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ZOO411

ENTOMOLOGY

ZOO 411: Entomology (2 Units C: LH 15; PH 45)

Course Code: ZOO 411

Course Title: Entomology

Course Unit: 2 Units C

Series 1: Origin And Phylogeny Of Insects

Series 2: Taxonomy And Biology Of Selected Insect Groups

Series 3: Control Of Insect Pests Of Crops And Stored Products

Series 4: Control Of Insect Vectors Of Diseases

Series 5: Techniques For Collection, Preservation, And Identification Of Insects Of Economic Importance

Series 1 Origin And Phylogeny Of Insects

Part 1.1 Origin of insects
- 1.1.1 Evolutionary background of arthropods
- 1.1.2 Emergence of insects from ancestral forms

Part 1.2 Phylogeny of insects
- 1.2.1 Major insect lineages and their relationships
- 1.2.2 Evolutionary adaptations and diversification

Part 1.3 Significance of insect phylogeny

1.3.1 Importance in taxonomy and classification
1.3.2 Relevance to ecological and economic studies

Introduction

Insects are among the most diverse and successful organisms on Earth, yet their evolutionary journey is often overlooked. Understanding their origin and phylogeny provides a foundation for studying their biology, ecology, and economic importance. This Series introduces you to the evolutionary background of insects, tracing their emergence from ancestral arthropods and examining how they diversified into the vast array of species we see today.

The aim of this Series is to explain the evolutionary origin of insects and to analyse their phylogenetic relationships, highlighting how these insights support taxonomy, ecology, and applied entomology.

We shall commence this Series by exploring the evolutionary background of arthropods and the emergence of insects from ancestral forms. Next, we will examine the phylogeny of insects, focusing on major lineages and their evolutionary adaptations. Finally, we will conclude by considering the significance of insect phylogeny, particularly its role in classification and its relevance to ecological and economic studies.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define the evolutionary background of arthropods,
- **SLO 1.2** explain how insects emerged from ancestral forms,
- **SLO 1.3** describe the major insect lineages and their phylogenetic relationships,
- **SLO 1.4** analyse evolutionary adaptations that contributed to insect diversification, and
- **SLO 1.5** evaluate the significance of insect phylogeny in taxonomy, ecology, and economic studies.

1.1 Origin Of Insects

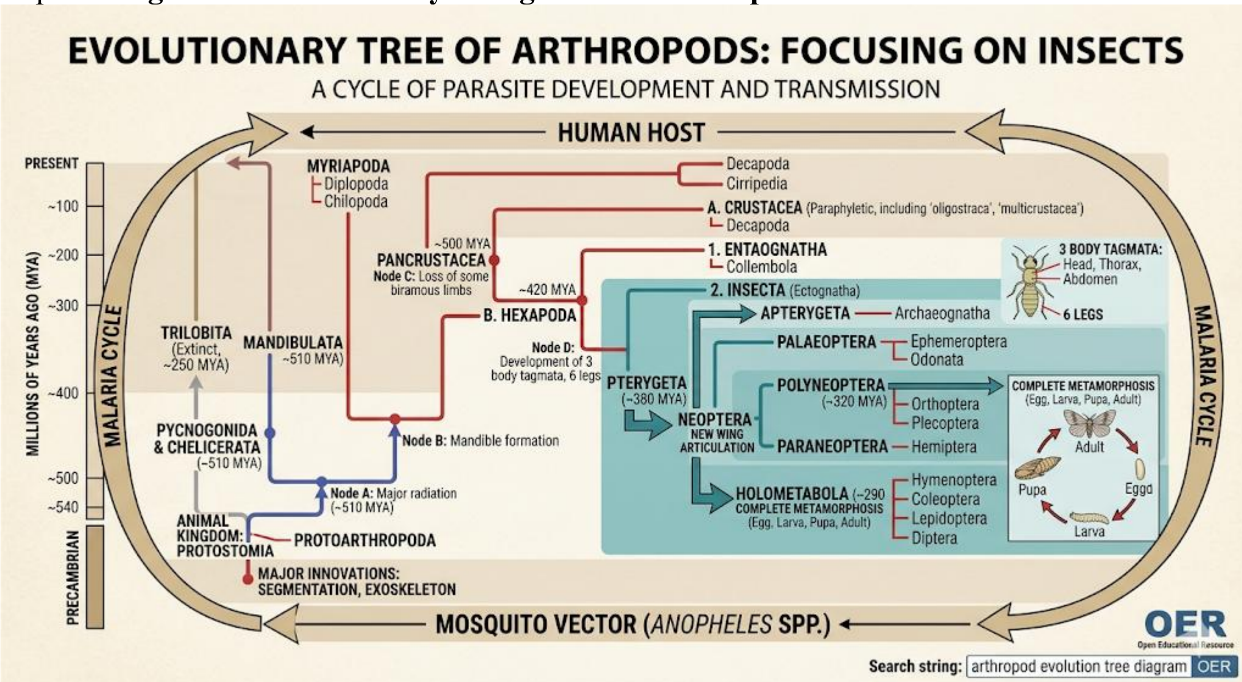
1.1.1 Evolutionary background of arthropods

Arthropods are a large group of invertebrates characterised by segmented bodies, jointed appendages, and an external skeleton made of chitin. They include crustaceans, arachnids, myriapods, and insects. Insects are believed to have evolved from primitive crustacean-like ancestors during the Devonian period, more than 350 million years ago.

The evolutionary success of arthropods lies in their adaptability, which allowed them to colonise land, water, and air. Insects, as one of the most diverse groups, developed specialised features such as wings, compound eyes, and varied mouthparts, enabling them to exploit different ecological niches.

Short description: Diagram showing evolutionary tree of arthropods highlighting insects.

Caption: **Figure 1.1 Evolutionary background of arthropods**



Fill in the blank: Arthropods are characterised by segmented bodies, jointed appendages, and an external ______.

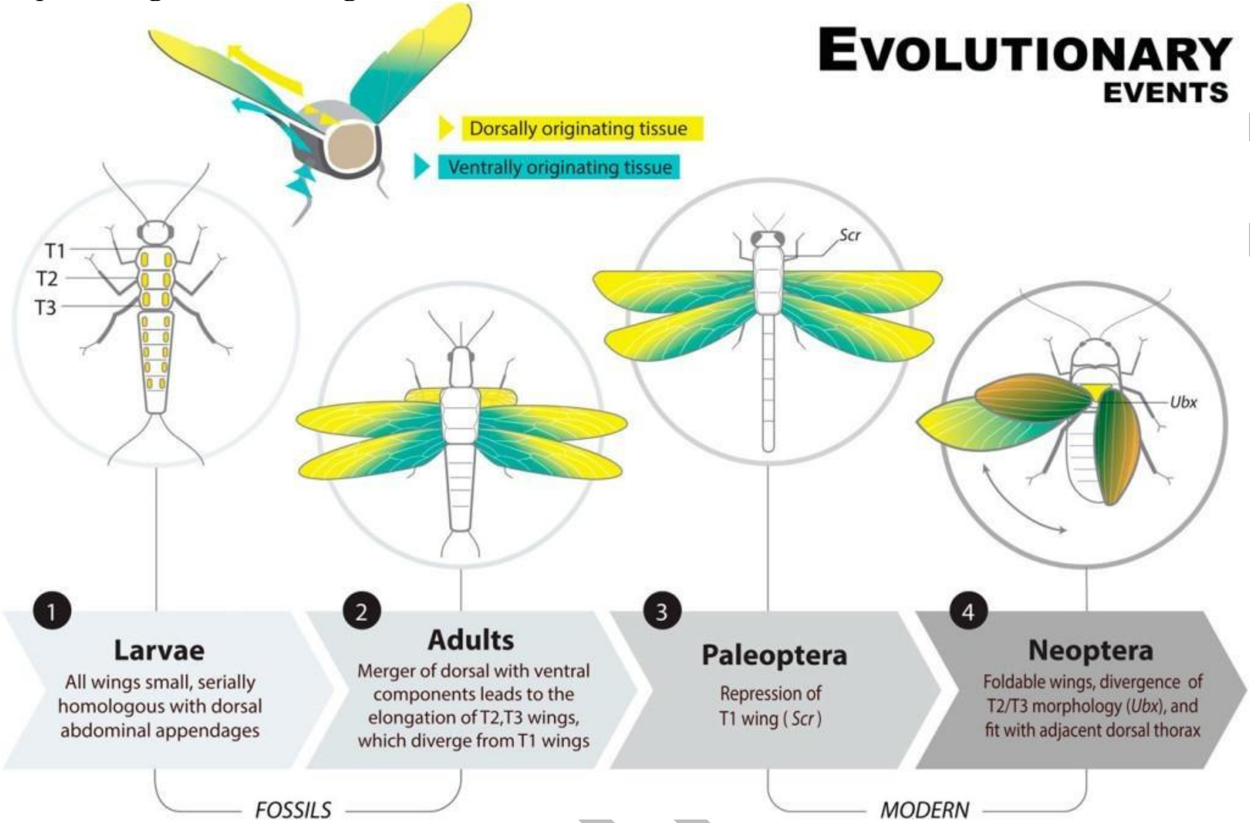
1.1.2 Emergence of insects from ancestral forms

The **emergence of insects** marked a significant evolutionary step. Early insects were wingless and lived in moist environments. The development of wings allowed them to disperse widely and occupy new habitats. This innovation contributed to their rapid diversification.

Insects also evolved specialised mouthparts suited to different diets, such as chewing, piercing, or sucking. These adaptations enabled them to exploit plants, other animals, and even decaying matter. The combination of wings and diverse feeding strategies made insects one of the most successful groups of organisms on Earth.

Short description: Diagram showing early wingless insects evolving into winged forms.

