Introduction to Inse

- **What is Entomology**
  - Study of insects
  - All relationships dealing with insects
  - Sometimes includes other arthropods –
    mites
- **Entomologist**
  - Person who studies insects or related organis
  - Studies relationships
  - Studies for criminology
  - Studies as a hobby
  - Studies for pest control

Introduction to Insects

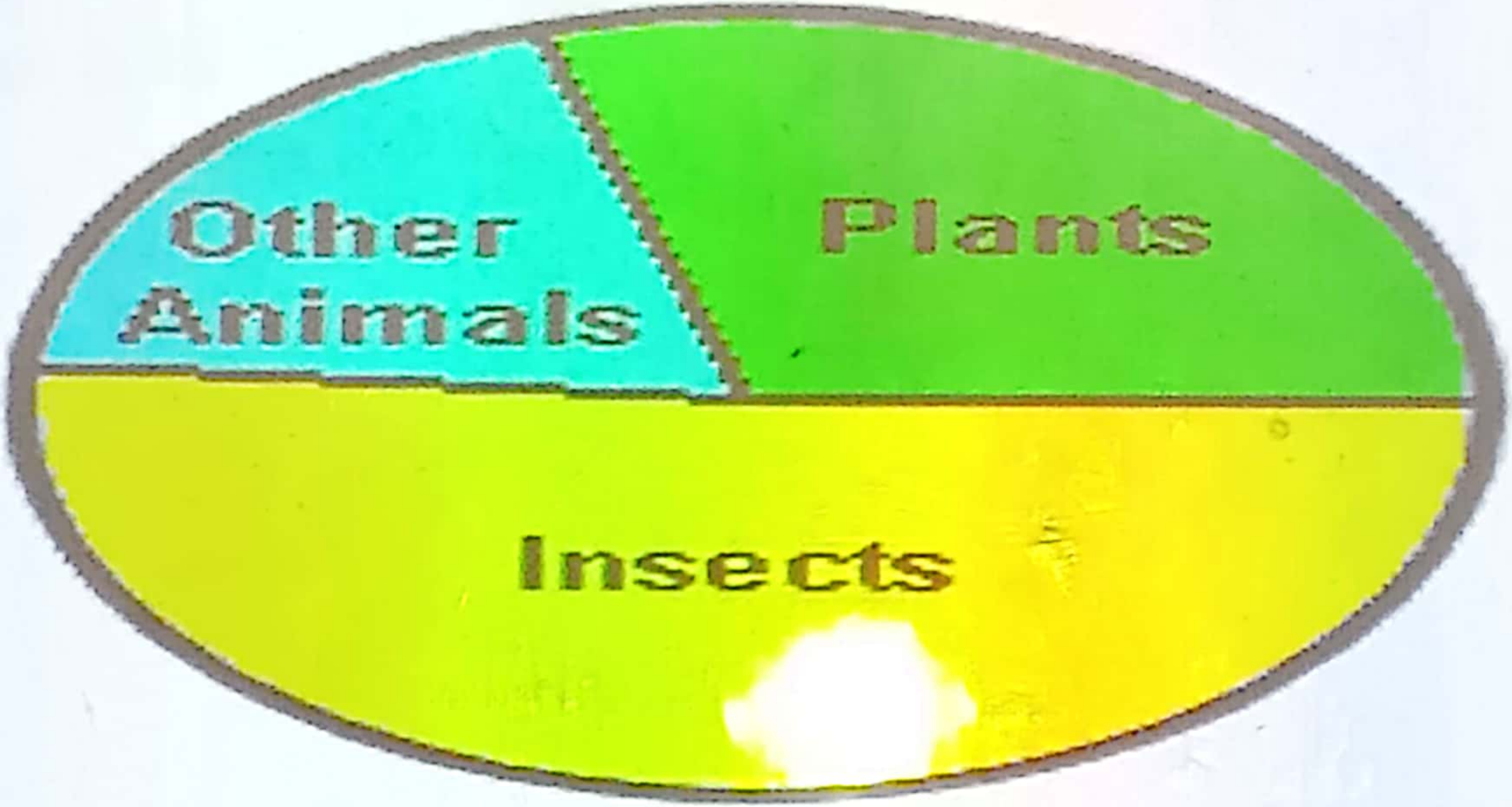
- **What are Insects?**
  - Are **Arthropods**
  - Arthropoda means "jointed feet"
- **General Characteristics of insects**
  - Have segmented bodies
  - Paired, segmented appendages
  - Bilateral symmetry
  - Exoskeleton
  - Dorsal heart and open circulatory system
  - Ventral nerve cord

Introduction to Insects

- **Why Study Insects?**
  - Most numerous creatures on Earth
  - More than 1 million species of insects
  - Represent greater than ¾ species in Animal Kingdom
  - 1 human being/200 million insects
  - 40 million insects/acre of land
  - Less than 3% are significant pests

Introduction to Insects

Insect make up 53% of organisms on earth



Introduction to Insects

- **Why Study Insects?**
  - Because they dominate all terrestrial environments that support human life, insects are usually our most important competitors for food, fiber, and other natural resources.
  - Insects play important ecological roles that support our human and animal life
  - Insect also transmit disease causing pathogens to crops, animals and humans

Introduction to Insects

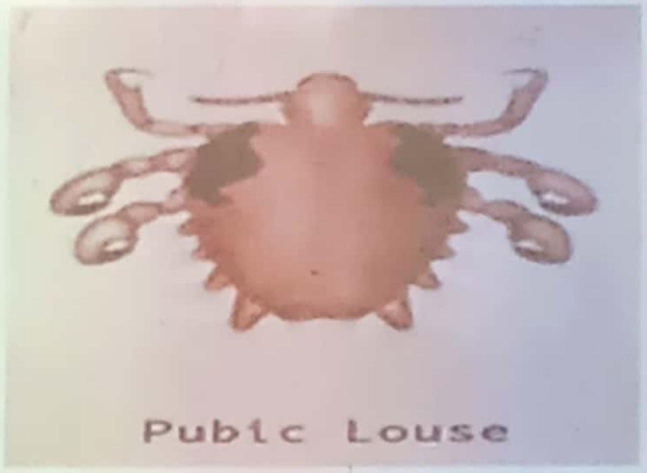
- **Why Study Insects?**
  - Because they dominate all terrestrial environments that support human life, insects are usually our most important competitors for food, fiber, and other natural resources.
  - Insects play important ecological roles that support our human and animal life
  - Insect also transmit disease causing pathogens to crops, animals and humans

Introduction to Insects

- **Impact of insects**
- Have a direct impact on agricultural food production by chewing the leaves of crop plants, sucking out plant juices, boring within the roots, stems or leaves, and spreading plant pathogens.
- Feed on natural fibers, destroy wooden building materials, ruin stored grain, and accelerate the process of decay.

Introduction to Insects

- **Impact of insects**
- They also have a profound impact on the health of humans and domestic animals by:
  - causing annoyance,
  - inflicting bites and stings, and
  - transmitting diseases such Malaria etc



Introduction to Insects

- **Impact of insects**
- The **economic impact** of insects is measured not only by the market value of products they destroy and the cost of damage they inflict but also by the money and resources expended on prevention and control of pest outbreaks.

Introduction to Insects

- **Benefits from insects**
- But despite the tremendous economic losses they may cause, it is not entirely fair to cast the members of **Class Insecta** as villains who rob us of our food and livelihoods.
- They are also cherished allies on whom we depend to keep the natural environment clean and productive.

Introduction to Insects

- **Benefits from insects**
- Insects supply unique natural products,
- They regulate the population densities of many potential pest species,
- They dispose of our wastes, bury the dead, and recycle organic nutrients.
- Indeed, we seldom stop to consider what life would be like without insects and how much we depend on them for our very survival.

