

COURSE CONTENTS ENT-402 APPLIED ENTOMOLOGY 3(2+1)

(E-SECTION)

OBJECTIVES:

1. To equip the students with knowledge of insect pests of crops, vegetables, fruits, stored grains, household and structural pests.
2. To familiarize the students with identification of insect pests and their control methods and pesticide application equipments.
3. To introduce the students with entomological cottage industry.
4. To increase the productivity of agricultural crops through insect pest control.

THEORY:

Introduction; causes of success and economic importance of insects; principles and methods of insect control i.e. cultural, biological, physical, mechanical, reproductive, legislative, chemical and biotechnological control; introduction to IPM; insecticides, their classification, formulations and application equipments; identification, life histories, mode of damage and control of important insect pests of various crops, fruits, vegetables, stored grains, household, termites and locust; entomological industries: apiculture, sericulture and lac-culture.

PRACTICAL:

Collection, identification and mode of damage of insect pests of various crops, fruits, vegetables, stored grains and household; insecticide formulations, their dilutions and safe handling; use of application equipments, practical instructions in apiculture, sericulture and lac-culture.

BOOKS RECOMMENDED:

1. Atwal, A.S. 2005. Agricultural Pests of Southeast Asia and their Management. Kalyani Publishers, Ludhiana.
2. Awastheir, V.B. 2009. Introduction to General and Applied Entomology. Scientific Publisher, Jodhpur, India.
3. Duncton, P.A. 2007. The Insect: Beneficial and Harmful Aspects. Kalyani Publishers Ludhiana.
4. Lohar, M. K. 2001. Applied Entomology, 2nd Ed. Department of Entomology, Sindh Agriculture University Tandojam Sindh, Pakistan.
5. Mathews, G.A. 2004. Pesticide Application Methods, 3rd. Ed. John Wiley & Sons, Inc. N.Y.
6. Pedigo, L.P. 2007. Entomology and pest management 5th Ed. Prentice Hall, Intl. Limited, London.

Open Source Materials: Students should go through this PDF format for necessary preparations

Instructor: Dr. Muhammad Waqar Hassan

Department of Entomology, UCA & ES

Topic 1: Why insects are so dominant/successful creature on earth

Insects have highest number of species and highest number of individual per species. They live in great variety of habitats and with long geological history. There are following factors for their dominance on earth:-

Power of flight: Insects can fly and can exploit variety of habitats for food and survival. Flight helps them in migration

Adaptability: They are highly adoptable

Small size: They use it to their advantage as small size requires less space, less food for survival and with abundant supply of food

Presence of exoskeleton: It is lighter in weight which can help in migration, outermost cement layer in epicuticle prevents from injury.

No desiccation i.e. wax layer in epicuticle prevents from water loss and reabsorption of water from fecal matter through rectum

Tracheal system for respiration: There is nonstop allocation of sufficient oxygen to breathing tissues.

Spiracles also have closing mechanism to avoid water loss.

High reproductive potential i.e., a termite queen can lay 6000-7000 eggs per day for fifteen years

Short generation time i.e., most insects complete development in less than 30 days under optimum condition of temperature and relative humidity

Diverse means of reproduction other than oviparity like Parthenogenesis, Polyembryony and Paedogenesis

TOPIC 2. METHODS OF CONTROLLING INSECT PESTS

Non-Chemical Methods

Many natural controls act to keep insects in balance

1. Weather factors like temperature and rainfall can restrict the distribution of an insect species. For example, mites and leafhoppers are usually more prevalent under dry conditions.
2. Geographic barriers like large bodies of water, mountains, and deserts can also limit insect distribution.
3. Frogs, toads, lizards, moles, and birds are some of the many animals that feed largely on insects.
4. Beneficial predator insects like ladybugs feed on aphids, while others like the braconid wasp and tachnid fly lay eggs on or in certain pests which are killed by the developing larvae. Insects are also attacked by viruses, fungi, and bacteria which help keep populations down.

Biological Control

Biological control is the purposeful introduction of predators, parasites or diseases to combat a harmful insect species. About 120 different insects have been partially or completely controlled by this method in various parts of the world. Microbial insecticides such as *Bacillus thuringiensis* (effective against a few types of caterpillars) are now commonly used by farmers and gardeners in many areas. Unfortunately, biological control measures are presently effective against a very small portion of harmful insect species.

Cultural controls

Cultural controls such as crop rotation, intercropping, burying crop residues, timing the crop calendar to avoid certain insects, and controlling weeds and natural vegetation that harbor insects are all effective control methods for some insects. In most cases, however, cultural controls need to be supplemented by other methods.

Varietal Resistance

Crop varieties differ considerably in their resistance to certain insects. For example, maize varieties with long, tight husks show good resistance to earworms and weevils. Researchers at CIAT have found that some bean varieties are relatively unaffected by leafhopper damage during the wet season, while others suffer yield losses of up to 40 percent. Screening for insect resistance is an important part of crop breeding programs.

"Organic" Controls

"Organic" control refers to non-chemical methods in general. These include the application of homemade "natural" sprays made from garlic, pepper, onions, soap, salt, etc., and the use of materials like beer to kill slugs and wood ashes to deter cutworms and other insects. Some of these "alternative" insecticides are slightly to fairly effective on small areas like home gardens and where insect populations are relatively low. They are seldom feasible or effective on larger plots, especially under tropical conditions that favor insect buildup.

Chemical Control

Chemical control refers to the use of commercial insecticides in the form of sprays, dusts, granules, baits, fumigants, and seed treatments. While some of these insecticides like rotenone and pyrethrin, are naturally derived, most are synthetic organic compounds that have been developed through research.

Advantages of Insecticides:

1. They act rapidly.
2. They are the only practical means of control once an insect population reaches the economic threshold of damage on a commercial-size plot.
3. They are available with a wide range of properties, species effectiveness, and application methods.
4. They are relatively inexpensive, and their proper usage can often return \$4.00 5.00 for every \$1.00 spent.

Disadvantages of Insecticides:

1. Insect resistance to pesticides
2. Outbreaks of secondary pests
3. Damage to non-target species: These include beneficial predators such as bees and wildlife.
4. Residue hazards: Some chlorinated hydrocarbon compounds like DDT, Aldrin, Endrin, Dieldrin, and Heptachlor are highly persistent in the environment and may accumulate in the fatty tissues of wildlife, livestock, and humans.
5. Immediate toxicity: Some insecticides are extremely toxic in small amounts to humans and animals. Again, it is important to realize that insecticides vary greatly in their toxicity.

Integrated Pest Control

The disadvantages of total reliance on insecticides have given rise to integrated pest control or pest management which involves the judicious use of these chemicals based on the following guidelines and principles:

1. The development and use of cultural and other nonchemical control methods to avoid or reduce insect problems.
2. Determining crop tolerance to pest damage based on the principle that complete freedom from pests is seldom necessary for high yields. Nearly all plants can tolerate a surprising amount of leaf loss before yields are seriously affected.
3. The appropriate timing and frequency of treatments to replace routine, preventative spraying. Treatments are not initiated before the particular insect has reached the economic damage threshold, which will vary considerably with the species. Insect scouting looking for related kinds and number of insects and their density and population counts-is an essential part of this system.

The advent of integrated pest control dates back to the early 1970's, and most of the efforts have been directed at cotton where insecticides frequently account for up to 80 percent of total production costs. Some remarkable successes have been achieved with other crops as well. For the reference crops, integrated pest control is still in the very early stage, especially in developing countries.

TOPIC 3. INSECTICIDES AND THEIR CLASSIFICATION

Insecticide, any toxic substance that is used to kill insects. Such substances are used primarily to control pests that infest cultivated plants or to eliminate disease-carrying insects in specific areas.

Classification of insecticides

Insecticides can be classified in any of several ways, on the basis of their chemistry, their mode of action or their mode of penetration. In the latter scheme, they are classified according to whether they take effect upon ingestion (stomach poisons), inhalation (fumigants), or upon penetration of the body covering (contact poisons). Most synthetic insecticides penetrate by all three of these pathways, however, and hence are better distinguished from each other by their basic chemistry.

Modes of Penetration

Stomach poisons: These are toxic only if they are ingested through the mouth and are most useful against those insects have biting or chewing mouth parts, such as caterpillars, beetles, and grasshoppers. The chief stomach poisons are the arsenicals e.g., Paris green (copper acetoarsenite), lead arsenate, and calcium arsenate; and the fluorine compounds, among them sodium fluoride and cryolite. They are applied as sprays or dusts onto the leaves and stems of plants eaten by the target insects. Stomach poisons have gradually been replaced by synthetic insecticides, which are less dangerous to humans and other mammals.

Contact poisons: These insecticides penetrate the skin of the pest and the contact insecticides can be divided into two main groups: naturally occurring compounds and synthetic organic ones. The naturally occurring contact insecticides include nicotine, developed from tobacco; pyrethrum, obtained from flowers of Chrysanthemum; rotenone from the roots of Derris species and related plants; and oils, from petroleum. Though these compounds were originally derived mainly from plant extracts, the toxic agents of some of them (e.g., pyrethrins) have been synthesized. Natural insecticides are usually short-lived on plants and cannot provide protection against prolonged invasions. Except for pyrethrum, they have largely been replaced by newer synthetic organic insecticides.