Caption: **Figure 1.2 Emergence of insects from ancestral forms**



Fill in the blank: The development of ______ allowed insects to disperse widely and occupy new habitats.

Pilot questions 1.1

What are the main characteristics of arthropods?
From which ancestral group are insects believed to have evolved?
Name one feature that contributed to the evolutionary success of insects.
What innovation allowed insects to disperse widely?
Give one example of specialised mouthparts in insects.

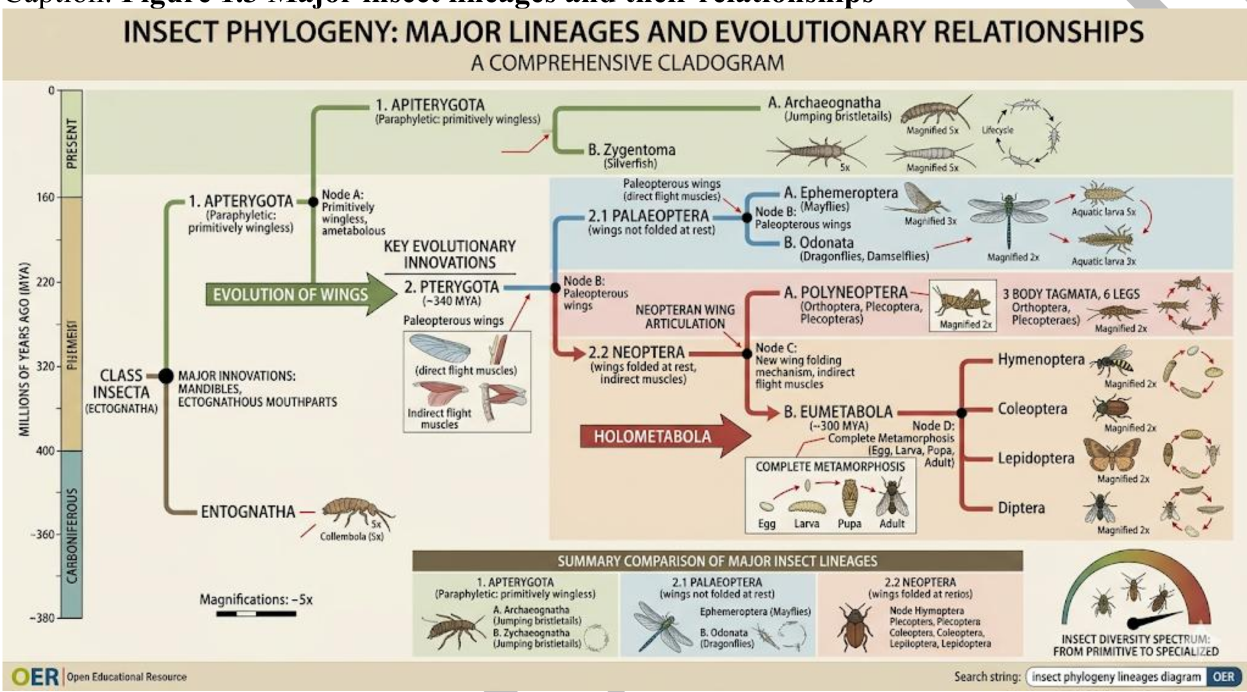
1.2 Phylogeny Of Insects

1.2.1 Major insect lineages and their relationships

Phylogeny refers to the evolutionary history and relationships among organisms. Insects are divided into several major lineages, each representing a distinct evolutionary path. These lineages include **Apterygota** (primitive wingless insects such as silverfish), **Palaeoptera** (ancient winged insects like mayflies and dragonflies), and **Neoptera** (modern winged insects that can fold their wings over their abdomen, such as beetles, butterflies, and flies).

Understanding these lineages helps us trace how insects diversified and adapted to different environments. For example, the ability of Neoptera to fold their wings gave them an advantage in protection and mobility, contributing to their dominance among insect groups.

Short description: Diagram showing major insect lineages (Apterygota, Palaeoptera, Neoptera) and their evolutionary relationships.
Caption: **Figure 1.3 Major insect lineages and their relationships**



Fill in the blank: Neoptera are modern winged insects that can ______ their wings over the abdomen.

1.2.2 Evolutionary adaptations and diversification

Insects have undergone remarkable **evolutionary adaptations**, which explain their success and diversity. Key adaptations include the development of wings, metamorphosis, and specialised mouthparts. **Metamorphosis** is the process by which insects change form during development, either through incomplete metamorphosis (gradual changes, as in grasshoppers) or complete metamorphosis (distinct stages: egg, larva, pupa, adult, as in butterflies).

These adaptations allowed insects to exploit new ecological niches. For instance, complete metamorphosis reduces competition between young and adult stages, since they occupy different habitats and feed on different resources. Specialised mouthparts also enabled insects to feed on a wide range of materials, from plant sap to animal blood.

Box 1.4 Key evolutionary adaptations of insects

Adaptation Category	Key Mechanism	Biological Innovation	Evolutionary Advantage
Flight (Wings)	**Chitinous Outgrowths**	Extensions of the thoracic exoskeleton (not modified limbs).	Rapid dispersal, predator avoidance, and the ability to find patchy resources (mates/food).
Development	**Complete Metamorphosis**	Four distinct stages: **Egg $\rightarrow$ Larva $\rightarrow$ Pupa $\rightarrow$ Adult**.	Prevents competition between adults and offspring; larvae focus on growth, adults on reproduction.
Development	**Incomplete Metamorphosis**	Three stages: **Egg $\rightarrow$ Nymph $\rightarrow$ Adult**.	Nymphs occupy the same niche as adults, allowing for rapid population growth in stable environments.
Mouthparts	**Piercing-Sucking**	Mandibles/maxillae modified into a needle-like **stylet**.	Access to high-energy internal fluids (blood in mosquitoes, sap in aphids).
Mouthparts	**Siphoning**	Labial palps modified into a coiled **proboscis**.	specialized for drinking nectar from deep floral tubes, facilitating co-evolution with plants.
Mouthparts	**Sponging / Lapping**	Labium modified into a fleshy, absorbent **labellum**.	Efficiently collects liquefied food or secretions from surfaces.

Fill in the blank: Complete metamorphosis includes four stages: egg, larva, _______, and adult.

Pilot questions 1.2

What does phylogeny refer to?
Name one primitive wingless insect group.

Which insect lineage can fold its wings over the abdomen?
What is metamorphosis?
Why does complete metamorphosis reduce competition between young and adult stages?

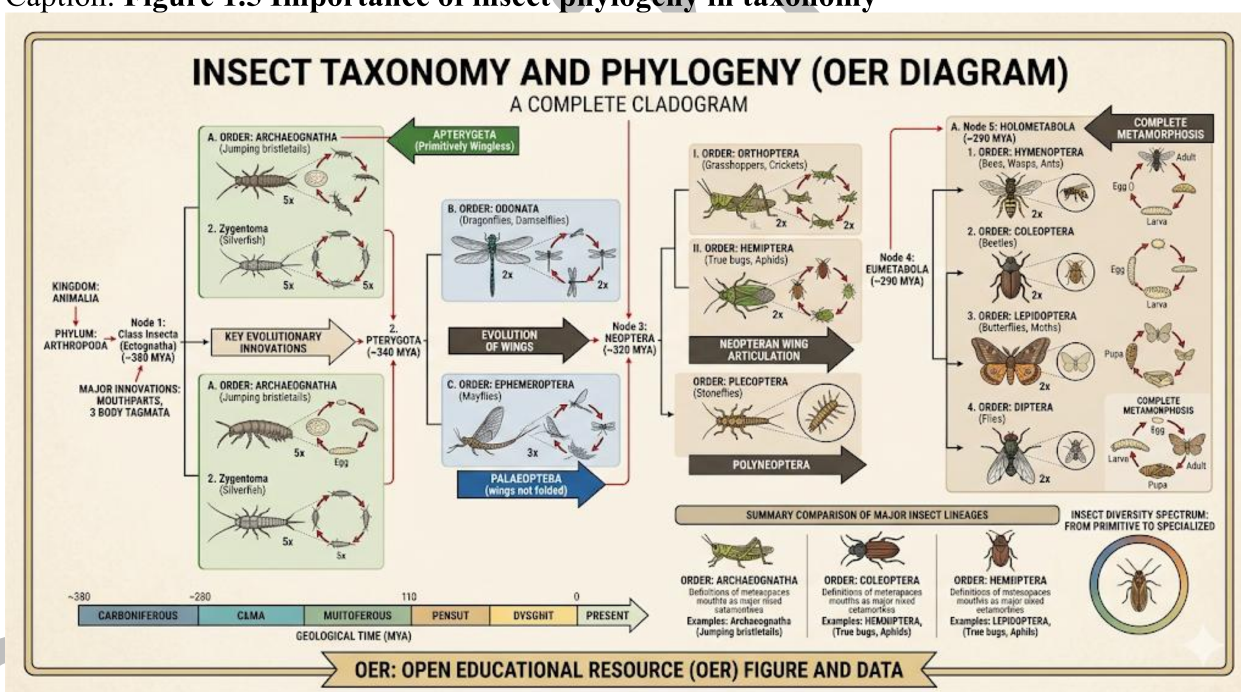
1.3 Significance Of Insect Phylogeny

1.3.1 Importance in taxonomy and classification

Taxonomy is the science of naming, describing, and classifying organisms. Insect phylogeny provides the evolutionary framework that supports taxonomy, ensuring that classification reflects natural relationships rather than superficial similarities. By studying phylogeny, entomologists can group insects into orders, families, and genera based on shared ancestry.

This approach helps avoid confusion and provides consistency in identifying insects. For example, knowing that beetles (Coleoptera) and butterflies (Lepidoptera) belong to distinct evolutionary lineages clarifies their differences and guides further study.