Introduction to Insects

- **Food Source**
- Insects represent an important **food source** for a wide variety of other animal species.
- Freshwater fish such as trout, bass, and bream feed extensively on aquatic insects like mayflies, stoneflies etc.
- Artificial "flies" used by anglers are often made to resemble a fish's natural prey.
- Many toads, frogs, turtles, snakes, chameleons and lizards also consume insects as a major part of their diet.

Introduction to Insects

- **Food Source**
- Insectivory is common among land-dwelling birds. Purple martins, barn swallows, vireos, warblers, flickers, whippoorwills, and swifts, for example, survive almost exclusively on insects.
- There are also some insectivorous mammals: shrews, moles, bats, armadillos, and anteaters, for example that depend on insects.

Introduction to Insects

- **Food Source**
- Insects were undoubtedly an important **source of nutrition** for humans also.
- Insects are high in protein and low in fat,
- e.g. Caterpillars, grasshoppers, Katydids, Termites, cicadas, crickets etc

Introduction to Insects

- **Decomposers**
- Insects as **consumers, scavengers, and decomposers**, play a vital role in the biogeochemical cycling of nutrients.
- Insects help aerate the soil, improve its retention of rainwater, and enhance its tilthy.
- They turn more soil than earthworms and redistribute nutrients within the root zone as they burrow and nest in the ground.

Introduction to Insects

- **Decomposers**
- Within the ranks of **scavengers, and decomposers** , they are several major groups:
  - those that feed on dead or dying plant tissues
  - those that feed on dead animals (carrion), and
  - those that feed on the excrement (feces) of other animals.

Introduction to Insects

- **Parasitoids and Predators**
- **As parasitoids and predators** of other organisms, insects are part of a natural system of checks and balances that strengthens community stability and prevents explosive population growth from overrunning natural resources.
- So far, over 6000 insect species have been tested and released as biological control agents to fight insects and weeds that we regard as pests.
- But there are also countless other species that work for us as population regulators, often unnoticed until they are accidently destroyed by a natural disaster or human intervention.

Introduction to Arthropods

B. Arthropods

– Five Classes

1. Class Crustacea

a. Shrimp, crabs, lobsters, pillbugs

b. Mostly Aquatic

c. Fill marine niches where insects are not found

d. Most breathe with gills and have hard outer shell.

e. Body has two regions - cephalothorax and abdomen

f. 2 pair of antennae, legs for swimming

g. Beneficial - exceptions pillbugs, sowbugs and barnacles.

Introduction to Arthropods

2. Class Diplopoda

a. Millipedes

b. Cylindrical with 25 to 100 segments

c. Most segment have 2 pairs of legs

d. Beneficial - eat decaying matter

Introduction to Arthropods

3. Class Chilopoda

a. Centipedes

b. Flattened body with many segments

c. 1 pair of legs per segment

d. Beneficial - eat invertebrates

e. Some can inflict painful bite and inject venom

Introduction to Arthropods

4. Class Arachnida

a. Major - Spiders, Mites, Ticks, Scorpions

b. Most diverse next to insects

c. 2 body regions - cephalothorax and abdomen

d. No antennae

Introduction to Arthropods

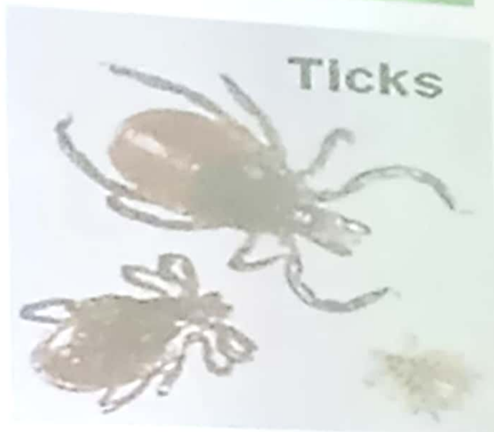
Spiders - Order Araneae

1. Unsegmented abdomen connected to cephalothorax by a thin stalk or pedicel
2. Eight legs
3. Mouthparts for crushing prey and sucking out juices
4. Silk spinning organs
5. Beneficial
6. Some poisonous

Introduction to Arthropods

Mites and Ticks - Order Acari

1. Pests of man, animals and plants
2. Unsegmented abdomen broadly joined to cephalothorax
3. Piercing sucking mouthparts
4. Mites
   a. feed on plants, animals and organic debris
   b. Scabies, plant pests
5. Ticks
   a. Feed on animals
   b. Transmit disease



Introduction to Arthropods

5. Class Insecta or Hexapoda

General characteristics of insects:

- The body is comprised of 3 distinct body regions -- head, thorax, and abdomen
- The thorax of adults bears 3 pairs of legs and 2 pairs of wings

Reasons for Insect Success

1. Exoskeleton
2. Ability to fly
3. Small in size ←
4. High reproductive potential
5. Adaptability
6. Complete metamorphosis
   (Holometabolous)
   Hemimetabolous - incomplete

Reasons for Success

- In brief, these attributes include:
  - an exoskeleton,
  - small body size,
  - ability to fly,
  - high reproductive potential,
  - complete metamorphosis, and
  - adaptability in an ever-changing environment.

Reasons for Success
Exoskeleton

- Unlike vertebrates, an insect's supporting skeleton is located on the outside of its body.

This exoskeleton is a marvelous structure that:

- gives shape and support to the body's soft tissues,
- provides protection from attack or injury,
- minimizes the loss of body fluids in both arid and freshwater environments,
- assures mechanical advantage to muscles for strength and agility in movement.

Reasons for Success
Exoskeleton

- The exoskeleton is a "suit of armour", that resist both physical and chemical attack.
- It is covered by an impervious layer of wax that prevents desiccation.

Reasons for Success
Small size

- In general, the insects are marvels of miniaturization.
- Most species are between 2 and 20 mm (0.1 - 1.0 inch) in length, although they range in size from giant moths that would nearly cover your computer screen to tiny parasitic wasps
- *Dichomorpha echmepterygis* is the smallest of the small. Discovered in 1997, this Costa Rican wasp (family Mymaridae) is a parasite of other insects' eggs.
- Adult males may be only 0.139 mm (0.00055 inch) in length -- nearly 1/3 smaller than some single-celled protozoa (e.g., *Paramecium caudatum*).

Reasons for Success
Small size

- Another advantage of small size is the minimal resources needed for survival and reproduction.
- A crumb is a feast; a dewdrop quenches thirst; a pebble provides shade.
- In some cases, food requirements are so modest that an insect may live on a single plant or animal for its entire life and never exhaust its food supply.

Reasons for Success

Small size

- Finally, small size is a big advantage to insects that must avoid predation.
- They can hide in the cracks of a rock, beneath the bark of a tree, behind the petal of a flower, or under a blade of grass.
- The exoskeleton is hard enough for them to burrow between individual grains of sand, yet flexible enough to let them squeeze through the tiniest of cracks.
- Small size, together with adaptations in body shape and coloration, gives many species the ability to blend so well with their environment that they become virtually undetectable.

Reasons for Success
Ability to Fly

- The forces of natural selection have shaped insect flight into a remarkably efficient process employing principles of aerodynamics that human engineers do not yet fully understand.
- Although the metabolic cost of flight (calories per unit of lift) is similar to that of birds and bats, an insect's flight musculature produces at least 2X more power per unit of muscle mass.
- This high efficiency is largely due to elasticity of the thorax -- 90-95% of the potential energy absorbed by flexion of the exoskeleton is released as kinetic energy during the wing's down stroke.

Reasons for Success
Ability to Fly

- Insects are the only invertebrates that can fly.
- Flight give insects a highly effective mode of escape from predators.
- It is also an efficient means of transportation, allowing populations to expand more quickly into new habitats and exploit new resources.