Fumigants: Fumigants are toxic compounds that enter the respiratory system of the insect through its spiracles, or breathing openings. They include such chemicals as phosphine, hydrogen cyanide, naphthalene, nicotine, and methyl bromide and are used mainly for killing insect pests of stored products or for fumigating nursery stock.

Synthetic Insecticides

The synthetic contact insecticides are now the primary agents of insect control. In general they penetrate insects readily and are toxic to a wide range of species. The main synthetic groups are the chlorinated hydrocarbons, organic phosphates (organophosphates), and carbamates.

Chlorinated hydrocarbons

The chlorinated hydrocarbons were developed beginning in the 1940s after the discovery (1939) of the insecticidal properties of DDT. Other examples of this series are BHC, lindane, Chlorobenzilate, methoxychlor, and the cyclodienes (which include aldrin, dieldrin, chlordane, heptachlor, and endrin). Some of these compounds are quite stable and have a long residual action; they are, therefore, particularly valuable where protection is required for long periods. Their toxic action is known to disrupt the nervous system. These are further classified as axonic poisons by disrupting normal transmission of nerve impulse through axons of neurons and become lethal. A number of these insecticides have been banned for their deleterious effects on the environment.

Organophosphates: Organophosphates are now the largest and most versatile class of insecticides. Two widely used compounds in this class are parathion and malathion; others are Diazinon, naled, methyl parathion, and dichlorvos. They are especially effective against sucking insects such as aphids and mites, which feed on plant juices. The chemicals' absorption into the plant is achieved either by spraying the leaves or by applying solutions impregnated with the chemicals to the soil, so that intake occurs through the roots. The organophosphates usually have little residual action and are important, therefore, where residual tolerances limit the choice of insecticides. Organophosphates kill insects by inhibiting the enzyme cholinesterase, which is essential in the functioning of the nervous system in synapse region of neurons so they are known as synaptic poisons.

Carbamates

The carbamates are a group of insecticides that includes such compounds as carbamyl, methomyl, and carbofuran. They are rapidly detoxified and eliminated from animal tissues. Their toxicity is thought to arise from a mechanism somewhat similar to that for the organophosphates but their basic mode of action is similar to Organophosphates and these inhibit action of acetylcholinesterase in synapse region of neurons and are hence known as synaptic poisons.

Pyrethroids

These insecticides are developed in laboratory by following the chemistry of natural pyrethrum. These are less stable in environment compared with Organsophosphates and carbamates. Some of them are also used against house hold insect pests. Important examples include lambda cyhalothrin, bifenthrin, cypermethrin, deltamethrin etc.

TOPIC 4. INSECTICIDE FORMULATIONS AND APPLICATION EQUIPMENTS

Introduction

Pesticide chemicals in their raw or unformulated state are not usually suitable for pest control. These concentrated chemicals and active ingredients may not mix well with water, may be chemically unstable, and may be difficult to handle and transport. For these reasons, manufacturers add inert substances, such as clays and solvents, to improve application effectiveness, safety, handling, and storage. Inert ingredients do not possess pesticidal activity and are added to serve as a carrier for the active ingredient. Here are several inert substances, such as petroleum distillates and xylene. The mixture of active and inert ingredients is called a pesticide formulation. This formulation may consist of:

The pesticide active ingredient that controls the target pest

The carrier, such as an organic solvent or mineral clay

Adjuvants, such as stickers and spreaders

Other ingredients, such as stabilizers, safeners, dyes, and chemicals that improve or enhance pesticidal activity

Liquid Formulations

Liquid formulations are generally mixed with water, but in some instances labels may permit the use of crop oil, diesel fuel, kerosene, or some other light oil as a carrier. This section will present more detailed information about the common liquid pesticide formulations.

Emulsifiable Concentrates (EC)

An emulsifiable concentrate formulation usually contains a liquid active ingredient, one or more petroleum-based solvents (which give EC formulations their strong odor), and an agent—known as an emulsifier—that allows the formulation to be mixed with water to form an emulsion. Upon mixing with water, they take

on a "milky" appearance. They are adaptable to many types of application equipment including portable sprayers, hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aircraft sprayers.

Advantages of emulsifiable concentrates include:

Relatively easy to handle, transport, and store

Little agitation required; will not settle out or separate when equipment is running

Not abrasive

Will not plug screens or nozzles

Little visible residue on treated surfaces

Their disadvantages:

High active ingredient (a.i.) concentration makes it easy to overdose or underdose through mixing or calibration errors

Easily absorbed through skin of humans or animals

Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate

May cause pitting or discoloration of painted finishes

Flammable—should be used and stored away from heat or open flame

May be corrosive

Solutions (S)

Some pesticide active ingredients dissolve readily in a liquid carrier, such as water or a petroleum-based solvent. When mixed with the carrier, they form a solution that does not settle out or separate. Formulations of these pesticides usually contain the active ingredient, the carrier, and one or more other ingredients.

Ultra-Low Volume (ULV)

These concentrates may approach 100% active ingredient. They are designed to be used "as is" or to be diluted with only small quantities of a specified carrier. They are used at rates of no more than 1/2 gallon per acre. These special purpose formulations are used mostly in outdoor applications, such as in agricultural, forestry, ornamental, and mosquito control programs.

Advantages of ultra-low-volume formulations include:

Relatively easy to transport and store

Remain in solution; little agitation required

Not abrasive to equipment

Will not plug screens and nozzles

Leave little visible residue on treated surfaces

Their disadvantages:

Difficult to keep pesticide on target—high drift hazard

Specialized equipment required

Easily absorbed through skin of humans or animals

Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate

Calibration and application must be done very carefully because of the high concentration of active ingredient

Flowables (F)/Liquids (L)

A flowable or liquid formulation combines many of the characteristics of emulsifiable concentrates and wettable powders. Manufacturers use these formulations when the active ingredient is a solid that does not dissolve in either water or oil. The active ingredient, impregnated on a substance such as clay, is ground to a very fine powder. The powder is then suspended in a small amount of liquid. The resulting liquid product is quite thick. Flowable and liquid suspensions settle out in their containers. Always shake them thoroughly before pouring and mixing. Because flowable and liquid formulations tend to settle, manufacturers package them in containers of 5 gallons or less to make remixing easier.

Aerosols (A)

These formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredients. There are two types of aerosol formulations: the ready-to-use type commonly available in pressurized, sealed containers and those products used in electric- or gasoline-powered aerosol generators that release the formulation as a "smoke" or "fog."

Ready-to-use aerosols are usually small, self-contained units that release the pesticide when the nozzle valve is triggered. The pesticide is driven through a fine opening by an inert gas under pressure, creating fine droplets. These products are used in greenhouses, in small areas inside buildings, or in localized outdoor areas. Commercial models, which hold 5–10 pounds of pesticide, are usually refillable.

Liquid Baits

An increasing number of insecticides and rodenticides are being formulated as liquid baits. Liquid rodenticides are mixed with water and placed in bait stations designed for these products. They have two major benefits. Liquid rodenticides are effective in controlling rodents, especially rats, in areas where they

cannot find water. They are also effective in areas of poor sanitation where readily available food renders traditional baits ineffective.

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

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.

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

Baits: 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

Granular formulations: 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.

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. 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. However, these are clearly labeled as fumigants. Do not confuse them with non-fumigant pellets.

Wettable powders (WP): They 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

Advantages of wettable 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:

TOPIC 5. COTTON INSECT PESTS

There are two types of pest insects attacking cotton crop. These are sucking pests which suck plant sap from leaves and inflorescence and those which chewing mouth parts and bite off pieces of plant parts including leaves flowers and fruit. These can be grouped as below

Sucking insect pests

Cotton jassid, White fly, thrips, aphid, mealy bug, red cotton bug, dusky cotton bug and chewing pests include army worm, bollworms complex (American bollworm, spotted bollworm, pink bollworm), Cotton Leaf Folder, cotton grey weevil.

Cotton Jassid

T.N. *Amrasca devastans* (Homoptera: Cicadellidae)

Identification: It is small sucking pest around 3 mm in length, color is yellowish green with piercing sucking mouth parts. It is major sucking pest of cotton. Apart from cotton it also attacks okra and other winter vegetables

Life history and damage

Females lay eggs inserted in leaf veins. Both nymphs and adults suck cell sap by their piercing sucking mouth parts from leaves. In severe infestation leaves become cup shape and brick red in color. It also inject toxins along with saliva into leaves.