Short description: Diagram showing insect classification based on phylogeny.
Caption: **Figure 1.5 Importance of insect phylogeny in taxonomy**



Fill in the blank: Taxonomy is the science of naming, describing, and ______ organisms.

1.3.2 Relevance to ecological and economic studies

Insect phylogeny is also relevant to ecology and economics. Ecologically, it helps explain how insects interact with their environment and evolve specialised roles, such as pollinators, decomposers, or predators. Economically, phylogenetic knowledge assists in identifying insects of agricultural, medical, or veterinary importance, and in developing strategies for their control.

For instance, understanding the evolutionary relationships of disease-carrying mosquitoes can guide control measures by highlighting shared traits across species. Similarly, recognising the lineage of crop pests helps predict their behaviour and potential impact.

Box 1.6 Applications of insect phylogeny in ecology and economics

Insect Order	Key Phylogenetic Trait	Ecological Role	Economic Impact
Hymenoptera (Bees, Wasps, Ants)	**Sociality & Pollen-collecting hairs**	**Primary Pollinators:** Essential for the reproduction of 80% of flowering plants.	**Global Agriculture:** Honeybees provide pollination services valued at over $200 billion annually.
Diptera (Flies, Mosquitoes)	**Blood-feeding (in specific lineages)**	**Disease Vectors:** Co-evolved with pathogens to move between vertebrate hosts.	**Public Health:** Malaria, Zika, and Dengue transmission causes billions in healthcare costs and lost productivity.
Coleoptera (Beetles)	**Hardened Elytra (Protection)**	**Decomposers:** Specialized in breaking down wood, dung, and carrion.	**Soil Fertility:** Dung beetles save the cattle industry billions by recycling nutrients and reducing pasture fouling.
Hemiptera (True Bugs / Aphids)	**Piercing-Sucking Mouthparts**	**Primary Consumers:** Efficiently extract nutrients directly from plant vascular systems.	**Agricultural Pests:** Massive crop losses; many species also transmit devastating plant viruses.
Lepidoptera (Butterflies, Moths)	**Complete Metamorphosis**	**Herbivory & Pollination:** Larvae are major	**Silk Production:** Silkworms (*Bombyx mori*) support a multi-billion

Insect Order	Key Phylogenetic Trait	Ecological Role	Economic Impact
		consumers of foliage; adults are pollinators.	dollar global textile industry.
Orthoptera (Locusts, Crickets)	**Saltatorial (Jumping) Legs**	**Energy Converters:** Transform plant biomass into protein for higher trophic levels (birds/reptiles).	**Food Security:** Locust swarms can destroy enough crops in one day to feed 35,000 people.

Fill in the blank: Phylogenetic knowledge assists in identifying insects of agricultural, medical, or ______ importance.

Pilot questions 1.3

Why is insect phylogeny important in taxonomy?
How does phylogeny help avoid confusion in classification?
Name one ecological role of insects explained by phylogeny.
How can phylogeny guide control measures for disease vectors?
Give one example of economic importance linked to insect phylogeny.

Series Summary

This Series introduced the origin and phylogeny of insects, providing a foundation for understanding their evolutionary history and relationships. We began by examining the evolutionary background of arthropods and the emergence of insects from ancestral forms. Then, we explored the phylogeny of insects, focusing on major lineages and their evolutionary adaptations. Finally, we considered the significance of insect phylogeny, particularly its importance in taxonomy, classification, ecology, and economic studies.

By completing this Series, you should now be able to define the evolutionary background of arthropods, explain how insects emerged from ancestral forms, describe major insect lineages, analyse adaptations that contributed to insect diversification, and evaluate the significance of insect phylogeny in both scientific and applied contexts. These achievements align directly with the Series Learning Outcomes and prepare you for deeper study of insect biology and control in subsequent Series.

Glossary of Terms

Apterygota: Primitive wingless insects such as silverfish.
Arthropods: Invertebrates with segmented bodies, jointed appendages, and an external skeleton made of chitin.
Metamorphosis: Developmental process in insects involving changes in form, either incomplete or complete.
Neoptera: Modern winged insects that can fold their wings over the abdomen.
Palaeoptera: Ancient winged insects such as mayflies and dragonflies.
Phylogeny: The evolutionary history and relationships among organisms.
Taxonomy: The science of naming, describing, and classifying organisms.

Concept Check Questions 1

Objective questions

Arthropods are characterised by segmented bodies, jointed appendages, and an external ______. (Linked to SLO 1.1)
Insects are believed to have evolved from primitive ______-like ancestors. (Linked to SLO 1.2)
Neoptera are modern winged insects that can ______ their wings over the abdomen. (Linked to SLO 1.3)
Complete metamorphosis includes four stages: egg, larva, ______, and adult. (Linked to SLO 1.4)
Taxonomy is the science of naming, describing, and ______ organisms. (Linked to SLO 1.5)

Short-answer questions
6. Define arthropods. (Linked to SLO 1.1)
7. Explain the significance of wings in insect evolution. (Linked to SLO 1.2)
8. Name one primitive wingless insect group. (Linked to SLO 1.3)
9. What is the difference between incomplete and complete metamorphosis? (Linked to SLO 1.4)
10. Why is insect phylogeny important in ecological studies? (Linked to SLO 1.5)

Long-answer questions
11. Describe the evolutionary background of arthropods and explain how insects emerged from ancestral forms. (Linked to SLO 1.1, 1.2)
12. Analyse the major insect lineages and their evolutionary adaptations. (Linked to SLO 1.3, 1.4)
13. Evaluate the significance of insect phylogeny in taxonomy, ecology, and economic studies. (Linked to SLO 1.5)

Answers to Concept Check Questions 1

Objective questions

Skeleton.
Crustacean.
Fold.

Pupa.
Classifying.

Short-answer questions
6. Invertebrates with segmented bodies, jointed appendages, and an external skeleton made of chitin.
7. Wings allowed insects to disperse widely and occupy new habitats.
8. Apterygota.
9. Incomplete metamorphosis involves gradual changes, while complete metamorphosis has distinct stages (egg, larva, pupa, adult).
10. It explains insect roles such as pollinators, decomposers, and vectors, aiding ecological understanding.

Long-answer questions
11. **Basic response**: Arthropods evolved with segmented bodies and jointed appendages, and insects emerged from crustacean-like ancestors.
Value-added response: Insects developed wings and specialised mouthparts, enabling them to colonise diverse habitats and become highly successful.

Basic response: Major lineages include Apterygota, Palaeoptera, and Neoptera.
Value-added response: Adaptations such as wing folding, metamorphosis, and specialised feeding strategies contributed to their diversification.
Basic response: Phylogeny supports taxonomy and classification.
Value-added response: It also informs ecological roles and economic importance, guiding pest control and disease management strategies.

Answers to Pilot Questions 1

Part 1.1

Segmented bodies, jointed appendages, external skeleton.
Crustacean-like ancestors.
Wings.
Wings.
Chewing mouthparts.

Part 1.2

Evolutionary history and relationships.
Apterygota.
Neoptera.
Developmental change in insects.
They occupy different habitats and resources.

Part 1.3

It provides an evolutionary framework for classification.
By grouping insects based on shared ancestry.
Pollinator.

By identifying shared traits across species.
Agricultural pest identification.

References And Attributions 1

Figures and Boxes suggested in Series 1:

Figure 1.1 Evolutionary background of arthropods
Figure 1.2 Emergence of insects from ancestral forms
Figure 1.3 Major insect lineages and their relationships
Box 1.4 Key evolutionary adaptations of insects
Figure 1.5 Importance of insect phylogeny in taxonomy
Box 1.6 Applications of insect phylogeny in ecology and economics

AI prompt suggestions used for illustration placeholders:

Diagrams showing arthropod evolution, insect wing development, insect lineages, and classification.
Boxes summarising evolutionary adaptations and ecological/economic relevance.

Open Educational Resource (OER) search strings suggested:

"arthropod evolution tree diagram OER"
"origin of insects wing evolution diagram OER"
"insect phylogeny lineages diagram OER"
"insect evolutionary adaptations OER"
"insect taxonomy phylogeny diagram OER"
"insect phylogeny ecology economic importance OER"

General references (APA style):

Grimaldi, D., & Engel, M. S. (2005). *Evolution of the Insects*. Cambridge University Press.
Gullan, P. J., & Cranston, P. S. (2014). *The Insects: An Outline of Entomology*. Wiley Blackwell.
OER Commons. (n.d.). *Entomology resources*. Retrieved from https://www.oercommons.org

ZOO411 Series 2 Taxonomy And Biology Of Selected Insect Groups

Part 2.1 Principles of insect taxonomy
2.1.1 Basis of classification and nomenclature
2.1.2 Major taxonomic ranks in insects
Part 2.2 Biology of agricultural insect groups
2.2.1 Insects affecting crops
2.2.2 Insects affecting stored products
Part 2.3 Biology of medical and veterinary insect groups
2.3.1 Insects as disease vectors
2.3.2 Insects affecting domestic animals
Part 2.4 Ecological and economic importance of insect groups

2.4.1 Beneficial roles of insects
2.4.2 Harmful roles of insects

Introduction

In the last Series, we explored the origin and phylogeny of insects, which provided us with a foundation for understanding their evolutionary history. Building on that knowledge, this Series focuses on the taxonomy and biology of selected insect groups, particularly those of economic importance. Taxonomy helps us organise insects into meaningful categories, while studying their biology reveals how they interact with crops, stored products, humans, and domestic animals.

The aim of this Series is to explain the principles of insect taxonomy and to describe the biology of selected insect groups, highlighting their ecological and economic significance.

We shall commence this Series by examining the principles of insect taxonomy, including classification and nomenclature. Next, we will explore the biology of agricultural insect groups, focusing on those affecting crops and stored products. Following that, we will consider the biology of medical and veterinary insect groups, particularly those acting as disease vectors or affecting domestic animals. Finally, we will conclude by analysing the ecological and economic importance of insect groups, considering both their beneficial and harmful roles.