Reasons for Success
Ability to Fly

- Efficient use of energy allows some insects to travel great distances or remain airborne for long periods of time.
- More than 200 species, including moths, dragonflies, locusts, flies, and beetles are known to migrate over long distances by air.
- The migratory locust, *Schistocerca gregaria*, can fly for up to 9 hours without stopping.
- Large swarms occasionally traverse the Mediterranean Sea.

Reasons for Success
High Reproductive Potential

- Reproductive success is one of the most significant measures of an organism's fitness.

In insect populations, females often produce large numbers of eggs (high **fecundity**), most of the eggs hatch (high **fertility**), and the life cycle is relatively short (often as little as 2-4 weeks).

Together, these three characteristics enable insects to produce remarkably large numbers of offspring.

Reasons for Success

High Reproductive Potential

- A typical female lays 100-500 eggs in her lifetime, but numbers in the thousands are not uncommon.
- The queen of an African termite colony may be the mother of more than ten million workers during her 20-25 year lifespan.
- Blow flies reared on a diet of owl meat produced an average of 144 progeny: half male, half female.
- Using this data (and assuming no mortality), a single pair of flies could give rise to 10,368 offspring in the third generation, 746,496 in the fourth generation, 53,747,712 in the fifth generation, and 3,869,835,264 in the sixth generation.

Reasons for Success
High Reproductive Potential

- Since most insects die before they ever have an opportunity to reproduce, a high reproductive potential is the species' best chance for survival.
- Many adaptations help maximize this potential.
- Most females, for example, can store sperm for months or years within the spermatheca, a special region of the reproductive system.
- A single mating can supply a female with enough sperm to fertilize all the eggs she will produce in her lifetime.

Reasons for Success
High Reproductive Potential

- An unbalanced sex ratio, where females outnumber males, is another way to maximize reproductive potential.
- Since most insects are not monogamous, a few males can supply sperm for a large number of females.
- And finally, there are many species (e.g. aphids, scale insects, thrips, and midges) where males are entirely absent -- all members of the population are female and contribute offspring through a process of asexual reproduction - **parthenogenesis**

Reasons for Success
Complete Metamorphosis

- Most insects undergo significant developmental changes as they grow from immatures to adults.
- These changes, collectively known as **metamorphosis**, may involve physical, biochemical, and/or behavioral alterations that promote survival, dispersal, and reproduction of the species.

Reasons for Success
Complete Metamorphosis

- In the more primitive insects, most of these changes occur gradually as the animal matures: organs of reproduction and flight develop incrementally during the immature stages and become functional only in adults.
- Since this transformation process is slow and does not include all body tissues (**incomplete metamorphosis**) the immatures and adults share many characteristics -- they often live in similar habitats and feed on similar types of food.

Reasons for Success
Complete Metamorphosis

- More advanced insects, however, undergo **complete metamorphosis** -- a dramatic transformation in form and function between the immature (larval) and adult stages of development.
- In these insects, a larva is primarily adapted for feeding and growth.
- It assimilates energy reserves which, in some cases, will sustain the insect for the rest of its life.
- When fully grown, a larva molts into a transitional stage, called the pupa, and begins a period of massive internal and external reorganization.
- An adult insect (imago) eventually emerges from within the pupal exoskeleton bearing little or no resemblance to its larval form.
- Its primary function is dispersal and reproduction.

Reasons for Success
Complete Metamorphosis

In the class Insecta, only 9 out of 28 orders undergo **complete metamorphosis**, yet these 9 orders represent about 86% of all insect species alive today.

The obvious advantage to this type of development lies in the compartmentalization of the life cycle.

Through natural selection, larval form and function can be optimized for growth and feeding without compromising adaptations of the adult for dispersal and reproduction.

Each stage of the life cycle is entirely free to adapt to its own ecological role.

In some cases, this means that immatures and adults may consume different types of food, exploit different environmental resources, and even occupy different habitats.

Reasons for Success
Adaptability

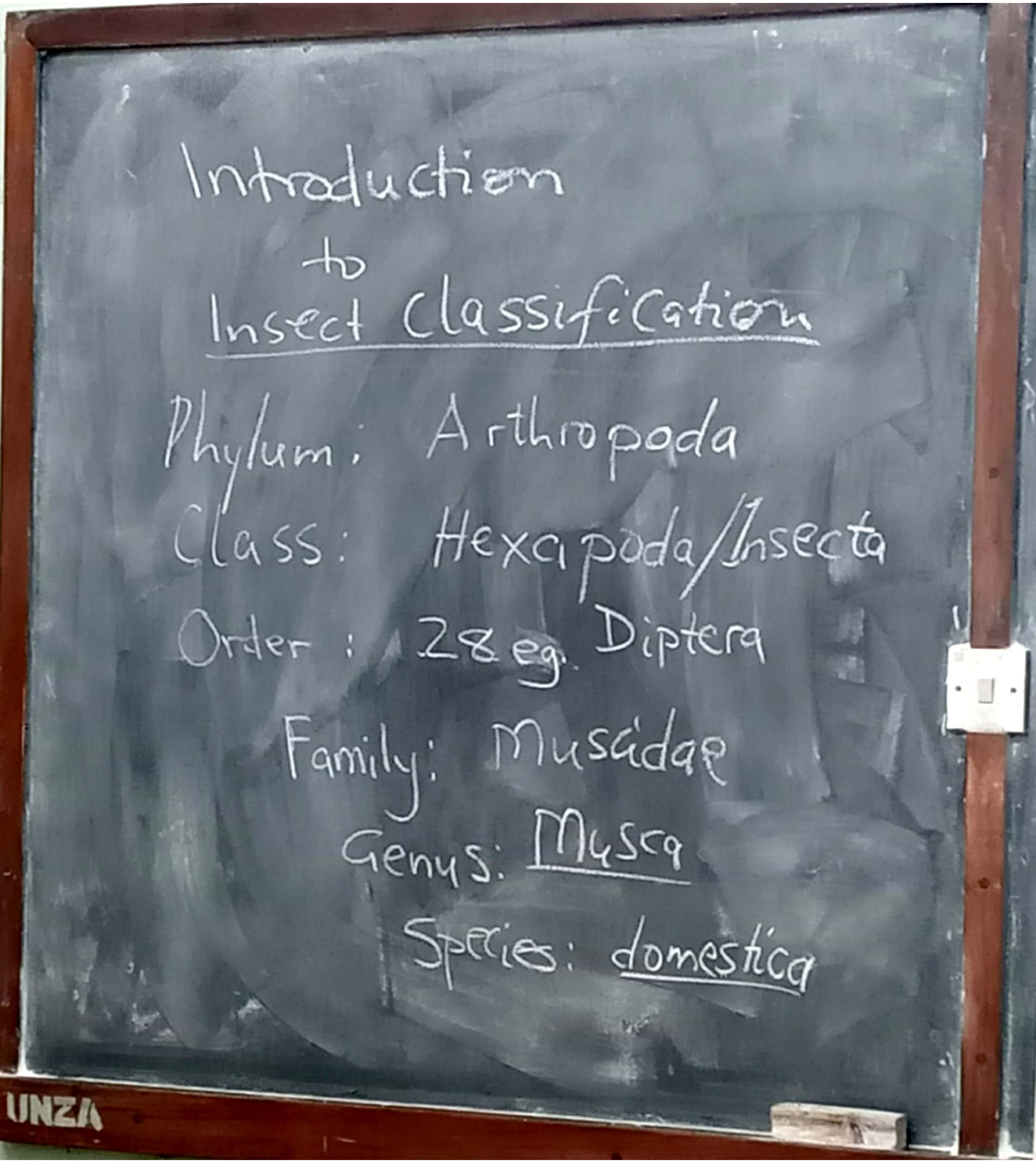
- A combination of large and diverse populations, high reproductive potential, and relatively short life cycles, has equipped most insects with the genetic resources to adapt quickly in the face of a changing environment.
- Their record of achievement is impressive:
  - they were among the first creatures to invade the arid expanses of dry land and exploit green plants as a source of food,
  - they were the first animals to use flight as an escape from predators, and
  - they were the first organisms to develop a complex social hierarchy with division of labor and cooperative care of the young.