Insecticides: Imidachloprida or others

Cotton White fly

T.N. *Bemesia tabaci* (Homoptera: Aleyrodidae)

Identification: These are very minute insects with white wings and yellowish body. They are very notorious pests in cotton and are polyphagous because it has greatest number of hosts on which it attacks

Life history and damage

Females lay eggs on leaves from which nymphs hatch and move about to search for a suitable place on which they insert their piercing sucking mouth parts and become sessile in later instars. There is a fourth stage in white fly called pseudopupa. Both adults and nymphs cause damage by sucking cell sap. Plant vigor is reduced due to sap feeding. They are also vectors of CLCV (Cotton Leaf Curl Virus) in cotton and affect highly cotton crop. They excrete honeydew on which sooty mold grows and due to which photosynthesis is affected as sunlight is intercepted because of presence of sooty mold on leaves. Overall yield of crop plants is heavily affected due to attack by white fly both in case of direct damage by sucking cell and also by indirect damage when these serve as vectors of CLCV and by the attack of sooty mold.

Insecticides: Imidachloprid and others

Thrips

T.N. *Thrips tabaci* (Thysanoptera: Thripidae)

Identification: They are minute slender insects. Body has yellowish color and have got wings to fly from plant to plant. Their mouth parts are rasping and asymmetrical

Life history and damage

Thrips attack crop plants by sucking cell sap from leaves. Both nymphs and adults cause damage. In severe infestation leaves have silvery appearance. Apart from cotton these also attack on other vegetables like onion and garlic. In some plants also transmit viruses.

Mealy bug

T.N. *Phenacoccus solenopsis* (Homoptera: Pseudococcidae)

Identification: Mealy bugs have soft and segmented appearance of body with white mealy powder. Nymphs and females look similar without wings but males are very different and have got flying wings.

Life history and damage

Mealy bug female lays eggs on plants. After hatching both nymphs and adult female attack plants by sucking cell sap from leaves and other plant parts. They also excrete honeydew on which sooty mold grows and due to decreased photosynthesis and sap sucking yield is affected.

Control: Integrated pest management should be practiced

Dusky cotton bug

T.N. *Oxycarenus hyalinipennis* (Hemiptera: Oxycarenidae)

Identification: These have dark color with semitransparent wings. Body is elongated about 4-5 mm length. Mouth parts are piercing sucking and directed back ward (opisthognathous)

Life history and damage

Egg laying on different plant parts. Both nymphs and adults cause damage by sucking cell sap from different plant parts. These also cause damage by sucking from cotton seeds. These get crushed with lint and quality of cotton is affected. Apart from cotton it also attacks other plants

Control: Different control measures as for other sucking pests

Red cotton bug

T.N. *Dysdercus koingii* (Hemiptera: Pyrrhocoridae)

Identification: These have larger body 15 mm size. They have reddish color, black wing tips and white dots along lateral sides, opisthognathous mouth parts

Life history and damage

Females lay eggs in leaf litter and loose soil near crop plants. Nymphs which are purely red reach cotton plants and attack crop plants along with adults in fruiting stage mostly. They suck the juices from bolls and seeds and transmit bacteria as well. Cotton gets stained due to their peculiar attack so they are also known as cotton stainer

Control: Cultural control of clean cultivation is recommendation. Some insecticides when infestation on plant is high is also recommended

Chewing Insect Pests

Army worm

T.N. *Spodoptera littura* (Lepidoptera: Noctuidae)

Identification: adults are deep brown in color with markings. It is larger moth. Larvae are greying color of layers on body. Body of larvae become much big when these old

Life history and damage

It is a serious pest of cotton and attacks in the form of army. Egg laying is in cluster from and egg masses are seen on leaves. After hatching young larvae move in the form of army and attack by removing tissue layers from leaves. Older larvae feed voraciously and only vein are left and skeleton is left behind. Crop has to sow again in case of sever attack in early stages. Yield is heavily affect and warrants control of the pest.

Control. Integrated Pest Management is recommended. BT cotton has no problem of this pest

American Bollworm

T.N. *Helicoverpa armigera* (Lepidoptera: Noctuidae)

Identification: it is large brown moth with stout body. On the back side of wings is kidney shape mark and hind wings appear smoky in color

Life history and damage

Eggs are laid singly on leaves and other plant parts. Larvae after hatching are greenish in color. There are pattern of lines on body. It is a polyphagous pest and attacks other crops and vegetables beside cotton crop. Its attack start on flowers, squares. After boll formation it attacks on bolls. The hole through which it feeds on bolls its half body is inside boll and half is outside boll. It damages multiple bolls by single larva. Yield is highly affected by its attack.

Control: Integrated Pest Management is desired. BT cotton is safe from this pest. Biological control is also recommended

Spotted Bollworm

T.N. *Earias insulana* & *Earias vitella* (Lepidoptera: Noctuidae)

Identification: *Earias insulana* adult moth is greenish in color while *E. vitella* has green and white bands. Larvae have brownish and white spots on body. It has spines on body so it is different from other bollworm larvae

Life history and damage:

It has multiple hosts apart from cotton. Larvae feed on bolls after boll formation. Larvae enter bolls and the hole through which larvae enter is filled with their excreta. Yield is affected.

Control: BT cotton is safe from this pest. Biological control is also recommended

Pink Bollworm

T.N. *Pectinophora gossypiella* (Lepidoptera: Gelechiidae)

Identification: adults are deep brown moth. Larvae are white at first and become pinkish in color later on

Life history and damage

It is monophagous. Larvae after hatching enter cotton bolls and hole through which these enter bolls are filled due to vegetative growth of plants. Larvae attack by feeding internal contents of boll and by joining two seeds together called double seeds which is identification of damage by this pest. Yield is heavily affected due to attack by this pest.

Control: It has shown resistance to BT cotton. Integrated pest management is recommended.

Cotton leaf roller

T.N. *Sylepta derogata*

Life history and damage

It is serious pest of cotton. It is also called cotton leaf folder. Older larvae join two edges of leaves and fold them to eat inside leaves biomass. Yield is affected heavily

Control: BT cotton is safer choice. Biological control is recommended. IPM is also recommended.

TOPIC 6. INSECT PEST OF RICE

Different sucking and chewing insect pests attack rice crop at nursery and seedling stage. Control of these pests is vital to get good yield

Sucking pests of rice

Brown Plant Hopper

T.N. *Nilaparvata lugens* (Homoptera: Delphacidae)

Identification: These are brownish in color. Brown color of body and hyaline wings.

Life history and damage

These suck sap from leaves. There is appearance of brownish spots on leaves which meet together and there is appearance of brownish hue in pataches which can be seen from distance. This is known as “Hopper burn” Yield is affected heavily.

Control: pest attack is severe when planting density is high. Therefore it is recommended to increase row to row and plant to plant distance in field to reduce humid conditions which favors this pest. Over dose of fertilizer and irrigation should be optimum which reduces its attack. Suitable insecticide should be sprayed.

White backed plant hopper

T.N. *Sogatella furcifera* (Homoptera: Delphacidae)

Identification: It has white back so it is called white backed plant. It is a sucking pest

Life history and damage. It damages the crop by sucking cell and brownish spots appear on leaves. Due to its attack yield is affected

Control: as for Brown plant hopper

Rice Green Leaf Hopper

T.N. *Nephotettix* Spp. (Homoptera: Cicadellidae)

Identification: These are greenish in color with black wing tips.

Life and Damage. They suck plant sap and become cause of reduction in rice yield.

Control: as for other sucking pests

Chewing Pests of Rice

Rice Leaf Folder

T.N. *Cnaphalocrocis medinalis* (Lepidoptera: Pyralidae)

Life history and damage:

Earlier instar larvae feed openly but later instars feed by folding two longitudinal edges of leaves together and feed with in leaf folds. They remove green matter from leaves and leaves cannot synthesize food due to loss of photosynthesis. Yield is affected heavily in severe infestation

Control: as for other chewing pests in rice

Yellow Stem Borer of Rice

T.N. *Scirpophaga incertulas* (Lepidoptera: Pyralida)

Identification: These are yellowish colored moths and pointed mouth parts

Life history and damage

Adults lay eggs on leaves. Larvae after hatching enter through midrib of leaves and make their way into the stem. They feed on growing points and central whorl of plants is killed which can be pulled easily. This is symptom of “Dead hearts” caused by borers in rice. Yield is affected heavily

Control: Granular pesticides like carbofuran is recommended to control borers. IPM is recommended

White Stem Borer of Rice

T.N. *Scirpophaga innotata* (Lepidoptera: Pyraliae)

Identification: These are whitish in color moths.

Life history and damage

The attack is by larvae which enter stem and cause formation of drying central whirl known as dead hearts. They affect yield of rice plants.

Control: as for yellow stem borer

Rice Hispa

T.N. *Dicladispa armigera* (Coleoptera: Chrysomelidae)

Identification: this is bluish black beetle parallel sided with constriction in the middle.

Life history and damage

Adults lay eggs on leaves. Larvae enter leaves and feed inside two layers of leaves like leaf miner and feed on internal contents. Yield can be affected in case of severe infestation.

Control: control can be done by flooding field and beetles float in water can be removed along with water. Clipping of rice leaf tips of nursery plant before transplanting is recommended for pests which lay eggs on leaf tips during nursery stage.