Series Learning Outcomes

Upon completing this Series, you should be able to:

SLO 2.1 define the basis of insect classification and nomenclature,
SLO 2.2 describe the major taxonomic ranks in insects,
SLO 2.3 explain the biology of insect groups affecting crops,
SLO 2.4 analyse the biology of insect groups affecting stored products,
SLO 2.5 describe the biology of insect groups acting as disease vectors,
SLO 2.6 explain the biology of insect groups affecting domestic animals,

SLO 2.7 evaluate the ecological and economic importance of insect groups, including both beneficial and harmful roles.

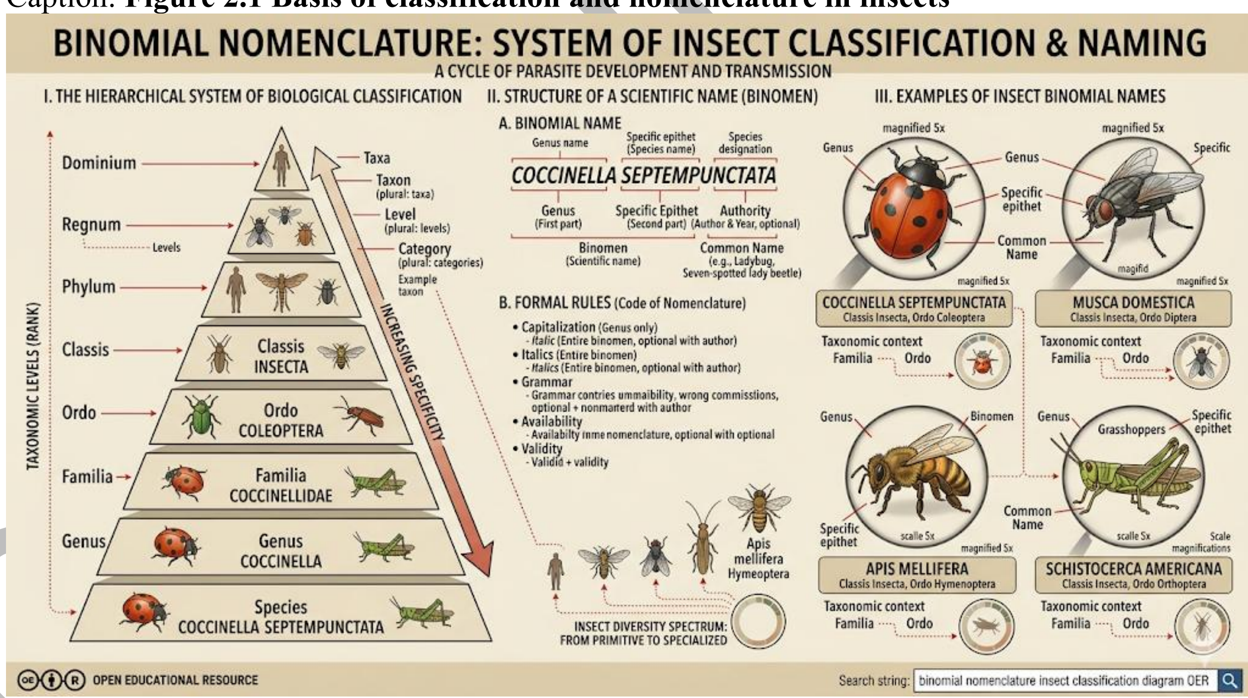
2.1 Principles Of Insect Taxonomy

2.1.1 Basis of classification and nomenclature

Taxonomy is the science of naming, describing, and classifying organisms. In insects, taxonomy provides a systematic way to organise the vast diversity of species into meaningful categories. The basis of classification often includes morphological features such as wing structure, mouthparts, antennae, and reproductive organs. Behavioural traits and ecological roles may also be considered.

Nomenclature refers to the rules and conventions used to assign names to organisms. The binomial system, introduced by Carl Linnaeus, is widely used. Each insect species is given a two-part name: the genus and the species. For example, *Anopheles gambiae* is the name of a mosquito species that transmits malaria.

Short description: Diagram showing binomial nomenclature with examples of insect names.
Caption: **Figure 2.1 Basis of classification and nomenclature in insects**



Fill in the blank: The binomial system gives each species a two-part name consisting of the ______ and the species.

2.1.2 Major taxonomic ranks in insects

Insects are classified into hierarchical ranks that reflect their evolutionary relationships. The major ranks include **Kingdom**, **Phylum**, **Class**, **Order**, **Family**, **Genus**, and **Species**. Insects belong to the Kingdom Animalia, Phylum Arthropoda, and Class Insecta.

Within Class Insecta, there are numerous orders such as Coleoptera (beetles), Lepidoptera (butterflies and moths), Diptera (flies), and Hymenoptera (ants, bees, and wasps). Each order contains families, which are further divided into genera and species. This hierarchical system helps entomologists organise insects and study their biology more effectively.

Box 2.2 Major taxonomic ranks of insects

Taxonomic Rank	Example: Honeybee	Defining Characteristics / Notes
Kingdom	Animalia	Multicellular, eukaryotic, heterotrophic (must ingest food).
Phylum	Arthropoda	Segmented bodies, chitinous exoskeleton, and jointed appendages.
Class	**Insecta**	**The "Rule of Threes":** Three body segments (head, thorax, abdomen) and three pairs of legs.
Order	Hymenoptera	"Membrane wings." Includes bees, wasps, and ants. Many exhibit social behavior.
Family	Apidae	Includes "corbiculate" bees (those with pollen baskets on their hind legs).
Genus	*Apis*	The specific group of "true" honeybees.
Species	*Apis mellifera*	The Western Honeybee. Individuals that can interbreed and produce fertile offspring.

Fill in the blank: Insects belong to the Kingdom Animalia, Phylum Arthropoda, and Class ______.

Pilot questions 2.1

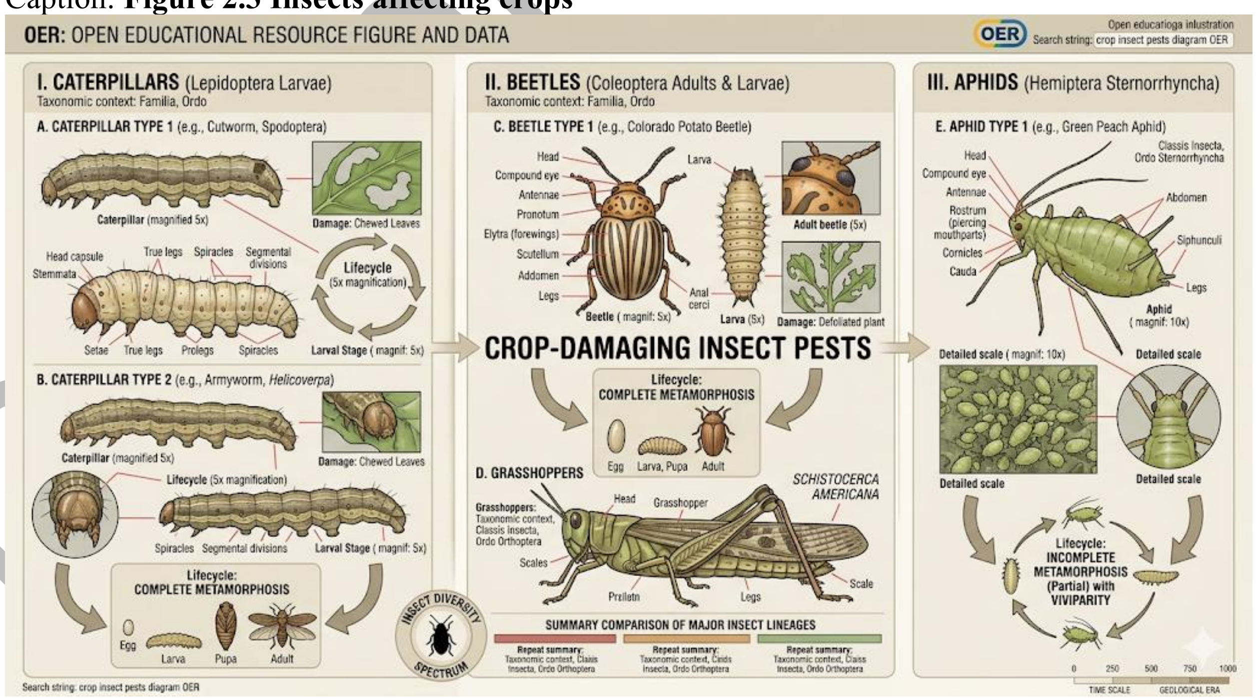
What is taxonomy?
What system is used to name insect species?
Give an example of a mosquito species named using binomial nomenclature.
List the major taxonomic ranks in order.
Name one insect order and give an example of an insect belonging to it.

2.2 Biology Of Agricultural Insect Groups

2.2.1 Insects affecting crops

Many insects are directly associated with crop damage, reducing yield and quality. These include **chewing insects**, such as caterpillars and beetles, which consume leaves, stems, and roots, and **sucking insects**, such as aphids and whiteflies, which pierce plant tissues and extract sap. Both groups weaken plants, stunt growth, and may transmit plant diseases.

Crop-damaging insects are often seasonal, with outbreaks linked to favourable environmental conditions. Farmers and researchers monitor these populations to predict infestations and plan control measures.

Short description: Diagram showing examples of crop-damaging insects (caterpillars, beetles, aphids).
Caption: **Figure 2.3 Insects affecting crops**


Fill in the blank: Aphids and whiteflies are examples of ______ insects that pierce plant tissues and extract sap.