Reasons for Success
Adaptability

- Adaptation is an ongoing process.
- Populations must continually change as new resources appear and old ones disappear.
- Insects have acquired a taste for new products that were not part of their "natural" environment: e.g., glue and wallpaper paste, book bindings, cardboard, tanned leather products, mummies, stuffed museum specimens, chocolate, ginger, yeast cakes, tobacco, pepper, and even potent drugs like marijuana and opium.

Reasons for Success
Adaptability

- But a few resistant flies managed to survive because they were endowed with an enzyme that could detoxify DDT.
- These survivors reproduced and passed this resistant trait to their offspring.
- Eventually, DDT-resistant flies repopulated their environment and the species now appears to be living happily ever after!


Introduction
to
Insect Classification
Phylum: Arthropoda
Class: Hexapoda/Insecta
Order: 28 eg. Diptera
Family: Muscidae
Genus: Musca
Species: domestica
UNZA

Insect Classification

- Insects are used in:
  - diversity studies,
  - ecological projects,
  - biological control projects, and
  - monitoring of environmental change,
- It is therefore important to identify and understand the biology of the insects you are dealing with.
- If the identifications are not accurate, then any science that relies upon those determinations will be flawed.

Insect Classification

- **Taxonomy**: the study of the principles of scientific classification.
- Insect Taxonomists have come with a system of classifying insects

Insect Classification

- Ways of identifying insects:
  - Sending it to an expert to identify it
  - Comparing it with labeled specimen in collection
  - Comparing it with pictures
  - Comparing it with descriptions
  - Using an analytical key or dichotomous key (step wise eliminations) and
  - Combination of above

Insect Classification

- **Elements of Classification**
- The procedure of modern Systematists { "the science of the diversity of organisms} was began in 1758 by Swedish botanist –**Carolus Linneaus**
- He is considered father of modern Taxonomy
- He proposed the system of **binomial nomenclature**
- Every organism can be assigned a specific name using a two name system
- Binomial name made up of **genus** and **species** name.

Insect Classification

- **Elements of Classification**
- Scientific names (**genus, species and subspecies**) are italicized or underlined with the genus (first) name capitalized.
- Names of the authors of species follow.
- These names are in parentheses if the classification of the species has changed since it was described.

Scientific names

- The scientific naming of animals follows certain rules, which are outlined in the **International Code of Zoological Nomenclature**.
- One of the first and important rules requires that scientific names be always printed in **italics**. If written or typewritten, italics are indicated by underlining. Scientific names are latinized, but may be derived from any language or from the names of people or places or colour descriptions. Most scientific names are from Latin or Greek words and usually refer to some characteristic of the animal or group named.

Scientific names cont.

- One important rule in scientific names is that the **genus, species** and **subspecies** names should be written in **italics** or **underlined** to show their origin as latin words. These names are then followed by the name of the author, the person who first determines an organism to be a species or subspecies. Authors' names should not be in italics.
- For example, the name *Musca domestica* Linnaeus for the house fly shows Linnaeus to have been the person that described this particular insect. The names of authors are often abbreviated, for example, the name Linnaeus is often abbreviated just L.

Scientific names cont.

- Continuing with the rules of scientific nomenclature, the names of genera (genus) and higher categories always begin with a **capital** letter. Species and subspecies names do not start with a capital letter.
- If the author's name is in parentheses, it means that he described the species or subspecies in some genus other than the one in which it is now placed. For example, in the name *Prostephanus truncatus* (Horn), it means that the species *truncatus* was described by Horn in some genus other than *Prostephanus.*

Scientific names cont.

- A species referred to but not named is often designated simply by **sp**. For example, *Ootheca* sp refers to a species of *Ootheca*. More than one species may be designated by **spp.** For example, *Ootheca* spp. Refers to two or more species of *Ootheca*.

Scientific names cont.

- If there are two similar names of an individual the first one is considered correct while the second one is designated as the **synonym.** No two genera of individuals may have the same name. No two species in the same genus may have the same name.
- When listing several species from the same genus it is usual to give genus name in full only once and thereafter use just the first letter, i.e., *Ophiomyia phaseoli*, *O. spencerella*, *O. centrosematis*.

Insect Classification

- **Elements of Classification**
- An insect name is complete if the **genus, species** and **author names** are given.
- The author is the person who first described the species as new to science.
- **Law of Priority.** -- This states that the first name given to a species is preferred if it is later described under another name.
- The later name for the same species is then called a **synonym**.

Insect Classification

- **Elements of Classification**
- **Common Name System.**
- This is used as a substitute for the names of orders and families, e.g. beetles, locusts, grasshoppers, crickets, leafhoppers, etc.
- It applies to a segment of an order.
- However, scientific names are more valuable in international discourse.

Common names

- Many common names of insects refer to groups such as subfamilies, families, suborders, or orders rather than to individual species.
- Most common names of insects that consist of a single word refer to the entire order e.g., the common name beetle refers to the order Coleoptera; fly refers to Diptera; and bug to Hemiptera, with only a few that refer to families, like ants to Formicidae and Mantids to Mantidae.

Common names cont.

- The names **fly**_ and **bug** are used for insects in more than one order, and the way the names of these insects are written may indicate the order to which the insect belongs.
- For example, when a fly belongs to the order Diptera, the **fly** part of the name is written as a separate word, as in **black fly, house fly, horse fly**, and **tsetse fly**. When the insect belongs to another order, the **fly** part of the name is written together with the descriptive word, as in **butterfly, dragonfly, sawfly,** and **damselfly**.

Common names cont.

- When a bug belongs to the order Hemiptera, sub-order Heteroptera) the **bug** of the name is written as a separate word, as in **stink bug**, **Assassin bug** and **damsel bug**. When it belongs to another order, the **bug** part of the name is written together with the descriptive word, as in **mealybug** and **junebug**.

Insect Classification

- Classification- Ordering into a hierarchy of categories
- The **Taxonomic Hierarchy-** start with most inclusive to the least
  - **Kingdom:**
    - **Phylum:**
      - **Class:**
        - **Order:**
          - **Family :**
            - **Genus :**
              - **Species :**
  - Each can be sub-grouped- i.e. Super or Sub

Insect Classification

- These groups often use a prefix of super- (above) or sub- (below) to indicate the position of the new group in the above list.
- Thus, superfamily groups fall between order and family while subfamily groups fall between family and genus.

Integrated Pest Management (IPM)

- It is a system that, in the context of associated environment and population dynamics of the pest species, utilizes **all suitable** techniques and methods in as **compatible a manner** as possible and maintains pest populations at levels below those causing economic injury (FAO, 1967)
- It is the intelligent selection and use of pest control tactics that will ensure favourable economical, ecological and sociological consequences (Luckmann & Metcalf, 1994)

IPM

- IPM, as it was originally conceived, proposed to manage pests though an understanding of their interactions with other organisms and the environment.
- Most of the 77 definitions for IPM listed in *The Database of IPM Resources (DIR)* website, <http://www.ipmnet.org/DIR/>, despite some differences in emphasis, agree with this idea and have the following elements in common:

IPM

1. A conception of a managed resource, such as a cropping system on a farm, as a component of a functioning ecosystem.

- Actions are taken to restore and enhance natural balances in the system, not to eliminate species. Regular monitoring makes it possible to evaluate the populations of pest and beneficial organisms.

2. An understanding that the presence of a pest does not necessarily constitute a problem.

Before a potentially disruptive control method is employed, appropriate decision-making criteria are used to determine whether or not pest management actions are needed.

