore into the tubers of carrots, potatoes and sweet potatoes.

Plants are more susceptible when water stressed. To reduce numbers wrap Dacron quilt wadding around the base of plants. The legs of the weevils get caught in the wadding. An alternative is to put aluminum foil or horticultural glue around the stems of plants. Weevils pupate in the soil and both these methods traps adult weevils moving up into the foliage, which interrupts the breeding cycle.

Whiteflies

Whiteflies are tiny, 1.5–2.0mm, sap-sucking insects that can damage vegetables grown in the open and in greenhouses.

Fig 6.7: White flies

Damage is worst in spring and autumn. The adults resemble small moths and fly in large numbers when disturbed. The young stages have no wings and look more like scale insects. Insects like lace-wings, ladybirds and hoverflies will feed on whiteflies.

Whiteflies can be difficult to control using pesticides. Control with sprays such as garlic extract or sprays containing pyrethrum and piperonyl butoxide. Horticultural soaps and soapy water may also reduce numbers.

Mites

Mites have eight legs compared to insects (which have six legs) and at less than 1mm in size are much smaller than most insects. Mites are sap-suckers and damage can range from stippling on the leaves of the plant, to bronzing of the stems and leaves.

Fig 6.8: Mites

They are most active in dry weather and sprays of water beneath the leaves will reduce numbers. Control with horticultural soap which should be sprayed beneath the foliage at the first sign of the mites. At night, the 10mm adults may attack stems and leaves of asparagus, beetroot, carrots, parsnips, peas, potatoes, rhubarb and silver beet.

Tomato russet mite on tomatoes

Most people are unaware of this pest because it cannot be seen with the naked eye. A lens which magnifies 20 times is needed to recognize these mites. In summer, the damage they cause is easily identified. The stems of the plant become bronzed, the lower leaves wither and die and the skin of the fruit becomes leathery.

Two-spotted mite or red spider mite

A serious summer pest of most crops, two-spotted mites are usually first noticed by the yellow stippling of the leaves, which look russetty and dry.

Fig 6.9: Two-spotted spider mite with ingested food visible in the stomach sacks

The undersides of the affected leave usually have fine webs, under which there are hundreds of small yellow to red mites about 1–2mm long and pearly eggs. The mites suck the sap of the leaves.

Other pests

Snails and slugs

These molluscs can attack most crops and chew holes in leaves and kill seedlings. They are most active at night, especially in moist weather. Control is especially important in April and May when the adults lay eggs.

Fig 6.10: Garden snail

Slaters, snails and slugs may be controlled with baits that contain methiocarb or metaldehyde. A copper silicate spray used on plants will repel the pests. Do not expose baits to children or pets.

For further information, including a recipe for organic baits, refer to the article snail and slug control.

Slaters

Slaters or woodlice are small crustaceans that hide in damp situations in the garden. Slaters feed on organic matter, but at high densities they can damage new seedlings and ripe fruit such as melons, strawberries and the roots of pot plants.

Fig 6.11: Slaters on a piece of timber

This is a list of common household pests – undesired animals that have a history of living, invading, causing damage, eating human foods, acting as disease vectors or causing other harms in human habitation.

Mammal

- Mice

Field mice

House mice

- **Rats**

Black rats

Brown rats

Wood rats

Cotton rats

- **Invertebrates**

Ants, Argentine ants, Carpenter ants, Fire ants, Odorous house ants, Pharaoh ants, Thief ants, Bed bugs, Beetles, Woodworms, Death watch beetles, Furniture beetles, Weevils, Maize weevil,

Rice weevil, Carpet beetles, Fur beetles, Varied carpet beetles, Spider beetles, Mealworm beetles, Centipedes, House centipedes, Cockroaches, Brown-banded cockroaches, German cockroaches, American cockroaches, Oriental cockroaches, Dust mites, Earwigs, Crickets, House crickets, Flies, Bottle flies, Blue bottle flies, Green bottle flies, House flies, Fruit flies, Mosquitoes, Moths, Almond moths, Indian meal moths, Clothes moths, Gypsy moths, Common clothes moths, Brown house moths, Paper Lice, Red spiders, Silverfish, Woodlice, Termites, Damp wood termites, Subterranean termites

Practical No: 7
Insecticide formulations, their dilutions and safe handling

Apesticide formulation is a combination of active and inert ingredients that forms an end-use pesticide product. Pesticides are formulated to make them safer or easier to use. This is because many pesticide active ingredients, in "pure" (technical grade) form, are not suitable for application. In their concentrated form, some are extremely toxic, many do not mix well with water, some are unstable, and some are difficult (or unsafe) to handle, transport, or store. To address these problems, manufacturers add inert ingredients to end-use pesticide products. Inert ingredients have no pesticidal activity, and some simply serve as diluents or carriers. In many cases, inert ingredients make the formulated product safer, easier to handle and apply, and/or more effective. So, in addition to the active ingredient intended to control the target pest, a formulated product may consist of: • A carrier or diluent, such as an organic solvent of mineral clay. • Surface-active ingredients, such as stickers and spreaders. • Other additives, such as stabilizers, dyes, and chemicals, which make the product safer or enhance pesticidal activity.

A = Aerosol

AF = Aqueous flowable

B = Bait

C = Concentrate

D = Dust

DF = Dry flowables

E = Emulsifiable concentrate

EC = Emulsifiable concentrate

F = Flowable

G = Granules

GL = Gel

L = Liquid

LC = Liquid concentrate

LV = Low volatile

M = Microencapsulated

P = Pellets

PS = Pellets

RTU = Ready-to-use

S = Solution

SP = Soluble powder (or soluble packet;)

ULV = Ultra-low volume

W = Wettable powder

WDG = Water-dispersible granules

WP = Wettable powder

WS = Water soluble

WSB = Water-soluble bag (water-soluble packet)

WSC = Water-soluble concentrate

WSL = Water-soluble liquid

WSP = Water-soluble powder

A pesticide formulation is a mixture of chemicals which effectively controls a pest. Formulating a pesticide involves processing it to improve its storage, handling, safety, application, or effectiveness. See the text box on Some Formulations.