2.2.2 Insects affecting stored products

Stored products such as grains, flour, and dried fish are vulnerable to insect infestation. **Stored product pests** include weevils, flour beetles, and moths. These insects feed on stored food, causing contamination, weight loss, and reduced nutritional value.

Infestation often begins in the field but becomes more severe during storage, especially under poor storage conditions. Effective management requires proper sanitation, airtight storage, and monitoring of pest populations.

Box 2.4 Common stored product pests

Pest Category	Common Name	Scientific Name	Primary Food Source	Diagnostic Feature / Sign
Internal Feeder	**Rice Weevil**	*Sitophilus oryzae*	Whole grains (Rice, Wheat, Corn)	Distinctive "snout" (rostrum) and four light spots on wing covers.
Internal Feeder	**Lesser Grain Borer**	*Rhyzopertha dominica*	Wheat, Corn, Wood	Head is tucked under the thorax; creates a large amount of fine powder/frass.
External Feeder	**Indian Meal Moth**	*Plodia interpunctella*	Flour, Cereals, Dried Fruit, Nuts	Larvae produce thick **silken webbing** that clumps food together.
External Feeder	**Saw-toothed Grain Beetle**	*Oryzaephilus surinamensis*	Cereals, Macaroni, Candy	Six saw-like "teeth" on the sides of the thorax; very flat body.
Secondary Feeder	**Confused Flour Beetle**	*Tribolium confusum*	Processed flour, Cracked grain	Often found in flour mills; gives flour a "pinkish" tint and unpleasant odor.

Pest Category	Common Name	Scientific Name	Primary Food Source	Diagnostic Feature / Sign
Secondary Feeder	**Drugstore Beetle**	*Stegobium paniceum*	Spices, Dried herbs, Books	Hump-backed appearance; can penetrate aluminum foil and lead sheets.

Fill in the blank: Weevils, flour beetles, and moths are examples of ______ product pests.

Pilot questions 2.2

Name one chewing insect that damages crops.
What type of insects pierce plant tissues and extract sap?
Give one example of a stored product pest.
Why do infestations often become more severe during storage?
Mention one method of managing stored product pests.

2.3 Biology Of Medical And Veterinary Insect Groups

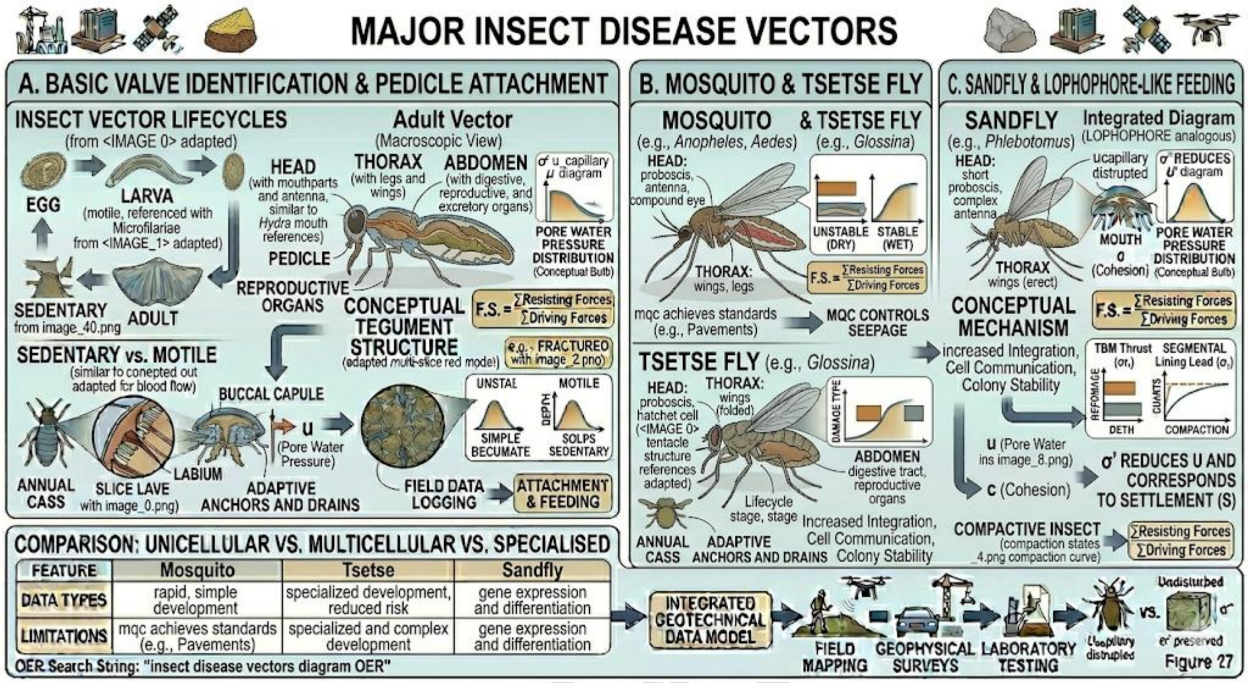
2.3.1 Insects as disease vectors

Certain insects act as **vectors**, meaning they transmit pathogens that cause diseases in humans. Mosquitoes are among the most important vectors, spreading malaria, dengue, and yellow fever. Tsetse flies transmit trypanosomiasis, while sandflies spread leishmaniasis. These insects are not harmful because of their feeding alone, but because they carry and transfer disease-causing organisms.

The biology of vector insects is closely linked to their ability to transmit diseases. For example, mosquitoes require blood meals for egg development, which brings them into contact with humans and animals. Their life cycle and breeding habits influence the spread of diseases, making them a major focus of medical entomology.

Short description: Diagram showing examples of insect vectors (mosquito, tsetse fly, sandfly).

Caption: **Figure 2.5 Insects as disease vectors**



Fill in the blank: Mosquitoes are important vectors because they transmit diseases such as ______ and dengue.

2.3.2 Insects affecting domestic animals

Insects also play a significant role in veterinary health by affecting domestic animals. Biting flies such as stable flies and horseflies cause irritation, blood loss, and reduced productivity in livestock. Lice and mites infest animals, leading to discomfort, anaemia, and sometimes secondary infections.

Ticks, although not insects but arachnids, are often studied alongside them because of their veterinary importance. They transmit diseases such as babesiosis and anaplasmosis in cattle. Understanding the biology of these pests helps veterinarians and farmers design effective control measures to protect animal health and productivity.

Box 2.6 Insects affecting domestic animals

Arthropod Group	Specific Example	Primary Host(s)	Mode of Action	Veterinary Impact
Sucking Lice	*Haematopinus* spp.	Cattle, Pigs, Horses	Piercing-sucking mouthparts to feed on blood.	Anemia, unthriftiness, and skin lesions from rubbing/scratching.
Chewing Lice	*Bovicola bovis*	Cattle, Sheep	Mandibles to feed on skin scales, hair, and debris.	Intense irritation and "wool break" in sheep, reducing fleece value.
Biting Flies	**Stable Fly** (*Stomoxys*)	Horses, Cattle, Dogs	Painful blood-feeding, usually on the lower legs.	**Fly Worry:** Animals stop grazing to "bunch" or stomp, leading to weight loss.
Myiasis Flies	**Cattle Grub** (*Hypoderma*)	Cattle	Larvae migrate through internal tissues to the back.	**Warbles:** Lumps on the back that ruin the hide for leather production.
Nasal Bots	*Oestrus ovis*	Sheep, Goats	Female flies "dart" at nostrils to deposit larvae.	**Snotty Nose:** Chronic nasal discharge, head-shaking, and secondary pneumonia.
Hard Ticks	*Rhipicephalus* spp.	Cattle, Dogs	Attachment for multi-day blood meals.	**Vectoring:** Transmission of **Babesiosis** and **Anaplasmosis** (Cattle Fever).
Mange Mites	*Psoroptes ovis*	Sheep, Cattle	Microscopic mites living on the skin surface.	**Sheep Scab:** Highly contagious; causes crusting, fluid oozing, and wool loss.
Fleas	*Ctenocephalides felis*	Dogs, Cats	Blood-feeding adults; larvae live in the bedding.	**Flea Allergy Dermatitis (FAD):** Hypersensitivity to flea saliva.

Fill in the blank: Stable flies and horseflies affect livestock by causing irritation, blood loss, and reduced ______.

Pilot questions 2.3

What is a vector in medical entomology?
Name one disease transmitted by mosquitoes.
Which insect transmits trypanosomiasis?
Give one example of an insect that affects domestic animals.
Why are ticks often studied alongside insects in veterinary entomology?