IPM

3. A consideration of all possible pest management options *before* action is taken.

4. A philosophy that IPM strategies integrate a combination of **all suitable techniques** in as **compatible a manner as possible**; it is important that one technique not conflict with another

Integrated Pest Management

- **What is a pest?**

An agricultural pest is any organism or infectious agent that causes stress or damage to a desired plant or plant product.

For example, a **weed** is a pest if it competes with a crop for resources, causing the crop stress it otherwise would not have.

Infectious bacteria, fungi, and viruses cause **diseases** and are therefore pests.

The most familiar pests are **insects**, ranging in size from the small whitefly to large swarms of locusts. Larger pests such as birds, mice, and rabbits can also cause damage in the field.

IPM Cont.

- When the topic of agricultural pest management is mentioned, most people think first about monitoring for pests or intervening to reduce pests: **scouting**, **pest identification**, and/or **application of pesticides** are some specific practices. However, prevention is an often-overlooked key strategy that farmers can use to minimize the likelihood of pest problems.

IPM cont.

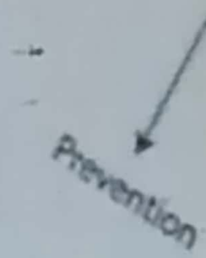
- **Pest prevention**

Pest prevention (sometimes called **pest avoidance**) is the deliberate minimization of the potential for pests to be present in the field. **Preventative measures are the foundation of IPM, minimizing risks of crop damage**.

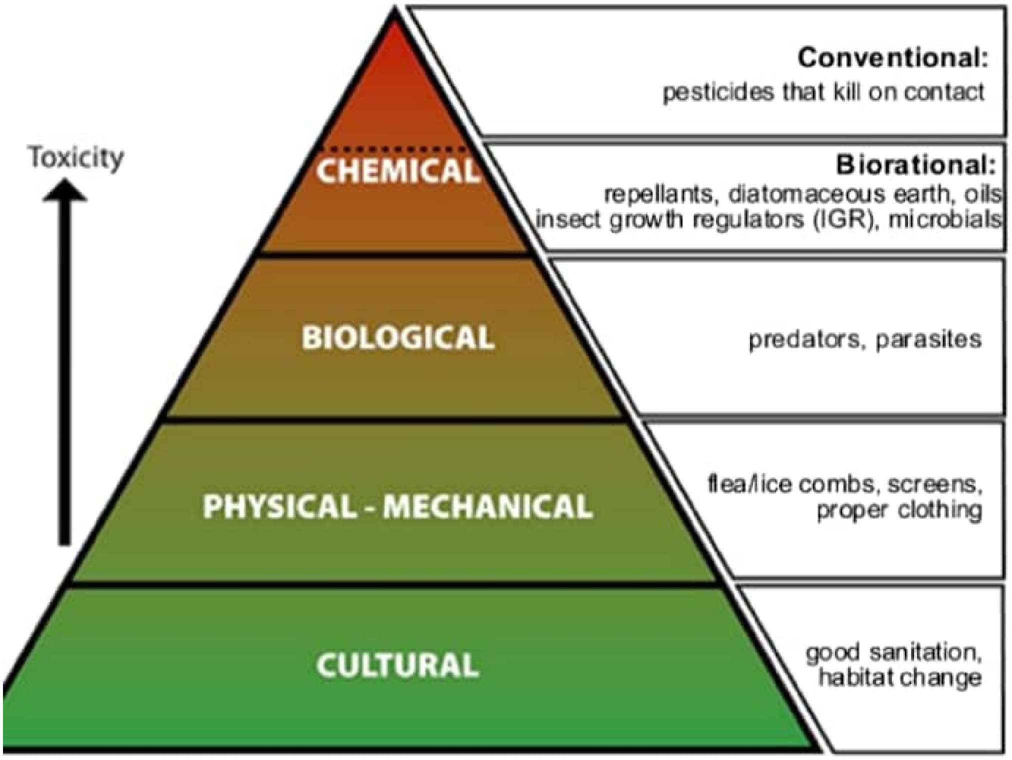
Among all pest control methods (e.g. biological, physical, cultural and chemical), some techniques are preventative while others are suppressive (Figure 1).

Preventative techniques create unfavourable conditions for pests, for example by limiting pests' access to water, food sources, or shelter.

Suppressive techniques kill or trap pests, reducing existing populations. This section focuses only on preventative methods. This is considered the foundation of IPM.



st Management (IPM)



opulations to levels below those ca
act, using multiple & compatible te

onmental impact of pest manage


IPM cont.

Prevention principles and examples

i. Select crops or varieties best able to resist pests

Crops differ in their natural defences against pests, and so do individual crop varieties. Plants actively defend themselves against pests in several ways.

IPM cont.

a. **Non-preference** plants have some trait (e.g. colour, odour, toxicity, or texture) that makes them undesirable to pests. For example, various bean species have trichomes (specific plant hairs) that trap insects or deter them from landing on or laying eggs on leaves.

As another example, some plants do not taste good or are toxic, which deters pests from eating them (at least the second time).

IPM cont.

b. **Resistant** plants respond to pest damage in ways that reduce the amount of damage that the pest can cause. Many resistant cultivars have been developed through crop selection. Carioca bean mutant resistant to bruchids (CA38-38-9-B).

c. **Tolerant** plants are more likely to remain relatively healthy and to maintain yield after pests damage them. They can fight off diseases and/or heal after damage has already been done.

IPM cont.

ii. **Maintain plant resilience to pests/disease**

The health of propagation material contributes to the establishment of a successful crop. Make sure the seed you collect and save is fully developed and mature. **Select healthy seed/propagation material** that is free of disease, is viable (alive), and has high vigour (is strong).

IPM cont.

iii. **Practice farm sanitation**

Pests sometimes remain and multiply on non-crop plants such as weeds that grow among crops. You can help control pest populations by **reducing or disrupting pest habitat around the crop**. Remove volunteer/weed plants that create habitat for pests, and plants or plant residues that are diseased. Good farm sanitation also includes **cleaning equipment after working around infected plants**.

IPM cont.

iii. **Practice farm sanitation**

Pests sometimes remain and multiply on non-crop plants such as weeds that grow among crops. You can help control pest populations by **reducing or disrupting pest habitat around the crop**. Remove volunteer/weed plants that create habitat for pests, and plants or plant residues that are diseased. Good farm sanitation also includes **cleaning equipment after working around infected plants**.

IPM cont.

v. **Design to divert or minimize pests (habitat management)**

Arguably, the most sustainable ways to prevent pest problems over the long term are linked to habitat management. This approach includes designing systems in ways that either divert pests away from agronomic crops or increase favourable conditions for pests' natural enemies. Almost all of the methods and techniques around habitat management will **increase a system's overall plant diversity**.

IPM cont.

iv. **Rotate crops (over time and/or spatially)**

Crops in the same family tend to be sensitive to similar pests and diseases. Crop rotation over time and/or space can break the life cycle of a pest by removing the crop host that the pest needs to survive. One option is to **rotate a specific field through crops that are sensitive to different pests, over time**.

IPM cont.

a. **Conserving native areas around crops** can help prevent pests in several ways. Native plants house beneficial insects that prey on pests or outcompete them for resources. Hedgerows around crops can also visually or physically block the entrance of some pests.

IPM cont.

b. Sometimes a farmer plants a **trap crop** on the outer perimeter of the plot. A trap crop is a preferred host plant for a pest that also affects a primary crop; by planting it around the perimeter, the pest is led away from the field crop to infest the trap crop instead.

IPM cont.

c. Farmers can **intercrop fields with companion plants**. Companion plants benefit crops in several different ways. Some deter pests to which cash crops are susceptible or sensitive. One example is marigold, which can reduce a number of pests in various crops (for more information about marigolds, see *EDN 132*). Other companion plants attract natural predators of pests.