Some Formulations	
A	Aerosol
B	Bait
D	Dust
DF	Dry flowable
E,EC	Emulsifiable concentrate
FL	Flowable
G	Granule
M	Microencapsulated
P	Pellet
RTU	Ready-to-use
SP	Soluble powder

ULV	Ultra-low-volume concentrate
WP	Wettable powder
WDG	Water-dispersible granule

What makes up a formulation?

The pesticide formulation is a mixture of active and other ingredients (previously called inert ingredients). An active ingredient is a substance that prevents, kills, or repels a pest or acts as a plant regulator, desiccant, defoliant, synergist, or nitrogen stabilizer.[4] Pesticides come in many different formulations due to variations in the active ingredient's solubility, ability to control the pest, and ease of handling and transport.

Synergists are a type of active ingredient that are sometimes added to formulations. They enhance another active ingredient's ability to kill the pest while using the minimum amount of active ingredient, but do not themselves possess pesticidal properties. For example, insecticides containing the active ingredient pyrethrins often contain piperonyl butoxide or n-octyl bicycloheptane dicarboximide as a synergist.

Other (or inert) ingredients may aid in the application of the active ingredient. Other ingredients can be solvents, carriers, adjuvants, or any other compound, besides the active ingredient, which is intentionally added. There are many types of other ingredients: solvents are liquids that dissolve the active ingredient, carriers are liquids or solid chemicals that are added to a pesticide product to aid in the delivery of the active ingredient, and adjuvants often help make the pesticide stick to or spread out on the application surface (i.e., leaves). Other adjuvants aid in the mixing of some formulations when they are diluted for application.

Dry or Solid Formulations

Dry formulations can be divided into two types: ready-to-use and concentrates that must be mixed with water to be applied as a spray. This section will present more detailed information about the common dry or solid pesticide formulations.

Dusts (D)

Most dust formulations are ready to use and contain a low percentage of active ingredients (usually 10% or less by weight), plus a very fine, dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles varies. A few dust formulations

are concentrates and contain a high percentage of active ingredients. These concentrates are mixed with dry inert carriers before applying.

Dusts are always used dry and can easily drift to nontarget sites. They are widely used as seed treatments and sometimes for agricultural applications. In structures, dust formulations are used in cracks and crevices and for spot treatments to control insects such as cockroaches. Insects ingest poisonous dusts during grooming or absorb the dusts through their outer body covering. Dusts also are used to control lice, fleas, and other parasites on pets and livestock.

Advantages of dust formulations include:

Most are ready to use, with no mixing

Effective where moisture from a spray might cause damage

Require simple equipment

Effective in hard-to-reach indoor areas

Their disadvantages:

Easily drift off target during application

Residue easily moved off target by air movement or water

May irritate eyes, nose, throat, and skin

Will not stick to surfaces as well as liquids

Dampness can cause clogging and lumping

Difficult to get an even distribution of particles on surfaces

Special dusts, known as tracking powders, are used for monitoring and controlling rodents and insects. For rodent control, the tracking powder consists of finely ground dust combined with a stomach poison. Rodents walk through the dust, pick it up on their feet and fur, and ingest it when they clean themselves. Tracking powders are useful when bait acceptance is poor because of an abundant, readily available food supply. Nontoxic powders, such as talc or flour, often are used to monitor and track the activity of rodents in buildings.

Baits (B)

A bait formulation is an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Federal regulations require that certain rodenticide baits must be contained in tamper-resistant bait stations. Pests are killed by eating the bait that contains the pesticide. The amount of active ingredient in most bait formulations is quite low, usually less than 5%. Baits are used inside buildings to control ants,

roaches, flies, other insects, and rodents. Outdoors they sometimes are used to control snails, slugs, and insects such as ants and termites. Their main use is for control of vertebrate pests such as rodents, other mammals, and birds.

Advantages of baits include:

Ready to use

Entire area need not be covered because pest goes to bait

Control pests that move in and out of an area

Their disadvantages:

Can be attractive to children and pets

May kill domestic animals and nontarget wildlife outdoors

Pest may prefer the crop or other food to the bait

Dead vertebrate pests may cause odor problem

Other animals may be poisoned as a result of feeding on the poisoned pests

If baits are not removed when the pesticide becomes ineffective, they may serve as a food supply for the target pest or other pests

Laws require that outdoor, above-ground placement of certain rodenticide bait products be contained in tamper-resistant bait stations

Pastes and gels are mainly used in the pest control industry for ants and cockroaches. Insecticides formulated as pastes and gels are now the primary formulations used in cockroach control. They are designed to be injected or placed as either a bead or dot inside small cracks and crevices of building elements where insects tend to hide or travel. Two basic types of tools are used to apply pastes and gels: syringes and bait guns. The applicator forces the bait out of the tip of the device by applying pressure to a plunger or trigger.

Granules (G)

Granular formulations are similar to dust formulations except granular particles are larger and heavier. The coarse particles are made from materials such as clay, corncobs, or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from less than 1 to 15 percent by weight.

Granular pesticides are most often used to apply chemicals to the soil to control weeds, fire ants, nematodes, and insects living in the soil or for absorption into plants through the roots (Figure

13). Granular formulations are sometimes applied by airplane or helicopter to minimize drift or to penetrate dense vegetation. Once applied, granules release the active ingredient slowly. Some granules require soil moisture to release the active ingredient. Granular formulations also are used to control larval mosquitoes and other aquatic pests. Granules are used in agricultural, structural, ornamental, turf, aquatic, right-of-way, and public health (biting insect) pest control operations.

Advantages of granular formulations include:

- Ready to use, no mixing
- Drift hazard is low, and particles settle quickly
- Little hazard to applicator; no spray, little dust
- Weight carries the formulation through foliage to soil or water target
- Simple application equipment needed, such as seeders or fertilizer spreaders
- May break down more slowly than WPs or ECs because of a slow-release coating

Their disadvantages:

- Often difficult to calibrate equipment and apply uniformly
- Will not stick to foliage or other uneven surfaces
- May need to be incorporated into soil or planting medium
- May need moisture to activate pesticide
- May be hazardous to nontarget species, especially waterfowl and other birds that mistakenly feed on the seed-like granules
- May not be effective under drought conditions because the active ingredient is not released in sufficient quantity to control the pest

Pellets (P or PS)

Most pellet formulations are very similar to granular formulations; the terms often are used interchangeably. In a pellet formulation, however, all the particles are the same weight and shape (Figure 14). The uniformity of the particles allows use with precision application equipment. A few fumigants are formulated as pellets; some may be referred to as tablets (Figure 15). However, these are clearly labeled as fumigants. Do not confuse them with nonfumigant pellets.