2.4 Ecological And Economic Importance Of Insect Groups

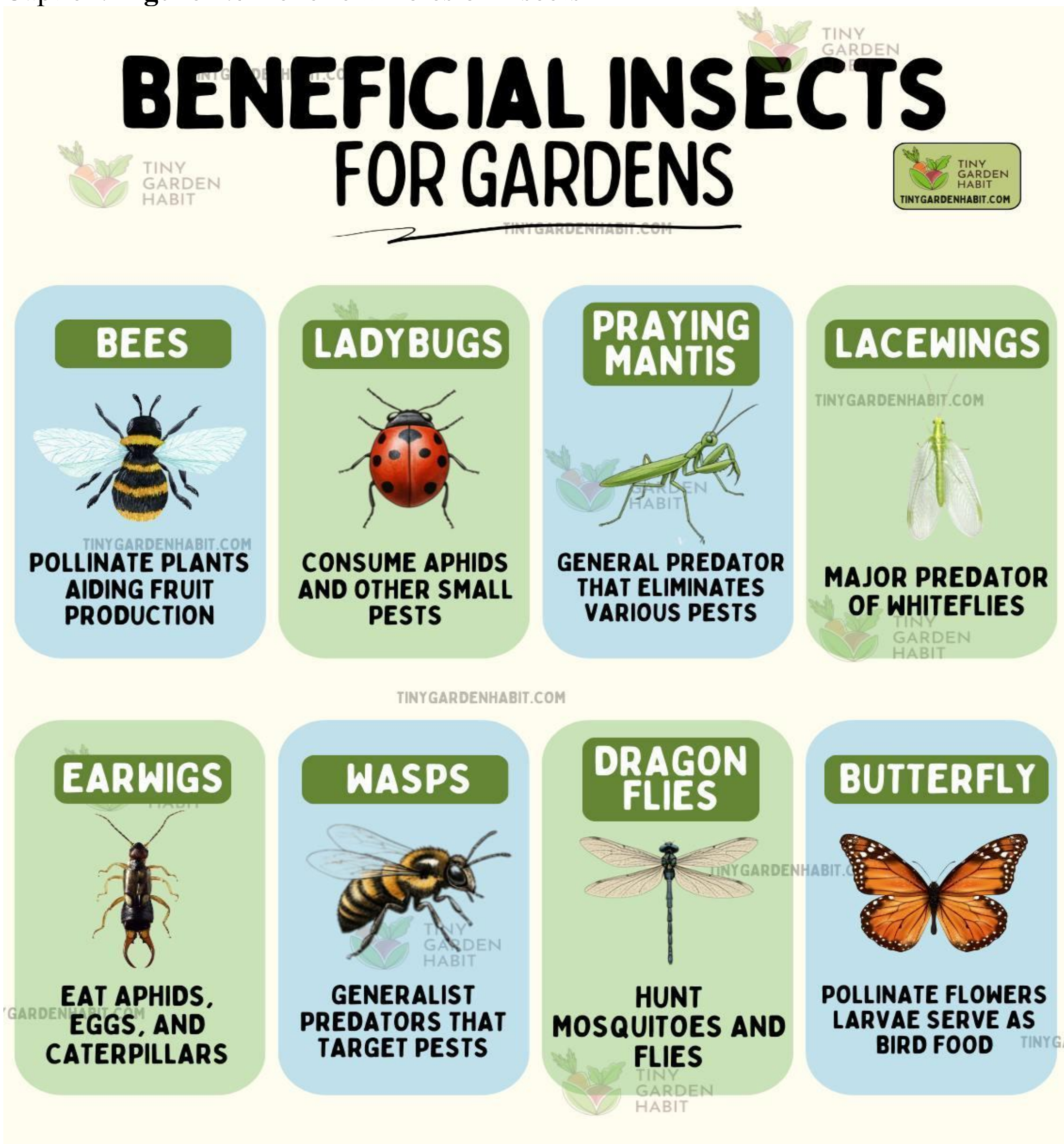
2.4.1 Beneficial roles of insects

Insects play many **beneficial roles** in ecosystems and human activities. They act as **pollinators**, transferring pollen between flowers and enabling fruit and seed production. Bees, butterflies, and certain flies are vital for agriculture and biodiversity. Insects also serve as **decomposers**, breaking down organic matter and recycling nutrients back into the soil.

Some insects are used in biological control, where predators or parasites help regulate pest populations. For example, ladybird beetles feed on aphids, reducing crop damage. Insects also contribute to products such as honey, silk, and dyes, which have economic value.

Short description: Diagram showing beneficial roles of insects (pollination, decomposition, biological control).

Caption: **Figure 2.7 Beneficial roles of insects**



AI prompt suggestion: “Generate a labelled diagram showing beneficial roles of insects such as pollination, decomposition, and biological control.”
Search string: “beneficial roles of insects diagram OER”

Fill in the blank: Bees and butterflies are important insect ______ because they transfer pollen between flowers.

2.4.2 Harmful roles of insects

Insects can also have **harmful roles**, particularly when they damage crops, stored products, or transmit diseases. Locusts, for instance, cause devastating losses by consuming large amounts of vegetation. Termites destroy wooden structures, while mosquitoes and tsetse flies spread diseases that affect humans and animals.

Economically, harmful insects reduce agricultural productivity, increase food storage losses, and raise costs of healthcare and pest control. Their impact highlights the need for effective management strategies that balance ecological roles with economic concerns.

Box 2.8 Harmful roles of insects

Category of Harm	Key Example	Scientific Group	Primary Mechanism of Damage	Global Impact
Agricultural	**Desert Locust**	*Schistocerca gregaria*	**Mass Defoliation:** Swarms consume their own body weight in vegetation daily.	**Food Insecurity:** Can trigger widespread famine and destroy the livelihoods of millions.
Medical	**Mosquito**	*Anopheles*, *Aedes*	**Vector Transmission:** Injects pathogens (Malaria, Zika, Dengue) during blood-feeding.	**Human Mortality:** Responsible for more human deaths annually than any other animal.
Structural	**Subterranean Termite**	Isoptera	**Cellulose Digestion:** Specialized gut microbes allow them to eat wood and paper.	**Infrastructure Loss:** Causes billions in damage to homes and wooden structures every year.
Veterinary	**Tsetse Fly**	*Glossina* spp.	**Blood-feeding:** Transmits *Trypanosoma* parasites to livestock.	**Economic Decline:** Prevents cattle farming across vast

Category of Harm	Key Example	Scientific Group	Primary Mechanism of Damage	Global Impact
				areas of Africa (Nagana disease).
Stored Product	**Rice Weevil**	*Sitophilus oryzae*	**Internal Feeding:** Larvae hollow out grains from the inside, leaving only husks.	**Post-Harvest Loss:** Significant reduction in the quality and quantity of stored food supplies.
Direct Injury	**Harvester Ant**	*Pogonomyrmex*	**Venom Injection:** Defensive stings that cause intense pain and allergic reactions.	**Public Safety:** Can cause anaphylactic shock in sensitive individuals or disrupt labor.

Fill in the blank: Locusts are harmful because they consume large amounts of ______, leading to crop losses.

Pilot questions 2.4

Name one beneficial role of insects in agriculture.
Give an example of an insect used in biological control.
What product is obtained from bees that has economic value?
Name one harmful insect that damages crops.
Why do harmful insects increase healthcare costs?

Series Summary

This Series focused on the taxonomy and biology of selected insect groups, emphasising their classification, ecological roles, and economic importance. We began by examining the principles of insect taxonomy, including the basis of classification and nomenclature, followed by the hierarchical ranks used to organise insects. Then, we explored the biology of agricultural insect groups, considering those that damage crops and stored products. Subsequently, we studied medical and veterinary insect groups, highlighting their roles as disease vectors and their impact on domestic animals. Finally, we analysed the ecological and economic importance of insects, discussing both their beneficial and harmful roles.

By completing this Series, you should now be able to define the basis of insect classification, describe taxonomic ranks, explain the biology of insect groups affecting crops and stored products, analyse their role as disease vectors and in veterinary contexts, and evaluate their ecological and economic importance. These outcomes align with the Series Learning Outcomes and provide you with a comprehensive understanding of insect diversity and its relevance to agriculture, health, and ecosystems.

Glossary of Terms

- **Binomial nomenclature**: A system of naming species using two parts, the genus and species.
- **Chewing insects**: Insects that feed by consuming plant tissues directly, such as caterpillars and beetles.
- **Decomposers**: Organisms that break down organic matter and recycle nutrients into the soil.
- **Family**: A taxonomic rank below order and above genus.
- **Genus**: A taxonomic rank below family and above species, grouping closely related organisms.
- **Nomenclature**: The system of naming organisms according to agreed rules.
- **Order**: A taxonomic rank within Class Insecta, grouping families with shared characteristics.
- **Pollinators**: Insects that transfer pollen between flowers, enabling fertilisation and seed production.
- **Species**: The basic unit of classification, representing a group of organisms capable of interbreeding.
- **Stored product pests**: Insects that infest stored food items such as grains, flour, and dried fish.
- **Taxonomy**: The science of naming, describing, and classifying organisms.
- **Vectors**: Insects that transmit pathogens causing diseases in humans or animals.

Concept Check Questions 2

Objective questions

- The binomial system gives each species a two-part name consisting of the ______ and the species. (Linked to SLO 2.1)
- Insects belong to the Kingdom Animalia, Phylum Arthropoda, and Class ______. (Linked to SLO 2.2)
- Aphids and whiteflies are examples of ______ insects that pierce plant tissues. (Linked to SLO 2.3)
- Weevils, flour beetles, and moths are examples of ______ product pests. (Linked to SLO 2.4)
- Mosquitoes are important vectors because they transmit diseases such as malaria and ______. (Linked to SLO 2.5)

Short-answer questions
6. Define taxonomy. (Linked to SLO 2.1)
7. List the major taxonomic ranks in order. (Linked to SLO 2.2)
8. Name one chewing insect that damages crops. (Linked to SLO 2.3)
9. Give one example of a stored product pest. (Linked to SLO 2.4)
10. Why are ticks often studied alongside insects in veterinary entomology? (Linked to SLO 2.6)

Long-answer questions
11. Explain the basis of insect classification and nomenclature. (Linked to SLO 2.1)
12. Describe the biology of insect groups affecting crops and stored products. (Linked to SLO 2.3, 2.4)
13. Analyse the biology of insect groups acting as disease vectors and affecting domestic animals. (Linked to SLO 2.5, 2.6)
14. Evaluate the ecological and economic importance of insect groups, considering both beneficial and harmful roles. (Linked to SLO 2.7)

Answers to Concept Check Questions 2

Objective questions

Genus.
Insecta.
Sucking.
Stored.
Dengue.

Short-answer questions
6. The science of naming, describing, and classifying organisms.
7. Kingdom, Phylum, Class, Order, Family, Genus, Species.
8. Caterpillar.
9. Weevil.
10. Because they transmit diseases and affect livestock health, similar to insect pests.

Long-answer questions
11. **Basic response**: Insects are classified based on morphology, behaviour, and ecological roles, and named using binomial nomenclature.
Value-added response: Classification also reflects evolutionary relationships, while nomenclature ensures consistency and avoids confusion across scientific communities.