IPM cont.

d. The **"Push-Pull"** approach for pest control simultaneously incorporates trap crops and companion plants.

PEST MONITORING, SURVEILLANCE AND FORECASTING

- Pest monitoring

  Monitoring phytophagous insects and their NEs is a fundamental tool in IPM-for taking management decision

- Estimation of changes in insect distribution and abundance
- Information about insects, life history
- Influence of biotic and abiotic factors on pest population.

PEST SURVEILLANCE

- Refers to the constant watch on the population dynamics of pests, its incidence and damage on each crop at fixed intervals to forewarn the farmers to take timely crop protection measures.
- Three basic components of pest surveillance

Determination of

i. the level of incidence of the pest species

ii. the loss caused by the incidence

iii. the economic benefits, the control will provide

Objectives of Pest Surveillance

1. To know existing and new pest species
2. To assess pest population and damage at different growth stage of crop
3. To study the influence of weather parameters on pest
4. To study changing pest status (minor to major)
5. To assess Nes and their influence on pests
6. Effect of new cropping pattern and varieties on pest

PEST FORCASTING

- Forecasting of pest incidence or outbreak based on information obtained from surveillance
- Uses

i. Predicting pest outbreak which needs control measure

ii. Suitable stage at which control measure gives maximum protection

PEST FORCASTING CONT.

- Two types of forecasting

1. Short term forecasting-based on 1 or 2 seasons
2. Long term forecasting-based on effect of weather parameters on pest

SURVEY

- Surveys are conducted to study the abundance of a pest species
- Types of Surveys

1. Roving survey (Extensive)-Assessment of pest population/damage from randomly selected spots representing larger area
2. Fixed plot survey (Intensive)-Assessment of pest population/damage from a fixed plot selected in a field.

Qualitative survey-Useful for detection of pest

Quantitative survey-Useful for enumeration of pest

SAMPLING TECHNIQUES

- Absolute sampling-to count all the pests occurring in a plot
- Relative sampling-to measure pest in terms of some values which can be compared over time and space e.g. light trap catch, pheromone trap

METHODS OF SAMPLING

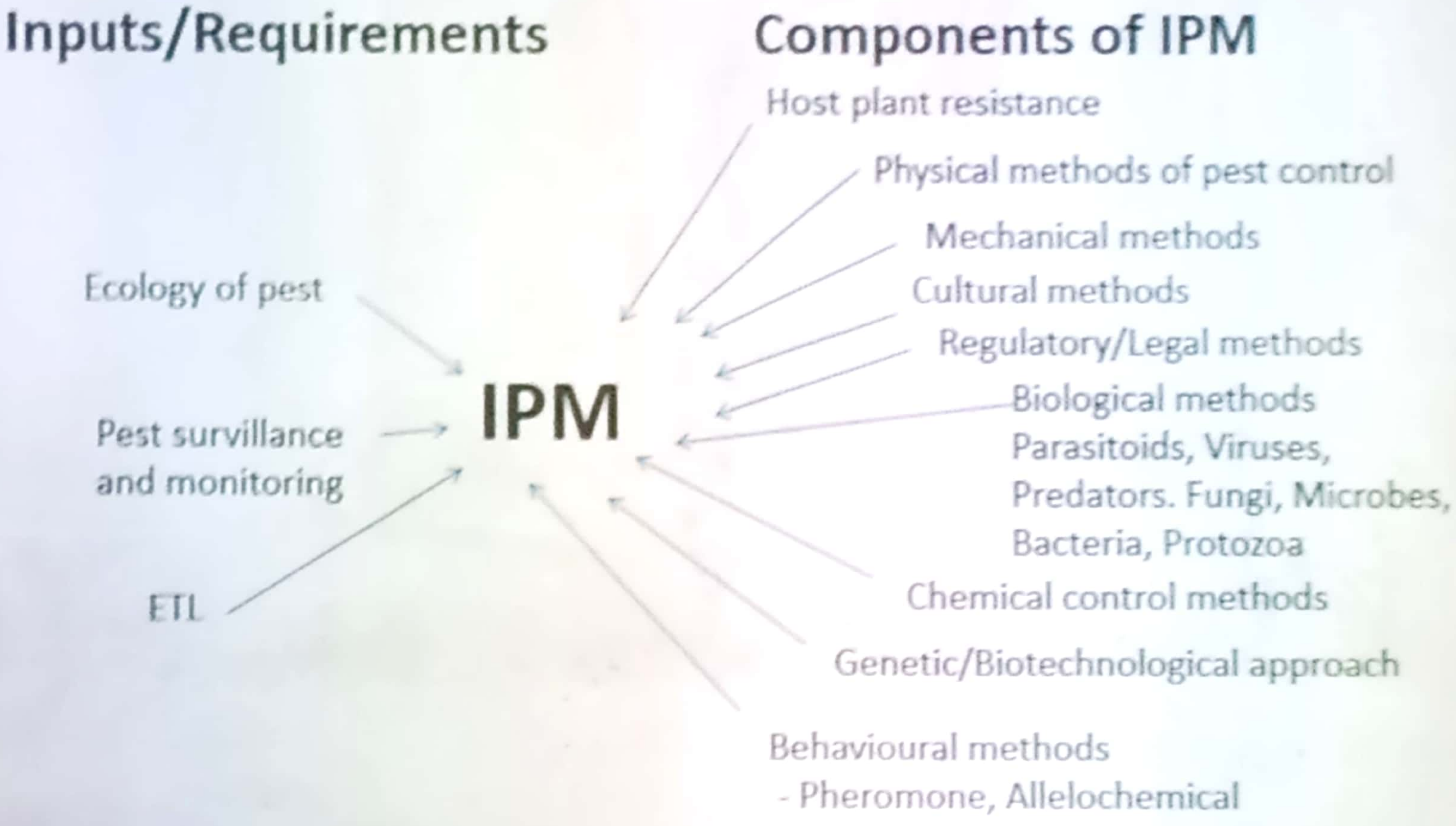
a. *In situ* counts-visual observation on number of insects on plant canopy (either entire plot or randomly selected plot)
b. Knock down (sudden trap)-collecting insects from an area by removing from crop and counting (jarring)
c. Netting-use of sweep net for leafhoppers, odonates, grasshoppers
d. Trapping- light trap for phototropic insects
   -Pitfall trap for crawling insects
   -Pheromone trap for species specific
   -Bait trap-Cutworms

STAGE OF SAMPLING

- Stage of sampling
  - ➢ Usually most injurious stage counted
  - ➢ Sometimes egg masses counted-
  - ➢ Hoppers-nymphs and adult counted
- Sample size

  Differs with nature of pest and crop

TOOLS OR COMPONENTS OF INTEGRATED PEST MANAGEMENT



IPM cont.

- **Economic injury level (EIL)** is defined as the lowest population density that will cause economic damage. Also defined as a critical density where the loss by the pest is equals the cost of control measures.
- **Economic Threshold Level (ETL)** is defined as the pest density at which control measures should be applied to prevent an increasing pest pop from reaching Economic Injury Level (EIL)
- ETL represents pest density lower than EIL to allow time for initiation of control measures

Tools or components of IPM

1. Cultural control: manipulation of cultural practices to the disadvantage of pests.

I. Farm level practices

S. No.	Cropping Techniques	Pest Checked
1.	Ploughing	Bean leaf beetle
2.	Pest free seed material	Potato tuber moth
3.	High seed rate	Sorghum shoot fly
4.	Earthing up	Bean stem maggot
5.	Plant density	Rice brown planthopper
6.	Destruction of weed hosts	Citrus fruit sucking moth
7.	Destruction of alternate hosts	American bollworm
8.	Timely harvesting	Sweet potato weevil
9.	Intercropping	Maize stem borer
10.	Trap cropping	Diamondback moth

Tools or components of IPM contd.