TOPIC 7. INSECT PESTS OF SUGARCANE

Sugarcane Top Borer

T.N. *Scirpophaga nivella* (Lepidoptera: Pyralidae)

Identification: moths are pure white. Female has tuft of hairs at the tip of its abdomen

Life history and damage

There are 4-5 generations in a year. Female moths lay eggs in masses which are covered with hairs from tuft of hair from female abdomen. After hatching enter from leaves into stems. First two generations cause formation of dry central whirl “Dead Hearts” due to feeding on growing points in stem and killing of shoot. 3rd and 4th generations cause tunneling in stem and pupate in tops of canes. Due to attack in cane when it has attained good height, there is appearance of side shoots called as “Bunchy Tops”. 5th generation larvae do not pupate and spend winter in crop remains left in field in winter season which become source of infestation in next season.

Control: Biological control with *Trichogramma* wasp is not as successful as egg masses are covered with hairs from female therefore parasitoids attack is not successful for top borer. Carbofuran is effective as insecticide for control of all borers in sugarcane and other crops like rice. Burning of crop residues is effective in offseason which serve as source of infestation in every next season.

Sugarcane Stem Borer

T.N. *Chilo infuscatellus* (Lepidoptera: Pyralidae)

Life history and damage

Larvae of last generation in crop stubbles pupate and adults emerge in spring season. Adults lay eggs on leaves. Larvae hatch from eggs and attack plants. There are 4-5 generations in a year. First generation cause formation of dead hearts while later generations cause tunneling in stem. There is considerable reduction in yield of plants.

Control: As for sugarcane top borer. *Trichogramma* wasp is effective as biological control agent for this pest

Sugarcane Root borer

T.N. *Emmalocera depressella* (Lepidoptera: Pyralidae)

Life history and damage

Adults of first generation lay eggs on leaves. Larvae enter stems and in roots. There is formation of dead hearts. Insects can be controlled by Carbofuran insecticide. Cultural practices if taken appropriately pest infestation can be significantly controlled for all borers in sugarcane and rice.

Sucking Pests of Sugarcane

Sugarcane Pyrilla

T.N. *Pyrilla perpusilla* (Homoptera: Lophopidae)

Identification:

Adults are yellowish brown with prolong snout and sucking mouth parts. Nymphs are creamy white and early instar has long filaments from abdominal tip

Life history and damage

Females lay eggs in small batches in rows on under surface of leaves and in winter in leaf sheath. Nymphs pass through five stages (instars) to become adult. They feed by inserting mouthparts into leaves to suck sap. Plant vigor is reduced. They excrete honeydew on which sooty mold grows which affects photosynthesis and results of attack is that yield is less.

Control: Clean cultivation and removal of weeds is recommended. Biological control and chemical control are also effective to control its population

Sugarcane black bug

T.N. *Cavelerius excavates* ()

Identification: These have elongated body black color

Life history and damage

These are sucking pests of sugarcane. These suck plant sap and reduce yield of plants.

TOPIC 8. INSECT PESTS OF WHEAT

Wheat Aphid

There are different species of aphid which attack on wheat

T.N. Sitobion avenae, Scizaphis graminum (Homoptera: aphididae)

Identification

These are soft bodied insects small in size yellowish green in color. A pair tubes called cornicles are present on dorsal side of abdomen 5-6 segment

Life history and damage

Aphid has two different generation in wheat in the season. At first in start of spring season, they give birth to young ones. These are all females and reproduce by parthenogenesis. Aphids live in the form of colonies. Nymphs and adult females suck sap from leaves and reduce plant vigor if infestation is high so yield can also be affected. Number of grain per tiller can be affected. In summer season when wheat plants mature and there is no succulence in plants and leaves aphids develop wings (alate forms develop) and migrate to new alternate crop plants.

Control: Aphids if in low number do not cause significant damage but in high numbers these require control measures to be applied to reduce crop losses. Fast water spray is also effective to dislodge and kill them.

TOPIC 9. INSECT PESTS OF MAIZE

Maize Stem Borer

T. N. Chilo partellus (Lepidoptera: Pyralidae)

Identification: adults are small moths. Forewings are brownish yellow with dark scales. Hind wings are of pale color in males and are of white color in females. Larvae can be creamy white to yellow brown. Larvae have four stripes and these give spotted appearance. Eggs are oval and flat and creamy white in color

Life and damage: apart from maize it also attack certain other grasses including wild plants, sorghum etc.

Eggs are laid on upper and underside of leaves in batches close to midrib of leaves. Younger larvae feed on leaf whorl and older larvae tunnel into stem and in tunnels these feed and grow. Several generations are completed in a year. Earlier generations cause formation of dead heart in which these feed on growing points due to which central whorl is dried and can be pulled easily hence called dead hearts. Later generations make tunnels in stems and also attack maize on ears at earing stage. These cause significant reduction in crop plants.

Control: Trichogramma wasp is an egg parasitoid and is recommended for its control at eggs stage. Insecticides are recommended for its control like carbofuran. Cultural control is very important and destruction of previous crop residues is highly recommended to reduce carry over of pest to next season.

Maise Shoot Fly

T.N. *Atherigona soccata* (Diptera: Muscidae)

Identification: it is small in size about the size of common house fly. Its color is somewhat dark and dull in appearance, wings are semitransparent

Life history and damage

Adults lay eggs near plant base and young one (maggots) enter plant roots. These larvae on young seedling and cause formation of dead hearts. Yield is affected badly in severe infestation

Control: Chemical control is recommended. Carbofuran is effective against this pest.

TOPIC 10. INSECT PESTS OF VEGETABLES

Red Pumpkin Beetle

T.N. *Aulacophora foveicollis* (Coleoptera: Chrysomellidae)

Insect Pests of Cucurbits

Identification. These are elongated beetles orange red in color from dorsal side and black color from ventral side. It is severe pest of cucurbits

Life history and damage

These beetle lay eggs in soil near plants. Their immatures (grubs) feed on plant roots and fallen fruit and fruit touching the ground. These pupate in soil and adults come out of soil. Both larvae and adults cause damage by feeding on plants by their chewing mouth parts. They can significantly affect yield when in high numbers

Control: Neem and carbamates are effective against this pest

Hadda Beetle

T.N. *Epilachna dodecastigma*, *E. demurilli*, *E. vigintioctopunctata* (Coleoptera: Coccinellidae)

Identification: these have convex shape from dorsal side and with copper color with dark spots. Species identification is done by counting number of spots on elytra and by color of dorsal side. It is serious pest of pumpkins and gourd etc

Life history and damage

Beetle lay eggs on plant parts. After hatching larvae feed on plants by removing leaf tissues from leaves and leaves appear sieve like. Photosynthesis is affected in severe infestation which lead to reduce yield. Both adults and larvae cause damage by feeding on plant with their chewing mouth parts.

Control: manual collecting and killing of adults and larvae or eggs masses is recommended. Insecticides from carbamate or organophosphate groups are recommended

INSECT PESTS OF BRINJAL

Brinjal Shoot and Fruit Borer

T.N. *Leucinodes orbonalis* (Coleoptera: Pyralidae)

Identification: adults are moths with grey brown color, white wings. Wings have marginal hairs and pinkish dots on wings.

Life history and damage

Adults lay eggs in two to five days after emergence from pupae. Eggs are laid singly on different plant parts. Larvae enter plant tissues including stem and fruit. These fill the entry holes with their excreta. Larvae can attack multiple fruit. Adults live for two to five days. They reduce yield of egg plant/brinjal heavily

Control: clean cultivation is recommended. Attacked leaves and fruit should be plucked and destroyed to stop next infestation. Removal of weeds, fallen leaves should be destroyed. Insecticides are recommended for its control like carbaryl. Biological control is also recommended

TOPIC 11. INSECT PESTS OF FRUIT

Insect Pests of Mango

T.N. *Idioscopus clypealis*, *Amritodus atkinsoni* (Homoptera: Cicadellidae)

Identification: these are small straw colored pests, wedge like body. Wings are held over body roof like

Life history and damage

Adults lay eggs in underside of leaf veins. Nymphs are greenish or brown but small and can not fly. Both adults and nymphs cause damage by sucking cell sap during flushing period. They reduce plant vigor. Leaves dry up. They produce honey dew on which sooty mold grows and yield of plants is affected. There are two generations in a year. In off season these congregate in large numbers around tree trunk and create noise when there is some disturbance.

Control: Cropping distance should be increased eg., plant to plant distance should be increased. Over irrigation and fertilizer should be avoided. Chemicals like cypermethrin give good control

Mango fruit fly

T.N. *Bactrocera dorsalis*, *B. zonata*

Identification: Fruit flies have elongated body with reddish color, semitransparent wings. Yellowish marking are present on notum.