Basic response: Crop pests include chewing and sucking insects, while stored product pests infest grains and flour.
Value-added response: Their biology explains seasonal outbreaks and storage contamination, guiding effective management strategies.

Basic response: Mosquitoes, tsetse flies, and sandflies act as vectors, while lice and flies affect domestic animals.

Value-added response: Their feeding habits, life cycles, and ecological roles influence disease transmission and livestock productivity.

Basic response: Insects are beneficial as pollinators, decomposers, and biological control agents, but harmful as pests and vectors.

Value-added response: Their ecological and economic roles highlight the need for balanced management strategies that maximise benefits while reducing harm.

Answers to Pilot Questions 2

Part 2.1

The science of naming, describing, and classifying organisms.
Binomial nomenclature.
Anopheles gambiae.
Kingdom, Phylum, Class, Order, Family, Genus, Species.
Order Lepidoptera, butterflies.

Part 2.2

Caterpillar.
Sucking insects.
Weevil.
Poor storage conditions.
Airtight storage.

Part 2.3

An organism that transmits pathogens.
Malaria.
Tsetse fly.
Stable fly.
Because they transmit diseases affecting livestock.

Part 2.4

Pollination.
Ladybird beetle.
Honey.
Locust.
Because they transmit diseases that require treatment.

References And Attributions 2

Figures and Boxes suggested in Series 2:

Figure 2.1 Basis of classification and nomenclature in insects
Box 2.2 Major taxonomic ranks of insects

Figure 2.3 Insects affecting crops
Box 2.4 Common stored product pests
Figure 2.5 Insects as disease vectors
Box 2.6 Insects affecting domestic animals
Figure 2.7 Beneficial roles of insects
Box 2.8 Harmful roles of insects

AI prompt suggestions used for illustration placeholders:

Diagrams showing binomial nomenclature, crop pests, insect vectors, and beneficial roles.

Boxes summarising taxonomic ranks, stored product pests, veterinary pests, and harmful roles.

Open Educational Resource (OER) search strings suggested:

"binomial nomenclature insect classification diagram OER"
"insect taxonomy ranks hierarchy OER"
"crop insect pests diagram OER"
"stored product insect pests OER"
"insect disease vectors diagram OER"
"veterinary insect pests livestock OER"
"beneficial roles of insects diagram OER"
"harmful roles of insects OER"

General references (APA style):

Gullan, P. J., & Cranston, P. S. (2014). *The Insects: An Outline of Entomology*. Wiley Blackwell.

Pedigo, L. P., & Rice, M. E. (2014). *Entomology and Pest Management*. Waveland Press.

OER Commons. (n.d.). *Entomology resources*. Retrieved from https://www.oercommons.org

ZOO411 Series 3 Control Of Insect Pests Of Crops And Stored Products

Introduction

In the last Series, we examined the taxonomy and biology of selected insect groups, focusing on their roles in agriculture, health, and ecosystems. Building on that knowledge, this Series addresses the practical challenge of controlling insect pests that affect crops and stored products. Pest control is essential for safeguarding food security, reducing economic losses, and ensuring sustainable agricultural practices.

The aim of this Series is to explain the principles and methods of insect pest control in crops and stored products, and to evaluate integrated pest management as a sustainable approach.

We shall commence this Series by introducing the principles of insect pest control and the factors that influence pest outbreaks. Next, we will explore methods of controlling crop pests, including cultural, biological, and chemical approaches. Following that, we will consider methods of controlling stored product pests, focusing on preventive, physical, mechanical, chemical, and biological measures. Finally, we will conclude by analysing integrated pest management, highlighting its principles and advantages in agriculture and storage systems.

Series Learning Outcomes

Upon completing this Series, you should be able to:

SLO 3.1 define the principles of insect pest control and explain their importance,
SLO 3.2 analyse the factors influencing pest outbreaks,
SLO 3.3 describe cultural methods of controlling crop pests,
SLO 3.4 explain biological methods of controlling crop pests,

SLO 3.5 evaluate chemical methods of controlling crop pests,
SLO 3.6 describe preventive measures for controlling stored product pests,
SLO 3.7 explain physical and mechanical methods of controlling stored product pests,
SLO 3.8 evaluate chemical and biological methods of controlling stored product pests,
SLO 3.9 analyse the concept and principles of integrated pest management, and
SLO 3.10 evaluate the advantages of integrated pest management in agriculture and storage.

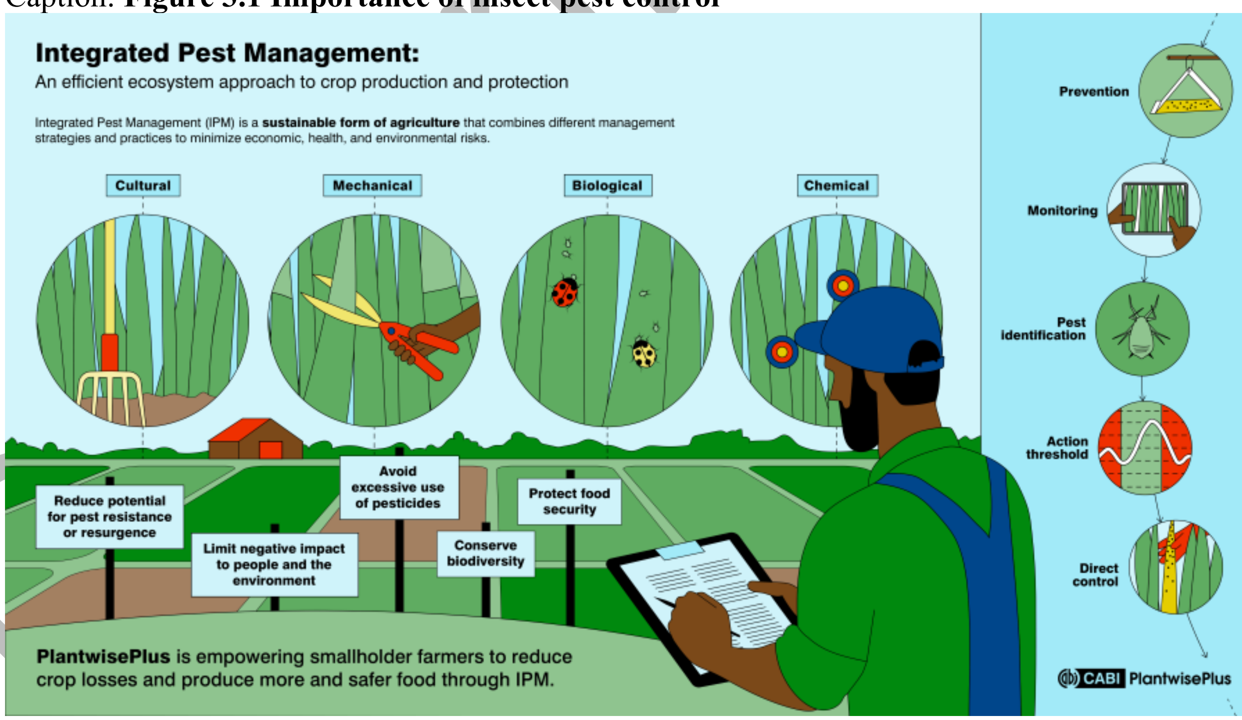
3.1 Principles Of Insect Pest Control

3.1.1 Definition and importance of pest control

Pest control refers to the management of insect populations that cause damage to crops or stored products. It is important because pests reduce agricultural yield, contaminate food, and increase economic losses. Effective pest control ensures food security, protects farmers' livelihoods, and supports sustainable agricultural practices.

The importance of pest control extends beyond agriculture. By reducing pest populations, we also minimise the spread of diseases and improve the quality of stored products. This makes pest control a critical component of both farming and food storage systems.

Short description: Diagram showing the importance of pest control in agriculture and storage.
Caption: **Figure 3.1 Importance of insect pest control**



Fill in the blank: Pest control is important because it reduces agricultural losses and ensures ______ security.

3.1.2 Factors influencing pest outbreaks

Several factors influence the occurrence of **pest outbreaks**, which are sudden increases in pest populations that cause significant damage. These factors include favourable environmental conditions such as temperature and humidity, availability of food sources, and absence of natural enemies.

Human activities also play a role. Practices such as monocropping, poor storage conditions, and excessive use of pesticides can create environments that encourage pest outbreaks. Understanding these factors helps farmers and researchers design effective control strategies.

Box 3.2 Factors influencing pest outbreaks

Category	Specific Factor	Mechanism of Action	Impact on Pest Population
Environmental	**Temperature Shifts**	Increases metabolic rate and shortens the life cycle.	**Rapid Turnover:** Allows for more generations per year (polyvoltine).
Environmental	**Climate Change**	Warmer winters reduce "overwintering" mortality.	**Range Expansion:** Pests survive in regions previously too cold for them.
Biological	**Loss of Natural Enemies**	Absence of predators, parasitoids, or pathogens.	**Unchecked Growth:** No biological "brakes" to keep the population stable.
Biological	**Host Abundance**	Sudden availability of high-quality food (e.g., a blooming crop).	**Nutritional Surge:** Increases the number of eggs laid per female (fecundity).
Human-Induced	**Monoculture**	Large areas planted with a single, genetically uniform crop.	**High Connectivity:** Pests move effortlessly from plant to plant without barriers.

Category	Specific Factor	Mechanism of Action	Impact on Pest Population
Human-Induced	**Invasive Introduction**	Accidental transport of pests to new continents/regions.	**Founder Effect:** The pest arrives without its evolved predators from home.
Human-Induced	**Pesticide Overuse**	Selection pressure favors individuals with resistant genes.	**The Pesticide Treadmill:** Survivors breed a new, "immune" population.