II. Community level practices

i. Synchronized sowing : Dilution of pest infestation e.g. wheat, cotton

ii. Crop rotation: Breaks insect life cycle

iii. Crop sanitation

a. Destruction of insect infested parts e.g. mealybug in eggplants

b. Removal of fallen plant parts e.g. citrus fruits

c. Crop residue destruction e.g. cotton bollworm

Cultural control

Advantages

- No extra skill
- No costly inputs
- No special equipment
- Minimal cost
- Good component in IPM
- Ecologically sound

Disadvantages

- No complete control
- Prophylactic nature
- Timing decides success

2. Physical control

Modification of physical factors in the environment to minimize or prevent pest problems.

A. Manipulation of temperature

i. Hot water treatment (50-55°C for 15 min) against nematode.

ii. Sun drying the seeds to kill the eggs of stored product pests.

iii. Cold storage of fruits and vegetables to kill fruit flies (1-2°C for 12-20 days).

Physical control contd.

B. Manipulation of moisture

i. Drying seeds (<10% moisture level) affects insect development.

ii. Flooding the field for the control of cutworms.

C. Manipulation of light

i. Treating the grains for storage using Infra-red light to kill all stages of insects (e.g.) Infra-red seed treatment unit.

ii. Providing light in commercial warehouses as the lighting reduces the fertility of Indian meal moth, *Plodia*.

iii. Light trapping.

Physical control contd.

D. Manipulation of air

Increasing the CO_2 concentration in controlled atmosphere of stored grains to cause asphyxiation in stored product pests

E. Use of greasing material

Treating the stored grains particularly pulses with vegetable oils to prevent the oviposition and the egg hatching e.g. bruchid adults

F. Use of abrasive dusts

Diatomaceous earth: injury to the wax layer resulting in loss of moisture leading to death. It is used against stored product pests.

3. Mechanical control

- Use of mechanical devices or manual forces for destruction or exclusion of pests.

1. Mechanical destruction: Life stages are killed by manual or mechanical force

a) Mechanical force

i. Hand picking large insects such as caterpillars, grasshoppers, beetles etc.
ii. Beating: swatting house fly and mosquito
iii. Sieving and winnowing: Red flour beetles, bruchids
iv. Shaking the plants: Dislodge large insects like beetles
v. Crushing: Bed bugs and lice
vi. Combing: Delousing method for Head louse
vii. Brushing: Woolen fabrics for clothes moth, carper beetle.

Mechanical control contdd.

viii. Tillage implements: soil borne insects
ix. Mechanical traps: rat traps of various shapes

b. Mechanical exclusion-mechanical barriers prevent access of pests to hosts

i. Wrapping the fruits: covering with polythene bag
ii. Tin barrier: Timber building structures with tin band to prevent rat damage
iii. Netting: mosquitoes, vector control in greenhouse
iv. Banding: Banding with grease or polythene sheets e.g. mango mealybug
v. Trenching: Trapping matching larvae of the African armyworm
vi. Sand barrier: Protecting stored grains with a layer of sand on the top

Mechanical control

Advantages

- Low equipment cost
- Ecologically safe
- Home labour utilization
- High technical skill not required in adopting

Disadvantages

- Limited applications
- Rarely highly effective
- Labour intensive

APPLIANCES IN CONTROLLING THE PESTS

1. Light traps: Most adult insects are attracted towards light in the night. This principle is used to attract the insect and trapped in a mechanical device.

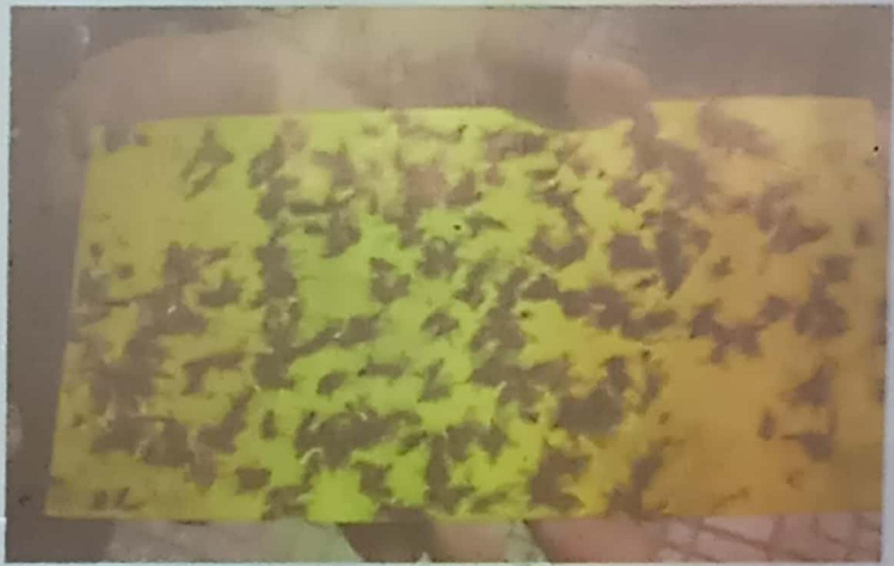
- For example the Mercury vapour lamp light trap: They produce primarily ultraviolet, blue and green radiation with little red e.g. Robinson trap.

APPLIANCES IN CONTROLLING THE PESTS Contd.

- 2. Pheromone trap: synthetic sex pheromones are placed in traps to attract males.

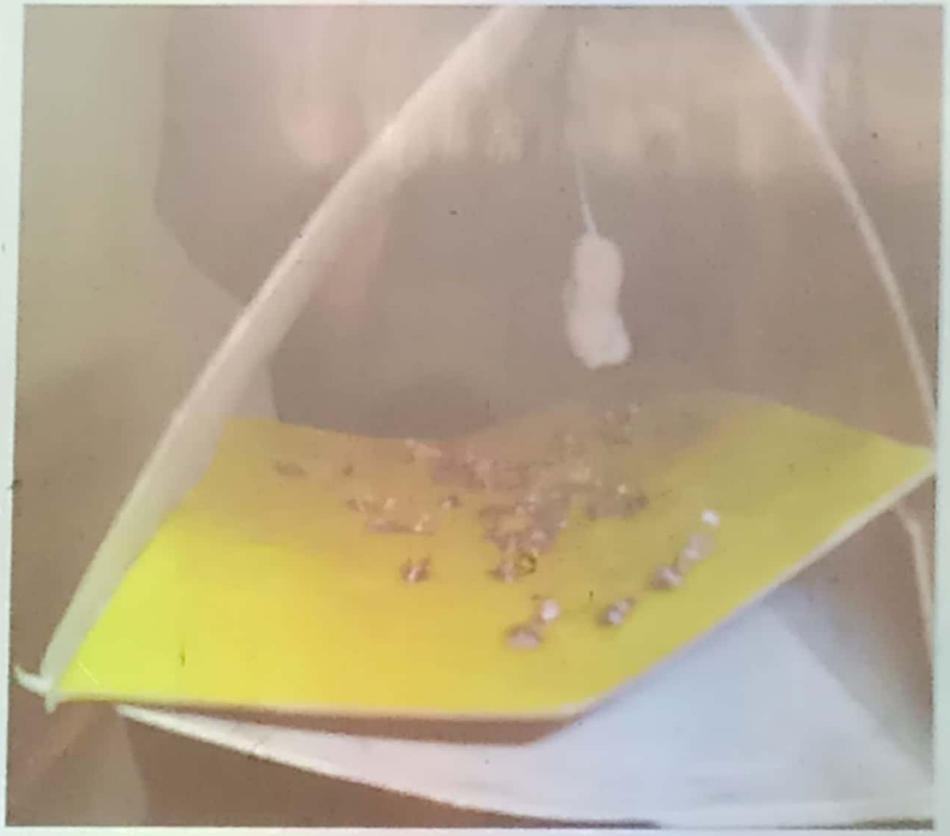
APPLIANCES IN CONTROLLING THE PESTS Contd..