Life history and damage

These damage all kind of fruit including mango, guava, ber etc. winter is passed in pupal stage under the soil in badly managed orchards or in the wild. In spring season adults come out of pupae and start laying eggs in mature or fallen fruit. Their immatures (young larvae called maggots) feed on pulp and when these become full fed these leaves fruit and pupate in soil. Orchard yield is heavily affected in badly managed orchards with weeds, grass and plenty of fallen fruit which serve as carrier for next generation of fruit fly to attack

Control: Clean cultivation is first and foremost recommendation for fruit fly control in orchards. Ploughing the soil in December below tree canopy and whole orchards is recommended to kill pupae hiding in soil which are source of attack by next generation in next season. In season methyl eugenol an attractive mixed with trichlorfon (insecticide) give good control. Its control requires efforts on large scale to diminish the pest.

Mango mealy bug

T. N. Drosicha mangiferae (Homoptera: margarodidae)

Identification:

This is serious pest of mango. Females and nymphs are white in color with segmented bodies. While male is winged. Damaged is caused by only adult females and nymphs

Life history and damage

It has only one generation in a year. Following season of fruiting females lay eggs in soil away from plants. In December to January when there is flushing on trees nymphs hatch and move to climb tree trunks. After reaching inflorescence they suck sap from leaves and inflorescence which become dry. Fruit fall prematurely due to their attack. Yield is affected badly

Control: before December plough the field in orchards to kill the eggs or nymphs. Wrap a polyethylene sheet 1 foot width around tree trunk of all mango trees one meter above ground will cause to fall off nymphs to soil from these can be collected and killed. Donot let nymphs to reach inflorescence to attack it. Spraying with carbaryl is recommended

INSECT PESTS OF CITRUS

Citrus Psylla/Asian Citrus Psyllid

T.N. *Diaphorina citri* (Homoptera: Liviidae)

Identification: adult is 4 mm long, brown mottled body and light brown head. Antenna are brown with black tips. While sitting on plant surface its tail end makes an angle.

Life history and damage

Eggs are laid on growing shoots. Females lay 800 eggs and it takes them five molting and seven weeks to reach adult stage. They suck plant sap and inject toxin into plant body. Leaves do not expand normally which are attacked. More important thing is that it is vector of a bacterium which causes citrus greening disease. Fruit are small and unsellable

Control: lacewings, hover flies and lady bugs are important predators. Integrated control is required to control citrus greening disease. Insecticides are also recommended for nymphs and adults control

Citrus Leaf Miner

T.N. *Phyllocnistis citrella* (Lepidoptera: Gracellariidae)

Identification: Adults' moths are small 4 mm wing span. These have white and silvery scales on front wings and black spot on each wing tip. Hind wings and body are white. Larvae are translucent, greenish yellow 3 mm in length. Pupa is in pupal cell at margin of leaf. Adults are very small but these are active in day and at evening.

Life history and damage

Eggs are laid singly on underside of host leaves. They are common on all citrus plants. Larvae after hatching enter immediately in leaf and feed by making serpentine mines. They pupate in pupal cell made near leaf margin. Mines are present as one per leaf but serious infestation results in multiple mines per leaf. Mines are on under surface of leaves but in serious conditions mines can also be seen on upper surfaces of leaves. Adults live only for few days in which these lay eggs and die.

The openings in mines can become source of bacterial attack like citrus canker.

Control: Applying oils is good as insecticides affect highly biocontrol agents

TOPIC 12. INSECT PEST OF STORED PRODUCTS

Stored Product Pests and their Management

Storage insect pests can be classified as internal feeders and external feeders. Internal feeders can feed on sound grains and their immature stages develop within individual grains. Within a commodity infested by internal feeders' only adults' stages while their larvae are not visible to eyes as these are usually developing within individual grains for example rice weevil, pulse beetles etc. On the other hand external feeders cannot feed on sound grains and they depend on broken kernels for survival inside stored cereal grains. They can feed on flour like material. They have weaker mouth parts for example red flour beetles, saw toothed grain beetle etc.

Internal feeders	Rice weevil, maize weevil, granary weevil Pulse beetles/cow pea weevil Angoumois grain moth Lesser grain borer
External feeders	Red flour beetle Khapra beetles Lesser grain borer Psocids

Apart from this in stored grains there are some accidentals which do not feed on grains but they come by chance.

Stored Product and Fabric Pests

There are five broad categories of stored product pests. These are based on how these pests feed on grain or other stored products. These categories are internal feeders, external feeders, scavengers, secondary pests, and miscellaneous pests.

Internal Feeders

Internal feeders develop as the larvae feed within kernels of whole grain or seeds such as beans and peas. They feed primarily on whole grain as opposed to processed grain. The main symptom of infestation of these pests is exit holes of emerging adults. Examples include rice and granary weevils, lesser grain beetles, and Angonois grain moth.

External Feeders

These arthropods feed on whole grain and may feed on grain products. Normally, they attack only part of grain such as the germ or softer parts of grain. Examples include the cigarette beetle, cadelle beetle, drugstore beetle, warehouse beetle, Indian meal moth, and Mediterranean flour moth.

Scavengers

These pests only attack grain and seeds that has been processed or injured by other insects. They consume flour and grain parts. Examples include the red legged ham beetle, merchant grain beetle, flour beetle, sawtoothed grain beetle, cadelle beetle, and dried fruit beetles.

Secondary Pests

These pests are found feeding in grain products that are moldy or severely damaged. Such items are frequently found in grain bins, abandoned rodent nests or grain waste found in exteriors or voids in granaries and mills.

Miscellaneous Pests

These types of pests are not as commonly found in grain products. Occasionally, they are found feeding on grain and grain products.

Red flour beetle (*Tribolium castaneum*) and Confused flour beetle (*Tribolium confusum*)

The most commonly encountered flour beetles are the red flour beetle and confused flour beetle. Both are similar in physical appearance. They are flat and oval in shape and usually are 1/8 inches long. Adults are reddish, shiny, and smooth textured. . They are the most common stored product pest in flour mills. Their relative small size permits them to move through cracks and crevices and infest homes and other structures. Once they are in areas with potential food sources, long term infestations can result in a sharp odor or moldy flavor. The red flour beetle is capable of short distances flights; the confused flour beetle is unable to fly.

Khaphra Beetles (*Trogoderma granarium*)

Adults are usually short-lived; Larvae mainly cause damage. Body of adults and larvae have hairs on body. Body of larvae is segmented with hair on side. Under optimal conditions, Khaphra beetles can sustain a population increase of 12.5 times per year. As a result, populations can build up rapidly in a short time under hot, dry conditions. They can survive in colder climates, heated situations such as warehouses, food plants, and grain storage. Completion of the life cycle usually lasts 4 to 6 weeks, but can last up to 3 years, depending on temperature, available food supply, and potential for diapause.

Grain Weevils (*Sitophilus* sp.)

There are 3 species of weevils that commonly infest whole grain, namely the granary weevil (*Sitophilus granarius*), the rice weevil (*Sitophilus oryzae*) and the maize weevil (*Sitophilus zeamais*). All species are very similar in appearance with a few minor but significant differences. These species have chewing mouthparts that are located at the end of their snouts and are about 1/8 to 3/16 inches in length.

The egg, larva, and pupa stages of these weevils are found in the grain kernels and are rarely seen. The female eats a hole in a kernel of grain large enough to insert its ovipositor and subsequently deposits a single egg. Oviposition takes as little as 3 minutes and is followed by the female sealing the hole. Eggs hatch in 3 days at lower temperature (65 degree F.). Feeding occurs within the grain kernel and adults cut exit holes to emerge. Emergence holes of the granary weevil are larger than those of the rice weevil, and tend to be more ragged than those of the granary weevils.

Lesser Grain Borer (*Rhizopertha domonica*)

It can be internal as well as external feeder of stored grains. Adults beetles are very small (approximately 1/8 inches) and dark brown to black in color. The body is cylindrical in shape with the head not visible from

a dorsal angle. The prothorax has dorsal blunt knobs or spines. There are distinct rows of pits running longitudinal along the elytra. The antennae are composed of 10 segments, including a 3 segment club. The larvae are white with a stout C-shaped body.

Development from egg to adult depends on temperature. In hot summer conditions, it may take as few as 30 days, but the average is about 58 days. Pupation takes place inside the hollow shell of the seed or in the flour that accumulates in infested grain.

Cowpea Weevil (*Callosobruchus maculatus*), Bean Weevil (*Acanthocelides obtectus*).

The adults are relatively small beetles, 0.13 to 0.2 inch in length, somewhat teardrop or triangular in shape, and olive-brown with darker brown and gray patches on the elytra. The elytra are shorter than the abdomen thus leaving a few segments exposed. The larvae are white grubs with a brown head. They are about 1/8 inch long at maturity and have a wrinkled, hump-backed appearance.

Control may be achieved by exposing peas or beans to 0 degrees F or less for 4 days. The beans may be stored at freezing temperature to prevent reinfestation, or they may be stored in containers. In order to avoid possible development of mold, the beans should be thoroughly dried prior to storage

TOPIC 13. HOUSE HOLD INSECT PESTS

A number of insects become problem in houses and become pests. These include those cause nuisance to serious pests of medical importance.