Fig 7.1: Pellet formulation: Fumigant formulated as tablets (pellets)

Wettable Powders (WP or W)

Wettable powders are dry, finely ground formulations that look like dusts (Figure 16). They usually must be mixed with water for application as a spray. A few products, however, may be applied either as a dust or as a wettable powder; the choice is left to the applicator. Wettable powders contain 5%–95% active ingredient by weight, usually 50% or more. The particles do not dissolve in water. They settle out quickly unless constantly agitated to keep them suspended. Wettable powders are one of the most widely used pesticide formulations. They can be used for most pest problems and in most types of spray equipment where agitation is possible. Wettable powders have excellent residual activity. Because of their physical properties, most of the pesticide remains on the surface of treated porous materials such as concrete, plaster, and untreated wood. In such cases, only the water penetrates the material.

Fig 7.2: Undiluted and diluted wet table powder formulation.

Advantages of wet table powders include:

Easy to store, transport, and handle

Less likely than ECs and other petroleum-based pesticides to cause unwanted harm to treated plants, animals, and surfaces

Easily measured and mixed

Less skin and eye absorption than ECs and other liquid formulations

Their disadvantages:

Inhalation hazard to applicator while measuring and mixing the concentrated powder

Require good and constant agitation (usually mechanical) in the spray tank or will quickly settle out if the agitator is turned off

Abrasive to many pumps and nozzles, causing them to wear out quickly

Difficult to mix in very hard, alkaline water

Often clog nozzles and screens

Residues may be visible on treated surfaces

Soluble Powders (SP or WSP)

Soluble powder formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily and form a true solution. After they are mixed thoroughly, no additional agitation is necessary. The amount of active ingredient in soluble powders ranges from 15% to 95% by weight; it usually is more than 50%. Soluble powders have all the advantages of wettable powders and none of the disadvantages except the inhalation hazard during mixing. Few pesticides are available in this formulation because few active ingredients are readily soluble in water.

Water-Dispersible Granules (WDG) or Dry Flowables (DF)

Water-dispersible granules, also known as dry flowables, are like wettable powders except instead of being dustlike, they are formulated as small, easily measured granules (Figure 17). Water-dispersible granules must be mixed with water to be applied. Once in water, the granules break apart into fine particles similar to wettable powders. The formulation requires constant agitation to keep them suspended in water. The percentage of active ingredient is high, often as much as 90 percent by weight. Water-dispersible granules share many of the same advantages and disadvantages of wettable powders except:

- They are more easily measured and mixed
- Because of low dust, they cause less inhalation hazard to the applicator during handling

Fig 7.3: Undiluted and diluted dry flowable formulation

Other Formulations

Other formulations include chemicals that cannot be clearly classified as liquid or as dry/solid pesticide formulations.

Microencapsulated Materials (M or ME)

Manufacturers cover liquid or dry pesticide particles in a plastic coating to produce a microencapsulated formulation. Microencapsulated pesticides are mixed with water and sprayed in the same manner as other sprayable formulations. After spraying, the plastic coating breaks down and slowly releases the active ingredient. Microencapsulated materials have several advantages:

- Highly toxic materials are safer for applicators to mix and apply
- Delayed or slow release of the active ingredient prolongs its effectiveness, allowing for fewer and less precisely timed applications
- The pesticide volatilizes more slowly; less is lost from the application site

In residential, industrial, and institutional applications, microencapsulated formulations offer several advantages. These include reduced odor, the release of small quantities of pesticide over a long time, and greater safety. Microencapsulated materials offer fewer hazards to the skin than ordinary formulations. Microencapsulated materials, however, pose a special hazard to bees. Foraging bees may carry microencapsulated materials back to their hives because they are about the same size as pollen grains. As the capsules break down, they release the pesticide, poisoning the adults and brood.

Breakdown of the microencapsulated materials to release the pesticide sometimes depends on weather conditions. Under certain conditions, the microencapsulated materials may break down more slowly than expected. This could leave higher residues of pesticide active ingredient in

treated areas beyond normal restricted-entry or harvest intervals with the potential to injure fieldworkers. For this reason, regulations require long restricted-entry intervals for some microencapsulated formulations.

Water-Soluble Packets (WSB or WSP)

Water-soluble packets reduce the mixing and handling hazards of some highly toxic pesticides (Figure 18). Manufacturers package precise amounts of wettable powder or soluble powder formulations in a special type of plastic bag. When you drop these bags into a filled spray tank, they dissolve and release their contents to mix with the water. There are no risks of inhaling or contacting the undiluted pesticide as long as you do not open the packets. Once mixed with water, however, pesticides packaged in water-soluble packets are no safer than other diluted pesticides.

Fig 7.4: Water-soluble packet dissolves in the tank.

Attractants

Attractants include pheromones, sugar and protein syrups, yeasts, and rotting meat. Pest managers use these attractants in various types of traps (Figure 19). Attractants also can be combined with pesticides and sprayed onto foliage or other items in the treatment area.

Fig 7.5: Insect cone trap containing pheromone

Impregnated Products

Manufacturers impregnate (saturate) pet collars, livestock ear tags, adhesive tapes, plastic pest strips, and other products with pesticides (Figure 20). These pesticides evaporate over time, and the vapors provide control of nearby pests. Some paints and wood finishes have pesticides incorporated into them to kill insects or retard fungal growth. Fertilizers also may be impregnated with pesticides.

Fig 7.6: Cattle ear tag impregnated with insecticide.