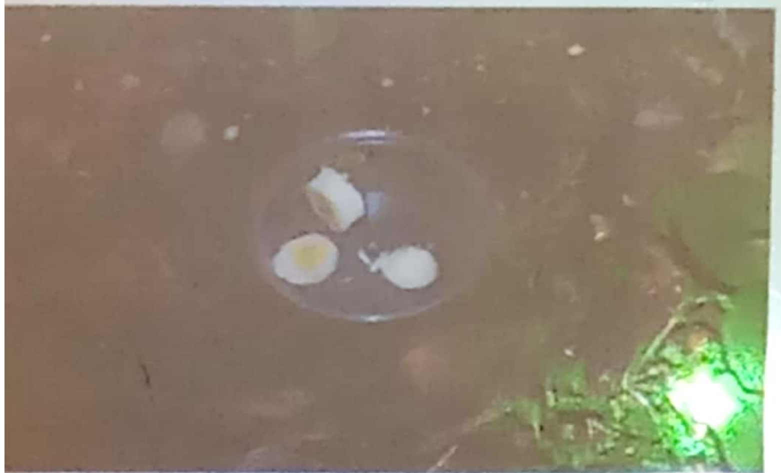
3. Yellow sticky trap:
   Cotton whitefly, aphids, thrips, prefer yellow colour. These insects are attracted to yellow colour and trapped on the sticky material.



APPLIANCES IN CONTROLLING THE PESTS Contd.

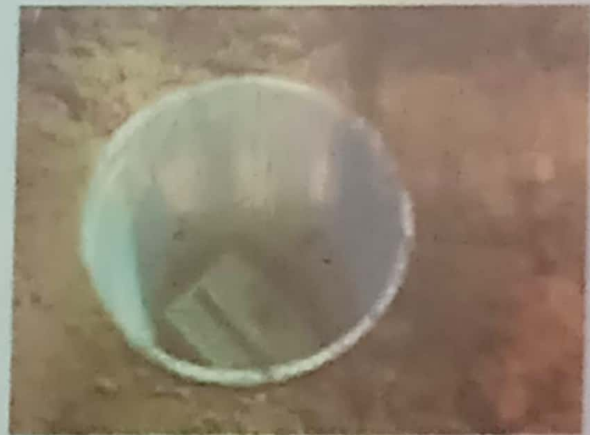
4. Bait trap: Attractants placed in traps are used to attract the insect and kill them e.g. fishmeal trap is used against sorghum shoot fly

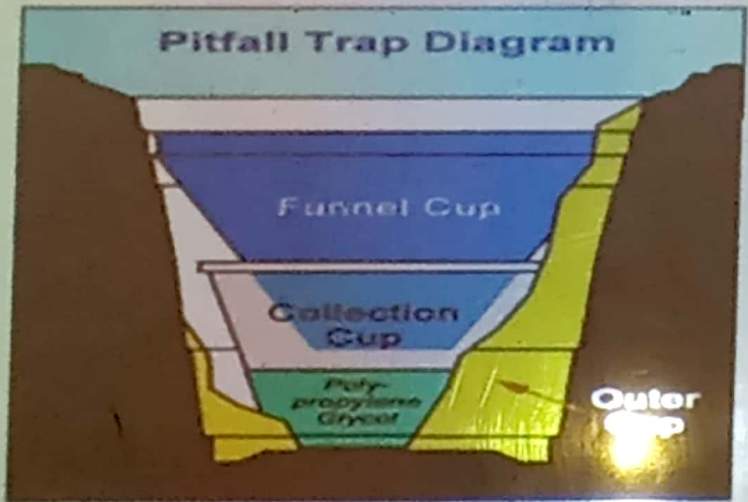


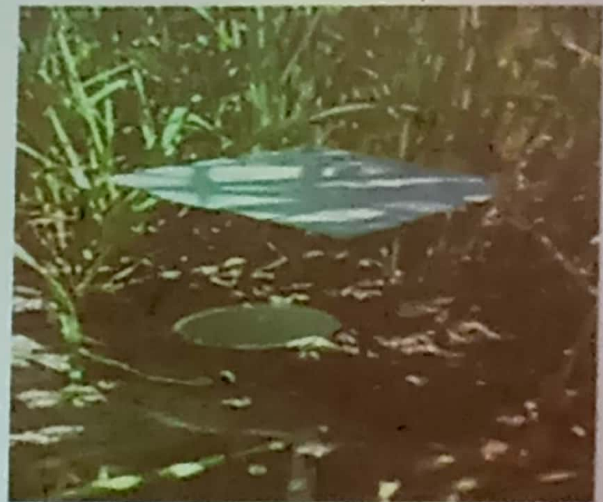


APPLIANCES IN CONTROLLING THE PESTS Contd..

5. Pitfall trap: It is used to trap crawling insects on the soil surface such as ground beetles, Collembola, spiders.







LEGISLATIVE CONTROL

- Defn. Preventing the entry and establishment of foreign plant and animal pest in a country or area and eradication or suppression of the pests established in a limited area through compulsory legislation or enactment

LEGISLATIVE CONTROL CONTD.

Pests accidentally introduced into Zambia

- Potato tuber moth, *Phthorimaea operculella* (Zeller)
- Diamondback moth, *Plutella xylostella* (L.)
- Spotted stem borer, *Chilo partellus* (Swinhoe)
- Larger grain borer, *Prostephanus truncatus* (Horn)
- Psyllid, *Heteropsylla cubana* Crawford
- Green spider mite, *Mononychellus tanajoa* (Bondar)
- Cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero
- Cabbage aphid, *Brevicoryne brassicae* (L.)
- Fall army worm, *Spodoptera frugiperda* (J. E. Smith)
- Tomato leafminer, *Tuta absoluta* (Meyrick)

Foreign Pests from which Zambi[a] is free

LEGISLATIVE CONTROL CONT.

- **Quarantine**-is isolation to prevent spreading of infection or pest.
- **Plant Quarantine**-Legal restriction of movement of plant materials between countries and between provinces within the country to prevent or limit introduction and spread of pests or diseases in areas where they do not exist.

CLASSES OF QUARANTINE

1. **Foreign Quarantine**

Legislation is to prevent the introduction of new pests, diseases and weeds from foreign countries.

a. Plant quarantine inspection and treatments at entry points-airports and borders
b. Import permits required for importation of plant material
c. Phytosanitary certificate from the country of origin is required.

CLASSES OF QUARANTINE

2. Domestic Quarantine

Legislation is to prevent the introduction of new pests, diseases and weeds within different parts of the country.

CLASSES OF QUARANTINE

3. Legislation is to take up effective measures to prevent spread of established pests.

E.g. The Cotton Act, Chapter 340 of the Laws of Zambia:

To provide for protection and control of the cotton industry; to regulate the importation of cotton seed; to prevent the spread of pests affecting cotton

Previous cotton crop to be removed before October 1 each year.

To keep land free of cotton for sometime.

Role of Plant Quarantine

Role of Plant Quarantine in the Export of Agricultural Commodities

- ✓ International Plant Protection Convention (1951) of FAO, UN Article V of the convention makes it mandatory for member countries to issue Phytosanitary certificate (PSC)
- ✓ It should be in conformity with Plant Quarantine Regulations of importing country.
- ✓ Agricultural commodities during export should be accompanied by PSC

Plant Quarantine Activities

I. Inspection of Imported consignments of Plant/Plant products.

II. Inspection of Plant/Plant products consignments for export.

III. Inspection of consignments of Plant/Plant products in transit.

IV. Inspection of travelers' luggage.

V. Inspection of imported postal parcels of plants/plant products.

VI. Monitoring the imported plant/plant parts for propagation under post-entry quarantine