Ants (Family Formicidae)

Ants are small, distinctly segmented insects (with constricted “waist”) that move quickly and often travel in trails. They can penetrate all packaged products with strong mouth parts and affect all stored and perishable commodities. They can also bite humans and pets at home. They are source of great nuisance at home.

Beetles (Order Coleoptera)

Insects with wings hidden under hard covers (elytra). Beetles can be pests of stored products, fabrics and furs, or they may just accidentally enter from outdoors. Although these are pest of stored products, cereals at country level but at home storage and kitchen small scale storage is heavily affected if left unattended and if it is not cared for.

Cockroaches (Order Dictyoptera)

Cockroaches are flattened insects with spiny legs. Some types are found exclusively indoors, others are outdoor species that also enter homes for food and shelter. They are almost omnivorous and feed every things which human consume. They are mostly found in places with food and water together. They are real problems in old houses with cracks and crevices in buildings.

Fabric and food pests

Fabric and food pests include beetles, moths, mites and others. Fabric feeders are usually found damaging furs, woolens, silks, feathers and animal hides.

Flies (Ordre Diptera)

Flies include house flies and others. House flies are source of germ transfer and are problems at home. These are distinguished from other insects by having only one pair of wings. Several different kinds of flies may be found indoors, and identifying the right kind is essential for control.

Termites and other wood destroying insects

Several types of insects can damage wood. Termites come in two forms: the soft-bodied, cream-colored workers; and dark, winged-forms seen mostly during swarming season. Wood destroying beetles are usually noticed when holes are left behind by emerging adults.

Termites (Isoptera: Termitidae)

Termites are great problem at home for furniture, kitchen cabinets, doors, all things and utensils which are made from wood. These make galleries which appear above ground but their nests are located deep in soil where reproductive cast the queen exists. One of the important species include

Odontotermis obesus

TOPIC 14. ENTOMOLOGICAL INDUSTRIES

Lac culture

Members of two families of Hemiptera, namely, Lacciferidae and Tachardinidae secrete lac over their bodies for protection. Lac Insect belongs Laccifer of superfamily Coccoidea of order Hemiptera. In all 22 species have been recorded under the genus Laccifer in Indian subcontinent.

India is still being regarded as the principal lac producing country of the world. Burma went into lac trading since sixteenth century. Lac culture in China probably dates back to 4000 years and they use lac for dyeing silk and leather goods. India produces about 65% of the world's total output. Bihar and Jharkhand account for 40% of India's total production of lac.

HOSTS

Plants such as, *Zizyphus mauritiana*, *Z. jujuba*, *Acacia arabica*, *Cajanus cajan*, *Ficus benghalensis*, *F. religiosa* are common hosts of the lac insect *Laccifer lacca*

BIOLOGY

Laccifer lacca is the commercially cultured lac insect. It is mainly cultured in India and Bangladesh on the host plants such as ber, *Zizyphus mauritiana* and other trees

Female insect is viviparous, producing about 1000 nymphs, deep red in colour with black eyes. The larvae settle down on a suitable place of the host plant gregariously. A day or two after settlement, the larvae start secreting lac all around the body except on the rostrum, spiracles and on the tip of abdomen. Thus it gets encased in a cell of lac which gradually increases in size along with the increase in size of the insect. The insect moults twice before reaching maturity. The male larvae produce elongated lac cells while the females produce oval cells

After the first moult larvae lose their legs, antennae and eyes and become bag-like. After the 3rd moult, the larvae pass on to a pseudo-pupal stage. Males emerge and copulate with the females and die. The female larvae never regain appendages and continue to remain under the lac cell, become adults and reproduce. As the lac insects remain close together, lac secretion from adjacent cells coalesces with each other and forms a continuous encrustation on the tree branch.

LAC CULTIVATION

Lac culture involves two important steps: (i) inoculation, and (ii) cropping. Inoculation can be carried out through artificial infection of tender branches by brood lac stick obtained from mature lac trees immediately after harvesting. In this process, the brood lac sticks are tied in bundles of 2 or 3 sticks on the branches of the host tree, allowing maximum contact with the branches.

When young shoots come up on branches, the brood sticks are tied adjacent to the growing tender branches in a way so that maximum contact between shoots takes place. Within a week or two the larvae emerge and settle down on tender shoots.

USES OF LAC

The various applications of lac can be summarized as follows:

Lac resin is used in food processing industry; cosmetics and toiletries industry; varnish and printing industry; coating of fruits and vegetables; electrical industry; leather industry; adhesive industry; pharmaceutical industry; perfumery industry; miscellaneous applications.

Lac dye (erythrolaccin) has been used in India as a skin cosmetic and dye for wool and silk. In China it is a traditional dye for leather goods. The use of lac for dye has been supplanted by synthetic dyes. It is used in medicine to protect liver and to fight obesity.

Lac is used in food, confectionery and beverages industry and textile industry.

Lac wax is used in polishes for shoe, floor, car polishes etc. It is used in electric insulations, lamination of papers, hat proofing and coating of pictures and fossils.

Lac is used for manufacture of tailors chalks, crayons, bottle sealers, lipsticks, enamels, printing inks, gramophone records and in fireworks.

Apiculture

Honeybees are indigenous to the Eurasian and African continents and were introduced to the Americas and Australia by European settlers. In India the genus *Apis* has the following species: the western honey

bee, *Apis mellifera*, the eastern honey bee, *Apis cerana indica*, the rock bee, *Apis dorsata* and the small bush bee *Apis florea*.

The Dwarf Honeybee or Bush Bee (*Apis florea*)

This species is considered the most primitive honey bee species and is also the smallest. *Apis florea* is brownish and the basal part of abdomen is always red.

The Rock Bee (*Apis dorsata*)

This is a large wild honey bee found in southern Asia, mainly in the forested areas. The workers are over 2 cm long and possess ferocious temperament. Hives are built in exposed places far above the ground, on the branches of trees or under the cliffs of rocks and also on the ceilings of ruins and abandoned buildings. The hive is made of a single vertical comb, sometimes more than a metre in length. During breeding season in March-April they swarm and migrate to different places in the forests looking for nesting sites.

The Asiatic honey bee (*Apis cerana indica*)

This is a medium sized honey bee found in southern Asia and all countries in the Himalayan Range, viz, Afghanistan to Indonesia and also in Japan, Malaysia and Thailand. *Apis cerana indica* is the subspecies still found in the wild in India, particularly in the Himalayan belt where it nests in tree holes and crevices of rocks. The species can be domesticated by farmers for honey production as it has gentle temperament and makes hive in enclosed spaces. *Apis cerana* is medium sized and has transverse stripes on abdomen. It is commonly found in Himalaya where temperate fruits bloom and provide abundant source of nectar. It can survive temperatures as low as 0°C in winter.

The Western honey bee or the European bee (*Apis mellifera*)

This species is not indigenous to India but is introduced from USA and European countries in order to increase honey production in apiaries. The species is slightly larger in size and lighter in color and higher capacity to produce honey and hence is preferred by apiarists.

However, the species is also amenable to diseases such as the American foulbrood which sometimes destroys large number of colonies.

LIFE CYCLE

Queen is the largest caste that has pupal period of 16 days. Queens are reared in enlarged cells in which their larvae are fed exclusively on royal jelly. New queens can be raised by the worker bees anytime if the main queen dies. The virgin queen takes to nuptial flights for mating and then settles in the hive for laying eggs. The sterile worker bees clean the hive and feed the larvae during the first 10 days of their lives, after which they build comb cells in the hive. On 16 to 20th day, the worker makes honey out of the nectar brought by forager. After the 20th day, the worker leaves the hive and spends the rest of life as a forager and eventually dies as a water carrier.

Workers, drones and queen larvae are fed on royal jelly during the first 3 days of life, after which the worker larvae are fed on pollen and diluted honey, while those destined to develop into queens are fed on protein rich royal jelly.

Queens are reared in specialized large queen cells which are specially constructed for queen larvae and have a vertical orientation. When the old queen dies or becomes weak, the workers will construct emergency cells known as **supersedure queen cells**, which are larger and project from the comb.

Drones are genetically haploid males, which possess weak mouthparts and hence they cannot forage for nectar or pollen themselves and have to be fed by the workers. Drones fertilize the queen by mating in nuptial flight, after which drone dies. The drones are generally expelled from the hive and die of cold and starvation. The queen stores sperms in small sac-like organ called the **spermatheca** located in the queen's abdomen.

Sericulture

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 domesticated silk moth) is the most widely used and intensively studied silkworm. Silk was believed to have first produced in China as early as the Neolithic period, but recent evidence suggests that it was circulating more than 2000 years earlier. By careful analysis of archaeological silk fiber found on Indus Civilization sites dating back to 2450–2000 BC, it is believed that silk was being used over a wide region of South Asia. 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.

Silkworm larvae are fed with mulberry leaves, and, after the fourth molt, they climb a twig placed near them and spin their silken cocoons. This process is achieved by the worm through a dense fluid secreted from its structural glands, resulting in the fiber of the cocoon. The silk is a continuous filament comprising fibroin protein, secreted from two salivary glands in the head of each larva, and a gum called sericin, which cements the filaments. The sericin is removed by placing the cocoons in hot water, which frees the silk filaments and readies them for reeling. This is known as the degumming process. The immersion in hot water also kills the silkworm pupa.