Repellents

Various types of insect repellents are available in aerosol and lotion formulations. People apply these to their skin or clothing or to plant foliage to repel biting and nuisance insects. You can mix other types of repellents with water and spray them onto ornamental plants and agricultural crops to prevent damage from deer, dogs, and other animals.

Animal Systemics

Systemic pesticides protect animals against fleas and other external blood-feeding insects as well as against worms and other internal parasites. A systemic animal pesticide is one that is absorbed and moves within the animal. These pesticides enter the animal's tissues after being applied orally or externally. Oral applications include food additives and premeasured capsules and liquids. External applications involve pour-on liquids, liquid sprays, and dusts. Most animal systemics are used under the supervision of veterinarians.

Pesticide/Fertilizer Combinations

Pest managers frequently use insecticides, fungicides, and herbicides in combination with fertilizers. This provides a convenient way of controlling pests while fertilizing crops or lawns. Homeowners commonly use these combinations, although the unit cost of pesticide in these

formulations is usually high. Dealers or growers often custom-mix pesticides with fertilizers to meet specific crop requirements.

Fumigants

Fumigants are pesticides that form gases or vapors toxic to plants, animals, and microorganisms. Some active ingredients are formulated, packaged, and released as gases (Figure 21); others are liquids when packaged under high pressure and change to gases when they are released. Other active ingredients are volatile liquids when enclosed in an ordinary container and, therefore, are not formulated under pressure. Others are solids that release gases when applied under conditions of high humidity or in the presence of water vapor. Fumigants are used for structural pest control, in food and grain storage facilities, and in regulatory pest control at ports of entry and at state and national borders (Figure 22). In agricultural pest control, fumigants are used in soil, greenhouses, granaries, and grain bins (Figure 23).

Fig 7.7: A: Gaseous fumigant stored under pressure. B: Structural fumigation of a dormitory on UF campus C: Soil fumigant application.

Advantages of fumigants:

• Toxic to a wide range of pests

• Can penetrate cracks, crevices, wood, and tightly packed areas such as soil or stored grains

• Single treatment usually kills most pests in treated area

Disadvantages of fumigants:

• The target site must be enclosed or covered to prevent the gas from escaping

• Nonspecific in that they are highly toxic to humans and all other living organisms

• Require the use of specialized protective equipment, including respirators specifically approved for use with fumigants

• Require the use of specialized application equipment

Adjuvants

Adjuvants are substances used with a pesticide to enhance performance. By themselves, they do not possess pesticidal activity. Adjuvants may be added to the product at the time of formulation or by the applicator to the spray mix just prior to treatment. Adjuvants include surfactants, compatibility agents, and antifoaming agents and spray colorants (dyes), and drift control agents.

Much of the confusion surrounding adjuvants can be attributed to the lack of understanding of adjuvant terminology. For example, many people use the terms adjuvant and surfactant interchangeably. These terms can refer to the same product because all surfactants are adjuvants. However, not all adjuvants are surfactants.

Care should be taken when selecting an adjuvant. Pesticide performance can differ depending on what type of adjuvant is used. The pesticide label will state if specific surfactants are required and the amount (%) of active ingredient it must contain.

Safety to people, animals and the environment

- Individuals who apply, handle, transport, or dispose of pesticides should know the proper manner in which to deal with them. Safety gear is important to minimize potential exposure to pesticides during an application. An applicator's proper personal protective equipment (PPE) may include a long sleeve shirt, pants, closed-toe shoes, chemically resistant rubber gloves, a respirator, and/or eye protection. The equipment required for an application will be listed on the label.
- In addition to the safety of those working with pesticides, the safety of people, pets, and the environment near the site of application need to be taken into account. To facilitate this, the label often has precautionary statements to protect wildlife and other non-target species.

Practical No: 8
Use of application equipment, instructions for apiculture, sericulture and lac-culture

Beekeeping equipment

A period of over a century of widespread movable-frame beekeeping with the common honeybee *Apis mellifera* in many parts of the world has resulted in the development and marketing of virtually all types and sizes of beekeeping equipment. Many innovations in design, and the use of different materials, enable beekeepers to select their equipment according to their own needs and preferences, but certain standard appliances and items of equipment are required in almost any type of beekeeping operation.

It is of great importance that the hive equipment used in any one apiary be of standard size under the Anglo-American or metric system 1/ not only because standardization of equipment offers beekeepers operating convenience and high resale value, but also because most of the supplies and appliances available commercially are tailored to fit standard size designs.

1. **Hive Bodies and Supers**

Properly speaking, the expression "hive body" refers to the box containing brood frames, whereas a "super" is a box placed above the hive body to accommodate frames containing combs of honey. The standard hive body is 9 1/2" (238-240 mm) high. Many beekeepers often use hive bodies as full-depth supers, but the height of supers can vary from full-depth (= standard hive body) through "honey supers"(3/4depth = 7 1/2" or 185 mm) to "section supers" (1/2-depth = 4 3/4" or 133 mm).

Since the dimensions of the Langstroth hive were originally established in the Anglo-American system. Whereas a number of countries in Asia currently use the metric system, the sizes of equipment discussed in this chapter are presented in both systems. It should be borne in mind however that the metric-system figures are not derived directly from the Anglo-American, but refer to similar (but not identical) measurements in general use in countries where the metric system has been adopted.

The width and length of standard 10-frame hive bodies and supers are 16 1/4" x 19 314" (405 x 505 mm) outer measurements and 14 3/4" x 18 1/2" (365 x 465 mm) inner measurements.

Running along the upper inner rim of the width of the box, a recess of 3/8" x 5/8" (10 x 13 mm), known as the "rabbet" or "rebate", serves to hold the top-bars of the free-hanging frames inside.

Wood is the material most generally preferred for hive construction, offering durability, flexibility and convenience, as well as improving the colony's efficiency in regulating hive interior temperature and humidity. Bodies and supers painted externally will last longer than those without paint; white is the colour generally preferred for its action in radiating direct heat from the sun.

Wooden hive bodies and supers should he built to be as strong as possible. The weakest points in the hive's architecture are the corners of the boxes. The three basic ways of making corner joints (box corner, special box corner and dove-tail joints) are illustrated.