Single filaments are combined to form thread, which is drawn under tension through several guides and wound onto reels. The threads may be plied to form yarn. After drying, the raw silk is packed according to quality.

Stages of production

The stages of production are as follows:

The silk moth lays thousands of eggs.

The silk moth eggs hatch to form larvae or caterpillars, known as silkworms.

The larvae feed on mulberry leaves.

Having grown and moulted several times, the silkworm extrudes a silk fiber and forms a net to hold itself.

It swings its head from side to side in a figure distributing the saliva that will form silk.

The silk solidifies when it contacts the air.

The silkworm spins approximately one mile of filament and completely encloses itself in a cocoon in about two or three days. The amount of usable quality silk in each cocoon is small. As a result, about 2500 silkworms are required to produce a pound of raw silk.

The intact cocoons are boiled, killing the silkworm pupa.

The silk is obtained by brushing the undamaged cocoon to find the outside end of the filament.

The silk filaments are then wound on a reel. One cocoon contains approximately 1,000 yards of silk filament. The silk at this stage is known as raw silk. One thread comprises up to 48 individual silk filaments.

DIFFERENT METHODS FOR INSECT COLLECTION AND PRESERVATION

Presented by: hessa al-obaid

Goals of sample collection



- As a hobby .
- Measure biodiversity.
- Detect changes in water quality .
- Acquire material for biological, physiological, ecological and molecular studies.

Because of the incredible diversity of insects, we must select an appropriate tool and an appropriate way for collection.

Equipment and Collecting Methods

- **Equipment or appropriate tool**
- Forceps, Vials containing alcohol or other preservatives
- Killing jars, Small boxes for storing specimens after their removal from killing jars.
- aspirators.
- Notebook
- A strong knife, hand lens
- A small, fine brush for picking up minute specimens.



Method or appropriate way:

- ❖ 1-picking up insects by hand
 - This method is simple and sometimes effective, **with** large terrestrial insects, Such as cockroaches where they are picked by hand and put it in a bottle.

2-Collecting Nets

Collecting nets come in three basic forms:

- Aerial nets

is designed especially for collecting butterflies and other flying insects. Both the bag and handle are relatively lightweight

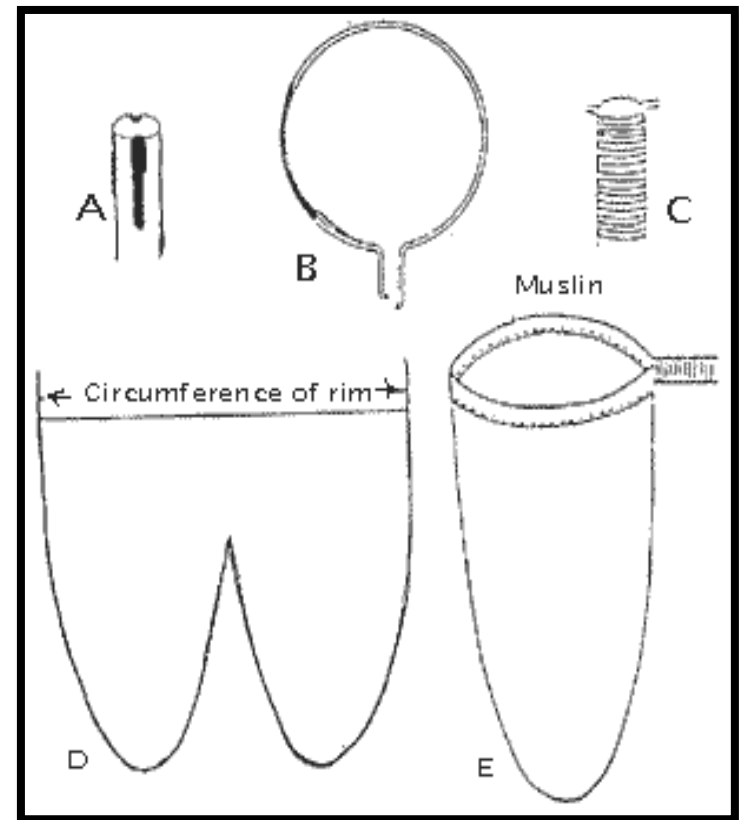


- Aquatic nets

are used for gathering insects from water.

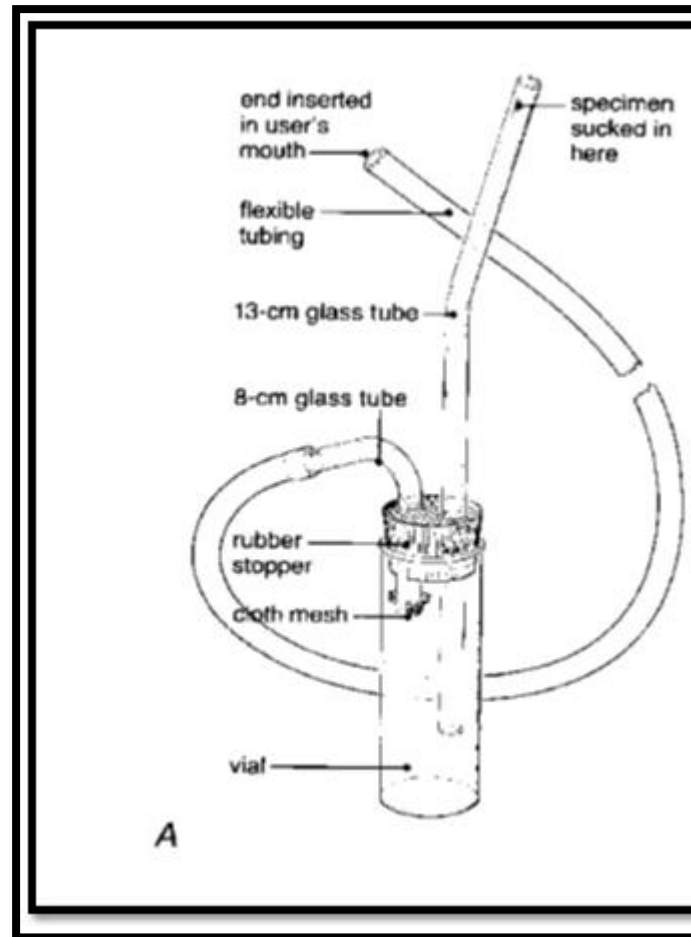
Sweeping Nets:

Made of thick fabric used in the compilation of most types of insects on crops such as wheat and clover ring, potatoes, herbs and grasses.



3- aspirator

- is effective device for collecting small insects. The following materials are

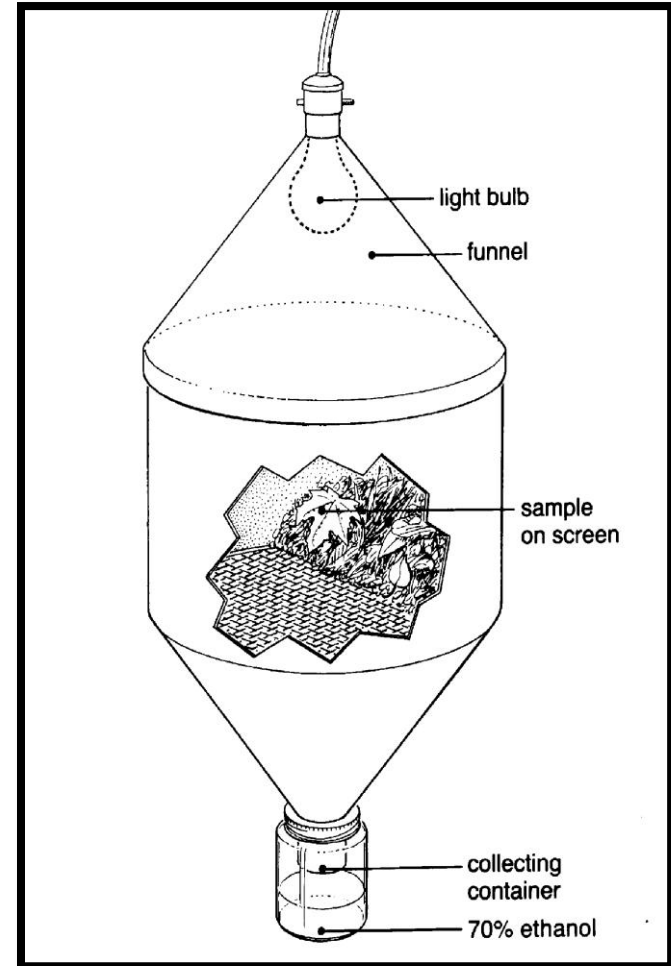


4-Beating Sheets

- Beating sheet should be made of durable fabric, preferably white, attached to a frame about 1 m.
- Place it under a tree and sharply beat the branches or foliage with a club or stick.
- Specimens will fall onto the sheet and may be removed from the light-colored material by hand or with forceps, a moistened brush, or an aspirator.
- useful in collecting beetles, true bugs, and larval Lepidoptera.