2. **Hive Cover**

The outer cover is essentially the roof of the hive. It should be long-lasting and provide good insulation for the bees. Most beekeepers prefer telescoping covers fitted with sheet metal or aluminum.

In some areas, an inner lid or cover is used in addition to the outer cover. In severe weather, it assists in insulating the interior of the hive. Inner covers are commonly made of boards, plywood or Masonite in a wooden frame.

3. **Bottom Board**

The bottom board, the floor of the hive, is built to fit the hive body. In order to provide a landing board for the bees, the length is extended past the front of the hive body for about 2 (50 mm), so that the total length of the bottom board is 22 (555-560 mm). The board consists of a flat floor mounted on side-rails. An entrance reducer is generally used at the front of the hive to permit alteration of the size of the hive entrance.

4. **Frames**

The concept of movable frames in box hives is the noblest innovation in beekeeping. The basic function of such frames is to hold individual combs firmly in place, so that the entire comb can be moved while remaining intact.

A frame consists basically of a top-bar, two end-bars and a bottom-bar, nailed together. Since the frames must fit the supers, and these are of uniform length, the top-bars of all frames must be 19" (482 mm) long; they are 3/4" (16 mm) thick and I 1/16" (25 mm) wide. The height of the end-her reflects the depth of the super: 9 1/8" (230 mm), 7 1/4" (175 mm) and 4 1/2" (125 mm) for full-

depth, three-quarter depth and half-depth respectively. End-bars are 1 3/8" (33 mm) wide and 3/8" (10 mm) thick. The bottom-her is 17 5/8" (450 mm) long, 3/4" (25 mm) wide and 3/8" (10 mm) thick. When these elements are assembled, both ends of the top-bar protrude so that the frame can rest on the rabbet.

5. **Comb Foundation**

The invention of comb foundation for use with movable frames marks another milestone In the history of beekeeping. Comb foundation is a thin sheet of beeswax stamped with a pattern of hexagons of a size equal to the base of natural brood cells. Providing beeswax foundation accelerates comb construction, thus making better honey harvests possible. It also leads the bees to construct comb whose cells are of a uniform size.

The overall dimensions of comb foundations available on the market are calculated to fit standard frame sizes: full-depth, three-quarter depth or half-depth. While foundation types vary, medium-brood plain foundation offers reasonably good performance under normal conditions. As a rule, foundation is fixed to the frames by being mounted on four fine but strong wires, threaded through holes in the end-bars and stretched tight. A spur embedder or an electrical heating device is used to embed the wires into the comb foundation.

Making comb foundation is a complicated task, requiring not only skill and experience but also a costly foundation mill, preferably of the type composed of two precision-engraved rollers, used by manufacturers. While a few large-scale beekeeping operators and cooperatives may be in a position to own such a mill, most beekeepers find it more convenient to buy their foundation ready-made.

Fig 8.1: Comb foundation in field

Fig 8.2: Comb foundation in field

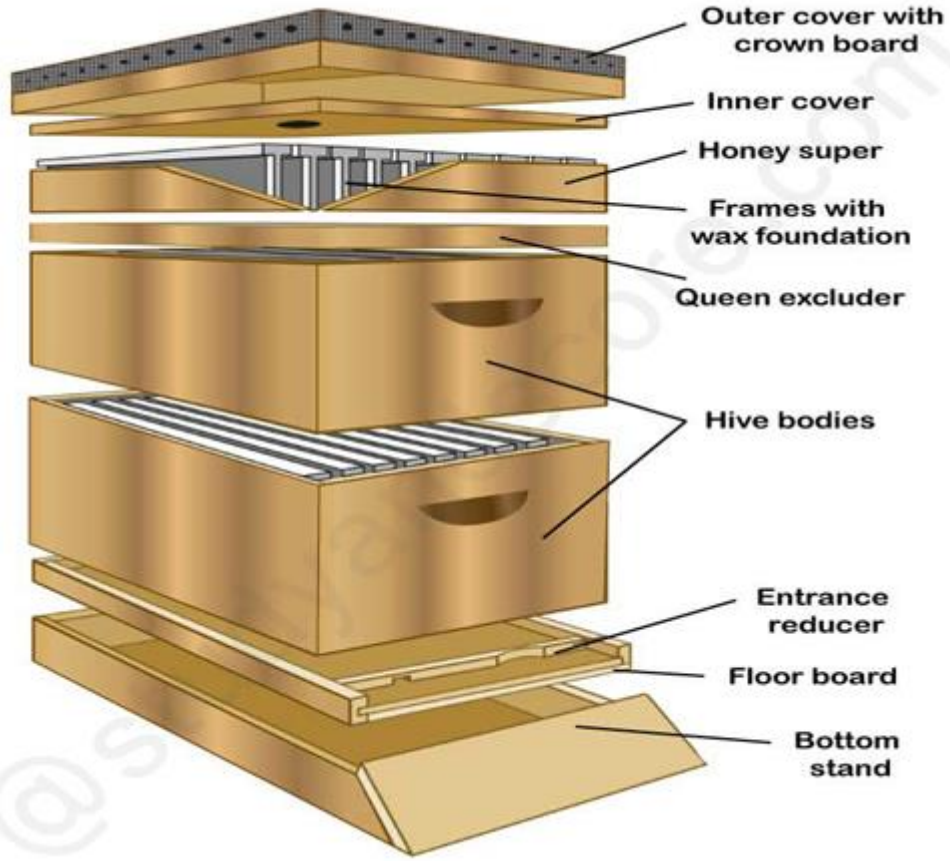

Fig 8.3: Modern method of apiculture: Moveable artificial hive

6. **Other Hive Equipment**

Pollen Trap: As its name implies, the pollen trap is used to scrape pollen pellets from the legs of foragers as they return to the hive; it is convenient for beekeepers who wish to obtain surplus pollen for sale or for feeding bees during the dearth period. When a pollen trap is set at the hive entrance, returning foragers have no way of entering the hive but to pass through the trap. As they do so, the pollen pellets attached to their hind legs are scraped off and fall into a receiving tray.