5-Sifters

- In this way use kind of Sifters or Berlese funnel
- to collect insects that live in ground litter, rotting wood, fungi, shore.
- The size of the mesh depends on the size of the specimens sought.
- To use the sifter, place the material to be sifted into the container and shake it gently over a white pan or piece of white fabric. As the insects and mites fall onto the fabric, they may be collected with forceps, a brush, or aspirator



6- Traps

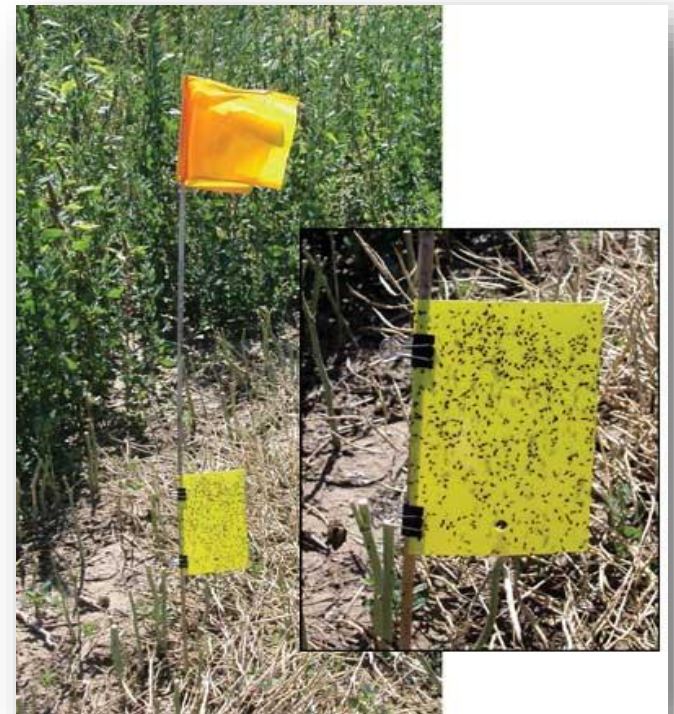
□ light traps

With light traps, advantage is taken of the attraction of many insects to a light source which increasingly active at night



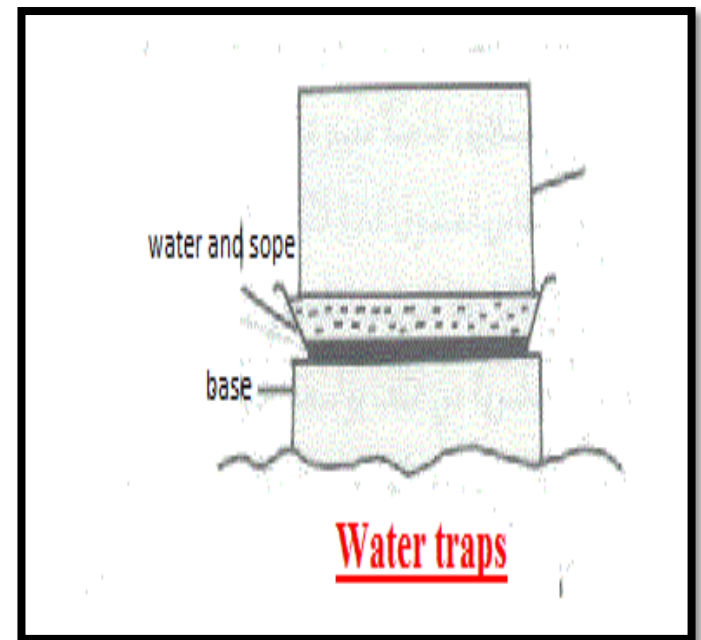
Sticky traps

- using in the collection of insects active at night and day, a cylinder or a glass tube coated with an adhesive, and placed on the pillar to the desired height then, stud and identify the insects stuck



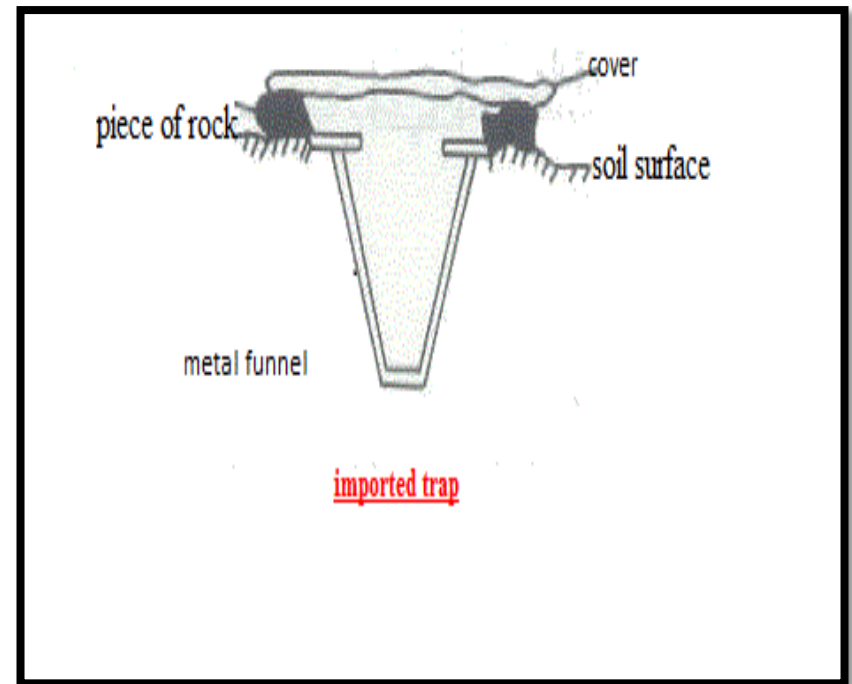
Water traps

- using to collect many kinds of insects such as flies, which is a time painted from the inside in yellow or white to attract insects to it.



Imported traps

- This method is used in the compilation of terrestrial insects such as ants. This traps are composed of glass container or plastics with a wide mouth jar and drown in a hole under the surface of the soil



killing insect

- ❑ After collecting living insects, put in jars.
- ❑ These bottles have different sizes and tight lid, chemicals are added to kill insects.
- ❑ The most important chemicals used to kill insects Cyanorsodium or potassium, chloroform and ethyl acetate.



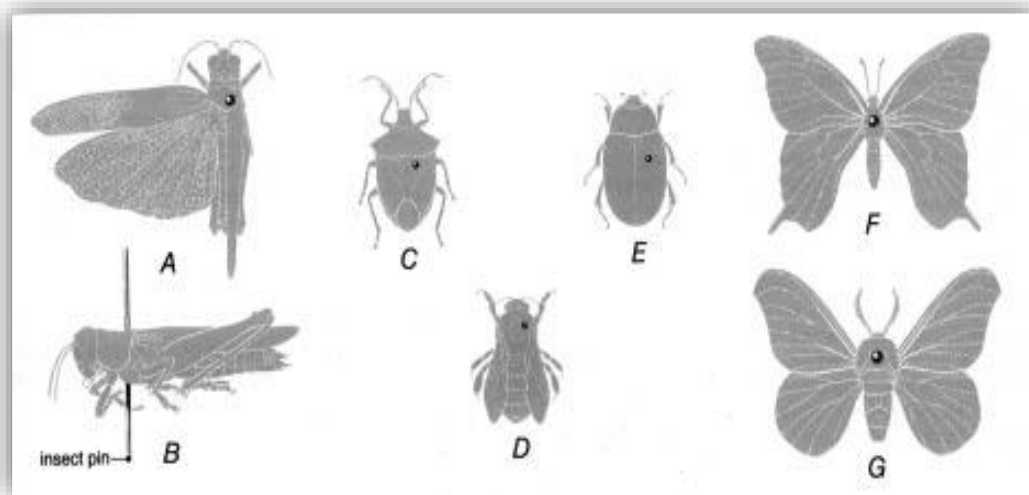
Preservation insect

□ Dry preservation:

used with insect have a hard outer cover to dry in good condition. Then kept Samples in special boxes made of wood with tightly closed.

□ labeled.

□ Avoid placing specimens collected at different times or places in the same container The process of pinning the insect immediately after killing and before the dry stick a pin vertically in the chest area, so that leaves about 4 / 1 pin along the top body



□ Liquid Preservation

used to save the insects that are difficult to maintain dry, or the insect collected by light traps in large numbers.

□ Save by microscopic slides

- used in the maintenance of very small insects which are placed in a liquid then carry on slides Such as fleas, aphid
- Most species have soft bodies
- save some parts of the body such as insect legs, antennae, wings and mouth parts

□ temporarily stored

placing specimens with the wings folded together dorsally (upper sides together) in folded triangles or in small rectangular envelopes of glassine paper, which are the translucent envelopes familiar to stamp collectors.



Lepidoptera temporarily stored in paper and glassine