Queen Excluder: The purpose of the queen excluder is to confine the queen to the brood box while allowing the workers to have access to the super, in order to ensure that the honey combs contain no brood. It is also used in producing royal jelly, in queen-rearing and in forming multi-queen colonies. Based on the fact that the bodies of workers are much smaller than that of the queen, it consists of a single sheet with openings large enough to allow the former to pass through, but too narrow for the queen. The conventional excluder is designed to be inserted horizontally between the super and the brood box of a multi-story hive, but vertical models also exist that can be placed between frames of brood and honeycomb in single-story hives.

Feeder: At certain times of the year the beekeeper may wish to feed his colonies with sugar syrup as a food supplement or to medicate them using syrup as a carrier. Among various types of feeders existing, two simple models can be recommended: the division-board feeder and the feeding pail or, jar.

In the broad sense, the division-board feeder is a rectangular syrup container whose length is the same as that of a frame; it is designed to be placed within the hive in the same manner as a frame. To prevent the bees from drowning, chips of wood or Styrofoam are placed in the feeder as floats.

Alternatively, plastic or glass pails or jars holding from 2 to 4 litres of liquid can be used as feeders, provided that they have relatively large and tight-fitting lids in which small holes can be pierced. When in use, the pail containing the sugar syrup is turned upside down and placed on the frames, allowing the syrup to seep through the holes. An empty super is installed between the hive cover and the honey chamber, in order to close the hive.

Hive Tool. Honeybees use propolis to seal frames and covers to hive bodies and supers. In order to separate these various pieces (e.g. to open the hive or remove a frame for inspection) the beekeeper prizes them apart with a hive tool, which is also useful in scraping excess propolis or

wax from hive parts. It is such a convenient piece of equipment that virtually all beekeepers carry one in their hand when working with their hives. It consists basically of a length of iron or steel, flattened at one end. A good commercial hive tool may be made of spring steel, but the sawn-off end of a crowbar can furnish equally satisfactory leverage.

Smoker: The bee smoker, used to calm bees, consists of two principal units: a metal fire-pot with a funnel-shaped cover, and a bellows. Some good models are equipped with a shield for protection against the heat generated. A smoke-releasing fuel (e.g. dried leaves. grasses, wood shavings, rice hulls, etc.) is burned in the fire-pot, and air is injected into the pot by operating the bellows; the smoke is then directed at the bees through the funnel.

Bee Brush: A soft camel-hair brush, used to brush the bees off combs and supers being manipulated, is considered one of the most necessary tools for harvesting frames of honey comb, particularly in small-scale beekeeping. In less sophisticated operations, a handful of grass or leaves may be used.

7. **Protective Equipment**

Bee Veil: Every beekeeper accepts that he will be stung many times during a season. However, no one likes being stung on the face, especially near such sensitive parts as the nose and eyes, and therefore wearing a bee veil is essential when honeybees are being handled. Such veils should be made to fit snugly around the hat or to cover the head, and to fit tightly to the shoulder, leaving enough space between the veil and the face. Black screen is preferred for the veil, since it provides the best visibility; 12-mesh screen wire or fabric are the preferred materials. Apart from the black screen, all parts of the veil, including the hat if one is worn, should be light in colour, to avoid antagonizing the trees and because such colours are cooler. When a hat is worn, it should have a wide brim.

Protective Clothing: No specific design of protective clothing for beekeepers exists, but white overalls are occasionally worn. Most clothing suitable for field work is also suitable for beekeeping, although light-coloured, smooth materials such as cotton are preferable because they are cooler and create less risk of antagonizing the bees. Beginning beekeepers may feel more secure in handling bees if they are wearing gloves, although experienced ones wear gloves only under extreme conditions. Bee gloves are made of tightly-knit cloth and/or soft leather; they cover the forearms up to the elbows.

Fig 8.4: Protective clothing in the field

8. **Uncapping and Extracting Equipment**

The basic equipment required for extracting honey from the comb consists of an uncapping knife, a honey extractor, a honey strainer, a wax melter and storage containers. The beekeeper should of course select equipment whose type and capacity are best suited to his needs.

Uncapping Knife: Worker bees seal honey-storage cells with a thin layer of wax, known as capping, which must be removed from the combs as a first step in honey extraction. Although normal long-bladed kitchen knives can be used for this purpose, the operation can be carried out with greater ease if heated knives are used. The beekeeper may use two knives and plunge them alternately in hot (preferably boiling) water, or he may decide to obtain a specially designed electrically heated knife or steam knife.

Honey Extractor: It has been estimated that in making 1 kg of wax for building comb, the bees consume 8 kg of honey. The honey extractor makes it possible for the beekeeper to save the comb for re-use by the bees and to increase his honey crop accordingly.

Basically, the honey extractor is a device that spins the combs so rapidly (up to 300 rpm) that the honey is flung out of them by centrifugal force. Different types and sizes are available, ranging from the motor-operated extractor accommodating hundreds of frames to the manually-operated two-frame extractor. Normally, the beekeeper working with several hundred hives will find a hand-operated extractor adequate for his needs; stainless steel models although somewhat more costly than those built of other materials, seem to offer enough advantages in their operation to justify the higher price.

Honey Strainer. After its extraction from the combs, honey is passed through a strainer to remove impurities. A large funnel lined with layers of cheese-cloth or fine wire mesh can serve the purpose in small apiaries, but larger operators may find it preferable to own a compact honey strainer, consisting of two or three "baskets" of different mesh sizes, fitted one within the other. Honey passes through the innermost, 12-mesh, basket and then through one or two others with finer meshes. Such strainers work well for most beekeeping operations.

Fig 8.4: Honey strainer

Fig 8.5: Honey strainer

Storage Container: Honey is a delicate, perishable product, and after it has been extracted and strained it must be properly stored. The beekeeper should be aware of some of its special properties: it can absorb moisture from the air, it reacts with metals, it changes colour if exposed to light over long periods, and its taste changes on heating, so that it must be neither heated nor stored in an excessively warm room.

If it is not bottled for sale immediately after extraction, honey should he stored in clean, noncorroding, tightly-sealed containers strong enough to withstand its weight (honey is about 1 1/2 times the weight of water). Glass-lined steel drums, off-white opaque heavy-duty polyethylene cans, and lacquer-coated or galvanized-iron cans are among the popular containers used.

Wax Melter: Beeswax is a valuable hive product, and it should be melted down with care. The equipment used in rendering it from cappings and broken combs, after all surplus honey has been extracted from them, includes solar wax melters, steam chests and presses. Since the first two of these can only recover from a third to half of the wax contained in the residue, a press is needed to obtain as much of the remaining wax as possible; steam-heated, underwater, screw-type or hydraulic presses are used for this purpose.

Sericulture Equipment – Consumables

Sericulture, or **silk farming**, is the cultivation of silkworms to produce silk. Although there are several commercial species of silkworms, Bombyx mori (the caterpillar of the domestic silkmoth) is the most widely used and intensively studied silkworm. Silk was believed to have first been produced in China as early as the Neolithic Period. Sericulture has become an important cottage industry in countries such as Brazil, China, France, India, Italy, Japan, Korea, and Russia. Today, China and India are the two main producers, with more than 60% of the world's annual production.

- **Equipment** for the mulberry plantation. (Agricultural machinery for cultivation, irrigation, pruning etc)
- **Equipment** for the Sericulture Unit.
- (Perforated Silkworm paper, special chemicals, cleaning and disinfecting products etc)
- **Equipment** for Fresh Cocoon processing.

Rearing House

- A separate house is ideal for rearing of silkworm

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

Important principles

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

Avoid

- Damp condition
- Stagnation of air
- Direct and strong drift of air
- Exposure to bright sun light and radiation

Ensure

- An equable temperature and humidity
- Good ventilation

Features

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

Preparation of rearing house

- Rearing room is to be kept ready after disinfection at least 3-4 days in advance of commencement of rearing.

- Preconditioning of the rearing house is essential i.e., arrangement of rearing appliances and provision of essential environmental conditions one day in advance.

Preparation for brushing

- Before commencement of each rearing, the rearing equipment's and rearing houses must be thoroughly washed and disinfected with chlorine dioxide.
- Chlorine dioxide is sprayed on equipment, walls, roof and floor uniformly to destroy the disease causing organisms.
- The rooms should be kept closed for about 24 hours after disinfection.
- The doors and windows should be kept open at least for 24 hours before commencement of rearing to avoid traces of disinfectants.
- To disinfect rearing room and rearing appliances, chlorine dioxide can be used. 500 ml of chloride dioxide is mixed with 50 g of activator and this is dissolved in 20 liters of water. To this, 100 g of lime powder has to be mixed.

Rearing appliances

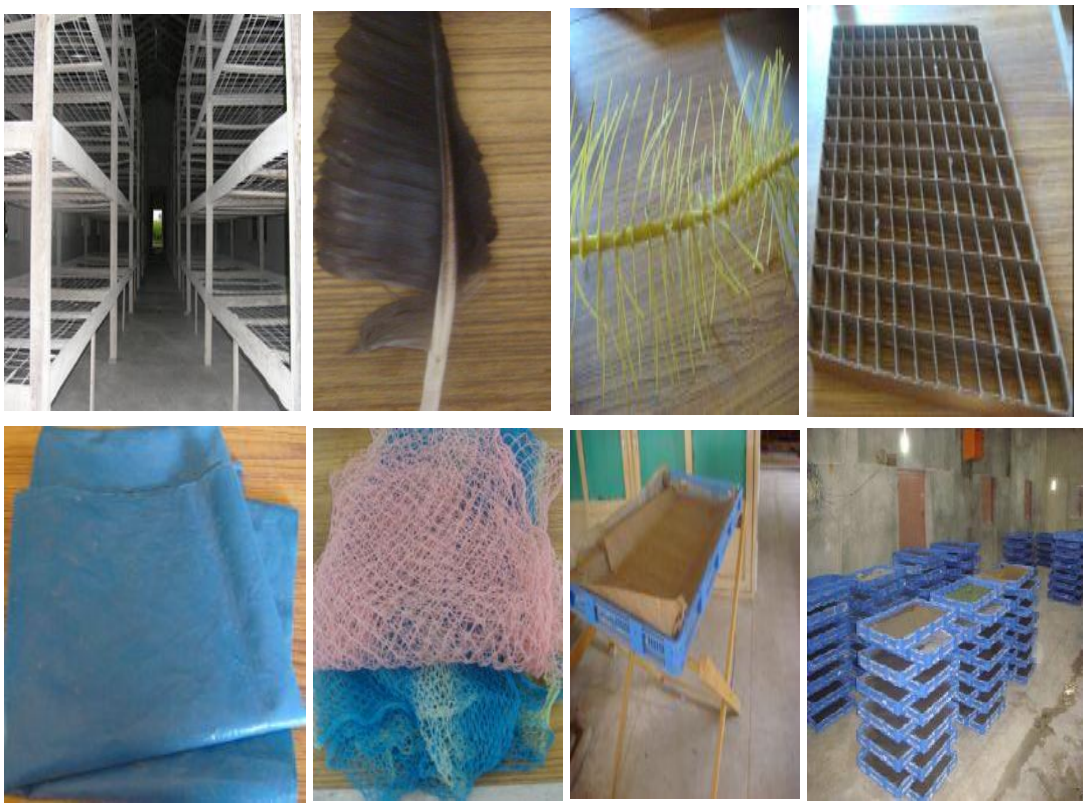

Fig 8.5: Brushing instruments

Non recurring (General)

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

Non-recurring (specific)

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

- Foam pads
- Foot rugs
- Leaf chamber for late age
- Leaf basket
- Cleaning nets

Recurring

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

Commercial Production of Lac

Lac cultivation is a complicated process. Proper care of the host plants, the propagation process and the collection of lac are the prominent steps in the cultivation of lac. The following are the process involved in the cultivation of lac:

1. Selection of site and the host plants
2. Pruning
3. Inoculation
4. Swarming
5. Harvesting of lac

Selection of site and the host plants

The selection of suitable host plants is of primary importance in lac cultivation as the quality and yield of the lac is directly proportional to the host plant number. The host plants include Babul, Pipal, Palas, Kusum, Khair etc. So, the site for the cultivation should have more and more numbers of the host plants.

The host plants must be quick growing, have low sap density, able to withstand heavy infestation of the lac insects. Of all the plants stated above, the lac from the host plant Kusum (Schleichera trijuga) attracts highest price in the market. Then

comes the host plants like Palas (Butea frondosa), Ber (Zizyphus jujuba), sirrus (Albizzia lebbak)

Pruning

The time of pruning also plays a prominent role in lac production. During pruning, proper care of the host plant is needed so that the host plants do not loose health, nutrition and also produce better quality and quantity of lac.

Pruning is generally done 6-12 months before inoculation of lac insect. The normal time of pruning is January-February if inoculation is to be done in June-July and pruning time is April-May is inoculation is to be done in October-November. The following points must be taken care of during pruning:

- Avoid excessive pruning. This helps in maintaining general health and strength of the tree.
- Cut only old branches of the host plant. Branches more than two inches of diameter must not be cut.
- Allow good shape of the tree to allow plenty of room for the growth of new shoots.
- Cut thin branches close to the trunk from which they arise.
- Remove dead and diseased branches
- Cut the split or broken branches below the split or break
- Avoid indiscriminate cutting of the lac bearing branches.

Inoculation

Inoculation is the first step in the cultivation of the lac insect. It is the process whereby the young ones get associated properly with the host plants. Inoculation can be done in two ways namely, natural inoculation or artificial inoculation.

Natural inoculation takes place in normal routine and it is very simple process where the swarmed larvae infect and suck out the sap from the same host plant again. On the other hand in artificial inoculation the twigs bearing the insect larvae which are about to swarm are cut. These cut pieces are tied to fresh trees so that the larvae swarm out to the new host plant. Artificial inoculation is generally considered to check all possible drawbacks of natural inoculation.

Swarming

Swarming is the important phase of the lac insect. At the time of swarming, the upper surface has yellow spot on the anal region. At this stage, the muscles contract and insect gets detached from the place of attachment. This leaves a hollow cavity which is later filled with resin. The exact time of swarming can be learned by experience.

Harvesting of lac

The process of collecting ready lac from host tree is known as harvesting. Harvesting can be of following two types:

Immature harvesting

Harvesting of the lac even before swarming is called immature harvesting. The lac thus obtained is called as Ari lac. This process has few drawbacks as the insects may be destroyed during harvesting and this will leave the cultivators in great loss. Ari lac harvesting is recommended only on Palas host plants.

Mature harvesting

Harvesting of the lac after swarming is called mature harvesting. The lac thus collected is called as mature lac. The largest yield of lac is obtained by harvesting twigs with the females still living. Harvesting can be done twice a year. The twig bearing the lac along with the eggs is called brood lac stick and the lac is called as brood lack or stick lac.

PROCESSING OF LAC

- Processing is done, after harvesting of the lac from the host plants. Processing starts with the scraping of the stick lac from the twig. Now this scrapped lac must be cleaned of the impurities like dead lac insects, eggs and coloring matter. After cleaning the lac is finally crushed with the help of hand-operated mortars. This crushed lac is air dried after which it forms pale yellow colored granules. This is called as seed lac.
- Seed lac is then soaked in water, washed, dried in sunlight, bleached and heated to melt in on charcoal file in cloth bag. During heating the bag is twisted and the lac is squeezed out of the bag with the impurities left out in the bag. This lac is called as Kirri lac.
- Kirri lac is allowed to cool down and solidify around button shaped forms to form button lac or pure lac. This pure lac is stretched into thin sheets called as sheet lac. The sheet lac when dissolved in water produces white or orange colored lac called as shell lac.

- The quality of the lac depends on the host plant. Kusumi lac is said to be the best and costly lac while dhak lac is said to be the worst and the cheapest one. The quality and the color of the lac vary depending on the presence of gum and resins in the host plant.

Types of lac

Ari lac- It is immature lac harvested from the host plants

Stick lac- It is matured lac harvested in the form of stick from host plants

Seed lac- It is obtained after removing and washing the lac from the stick

Dust lac- It is obtained after grinding seed lac

Shellac- It is prepared after heating the seed lac and dust lack

Composition of lac

Lac is a complex substance and it also contains sugar, water and other alkaline substances along with large amounts of resins. The percentages of various constituents ate as follows:

- Resin- 68-90%
- Dye- 2-10%
- Wax- 6%
- Albuminous matter- 5-10%
- Mineral matter- 3-7%
- Water-3%

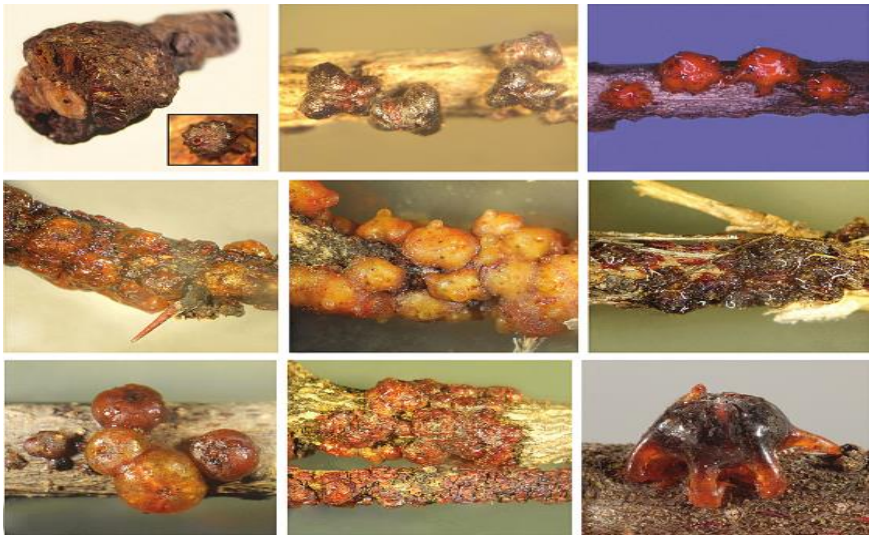

Fig 8.6: Stages Involved in Lac Cultivation