Fill in the blank: Monocropping and poor storage conditions are examples of ______ activities that encourage pest outbreaks.

Pilot questions 3.1

What is pest control?
Why is pest control important in agriculture?
Define a pest outbreak.
Name one environmental factor that influences pest outbreaks.
Give one human activity that can encourage pest outbreaks.

3.2 Methods Of Controlling Crop Pests

3.2.1 Cultural methods

Cultural methods are farming practices designed to reduce pest populations by altering the environment. Examples include crop rotation, intercropping, timely planting, and proper field sanitation. These practices disrupt pest life cycles, reduce food availability, and make the environment less favourable for pests.

For instance, rotating maize with legumes can reduce stem borer infestations, while removing crop residues prevents pests from breeding in leftover plant material.

Short description: Diagram showing crop rotation and intercropping as cultural pest control methods.

Caption: **Figure 3.3 Cultural methods of controlling crop pests**

Fill in the blank: Crop rotation helps reduce pest populations by disrupting their ______ cycles.

3.2.2 Biological methods

Biological methods involve using natural enemies of pests to regulate their populations. These include predators, parasites, and pathogens. Ladybird beetles feed on aphids, parasitoid wasps lay eggs inside caterpillars, and fungi such as *Beauveria bassiana* infect and kill insect pests.

Biological control is environmentally friendly and sustainable, but it requires careful monitoring to ensure that beneficial organisms are effective and do not harm non-target species.

Box 3.4 Examples of biological control agents

Category	**Agent Type**	**Key Mechanism**	**Representative Example**	**Target Pests**
Predator	**Ladybird Beetles**	Both adults and larvae actively hunt and consume entire prey.	*Harmonia axyridis*	Aphids, Scale insects, Mealybugs.

Category	Agent Type	Key Mechanism	Representative Example	Target Pests
Predator	**Green Lacewings**	Larvae (Aphid Lions) use curved mandibles to suck fluids from prey.	*Chrysoperla* spp.	Soft-bodied insects, Thrips, Mites.
Parasitoid	**Braconid Wasps**	Adults lay eggs *inside* the host; larvae consume it from within.	*Cotesia congregata*	Tomato Hornworms, Caterpillars.
Parasitoid	**Egg Wasps**	Tiny wasps that parasitize the *eggs* of the pest.	*Trichogramma* spp.	Cabbage Loopers, Codling Moths.
Pathogen	**Entomopathogenic Fungi**	Spores penetrate the cuticle and grow through the insect's body.	*Beauveria bassiana*	Whiteflies, Aphids, Beetles.
Pathogen	**Bacteria (Bt)**	Produces a crystalline protein that destroys the insect's gut.	*Bacillus thuringiensis*	Mosquito larvae, Gypsy moths.
Pathogen	**Viruses (NPV)**	Highly specific viruses that liquefy the internal tissues of larvae.	Nuclear Polyhedrosis Virus	High-density caterpillar outbreaks.

Fill in the blank: Ladybird beetles are biological control agents because they feed on ______.

3.2.3 Chemical methods

Chemical methods involve the use of pesticides to kill or repel pests. These include insecticides, fumigants, and repellents. Chemical control is often effective and fast, but it must be applied carefully to avoid environmental pollution, resistance development, and harm to beneficial organisms.

Farmers are encouraged to follow recommended dosages, apply chemicals at the right time, and combine chemical methods with other approaches for sustainable pest management.

Short description: Diagram showing spraying of insecticides on crops.
Caption: **Figure 3.5 Chemical methods of controlling crop pests**

Fill in the blank: Excessive use of pesticides can lead to pest ______, making them harder to control.

Pilot questions 3.2

What are cultural methods of pest control?
Give one example of a cultural method used in farming.
Name one predator used in biological pest control.
What type of organism is *Beauveria bassiana*?
Why must chemical methods be applied carefully?

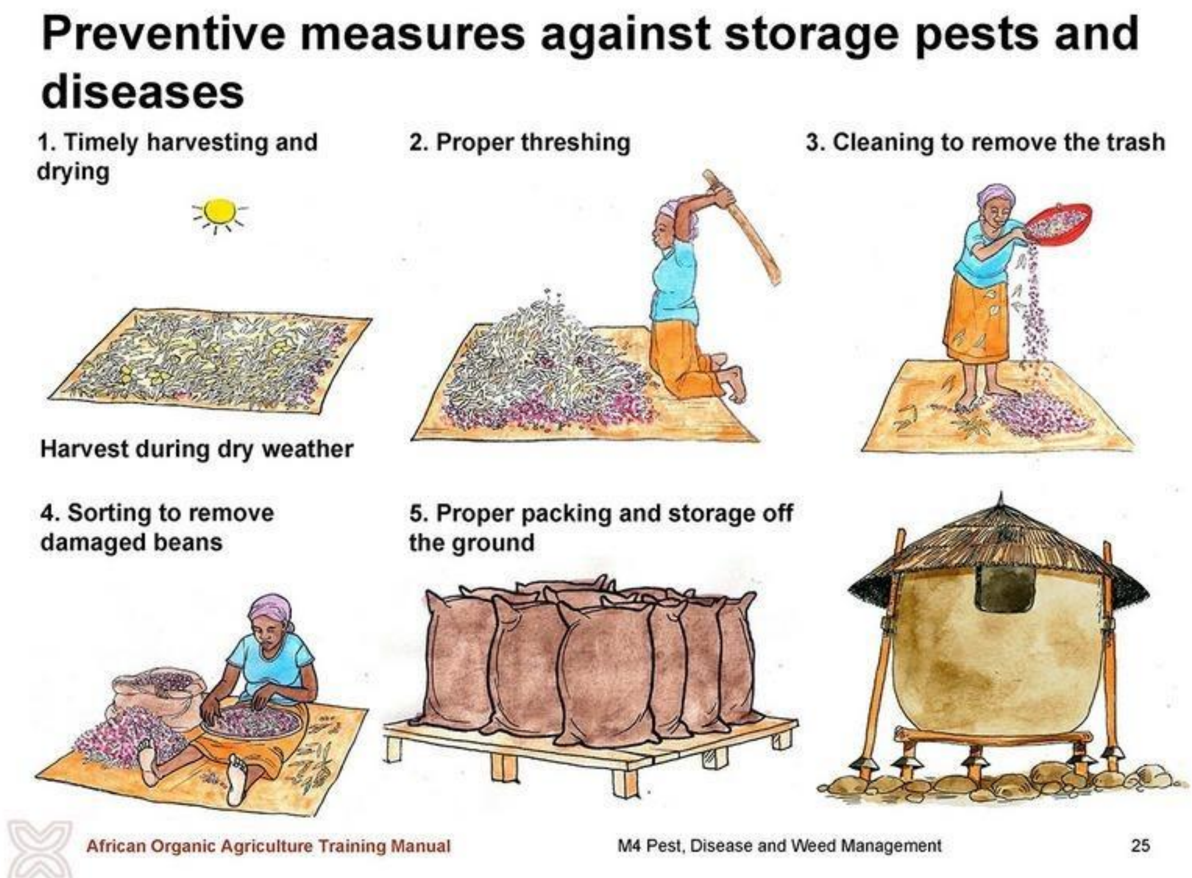
3.3 Methods Of Controlling Stored Product Pests

3.3.1 Preventive measures in storage

Preventive measures are practices designed to stop pests from infesting stored products in the first place. These include cleaning storage facilities, using airtight containers, drying grains properly before storage, and maintaining low humidity. Preventive measures are cost-effective and reduce the likelihood of pest outbreaks.

For example, thorough cleaning of silos before storing new grain prevents carry-over infestations, while drying grains to safe moisture levels reduces the risk of mould and insect attack.

Short description: Diagram showing preventive measures such as cleaning silos and drying grains.
Caption: **Figure 3.6 Preventive measures in storage**



Fill in the blank: Drying grains properly before storage reduces the risk of ______ and insect attack.

3.3.2 Physical and mechanical methods

Physical and mechanical methods involve using non-chemical techniques to control pests. Examples include sieving to remove infested grains, heating or cooling to kill insects, and using traps. These methods are safe, environmentally friendly, and suitable for small-scale storage systems.

Heating grains to specific temperatures can kill insects at all life stages, while cooling slows down their development. Mechanical traps are also effective for monitoring and reducing pest populations.

Box 3.7 Physical and mechanical methods of controlling stored product pests

Method	Technique	Primary Mechanism	Practical Application
Thermal	**Heat Treatment**	Denatures proteins and causes rapid desiccation (drying out).	Heating storage bins to **50–60°C** for 24 hours to kill all life stages.
Thermal	**Cold Storage**	Arrests development and kills through ice crystal formation in cells.	Maintaining grain below **10°C** to stop breeding; freezing at **-18°C** for 48 hours.
Atmospheric	**Hermetic Storage**	**Hypoxia/Hypercarbia:** Insects suffocate as O_2 is depleted and CO_2 rises.	Using air-tight PICS (Perennial Intensive Crop Systems) bags or sealed silos.
Mechanical	**Inert Dusts (DE)**	Diatomaceous earth abrades the waxy cuticle, causing death by dehydration.	Mixing food-grade silica dust into grain mass as a long-term protectant.
Mechanical	**Sieving / Cleaning**	Physically removes insects, eggs, and "dockage" (breeding debris).	Passing grain through vibrating screens and aspirators before final bagging.
Mechanical	**Impact (Entoleters)**	High-speed centrifugal force shatters insects and eggs upon impact.	Used in flour mills to ensure "clean" flour before it reaches the consumer.

Method	Technique	Primary Mechanism	Practical Application
Barrier	**Packaging**	Physical exclusion using insect-proof materials (foil, glass, thick poly).	Vacuum-sealing or using multi-layered laminate bags to prevent "borers."

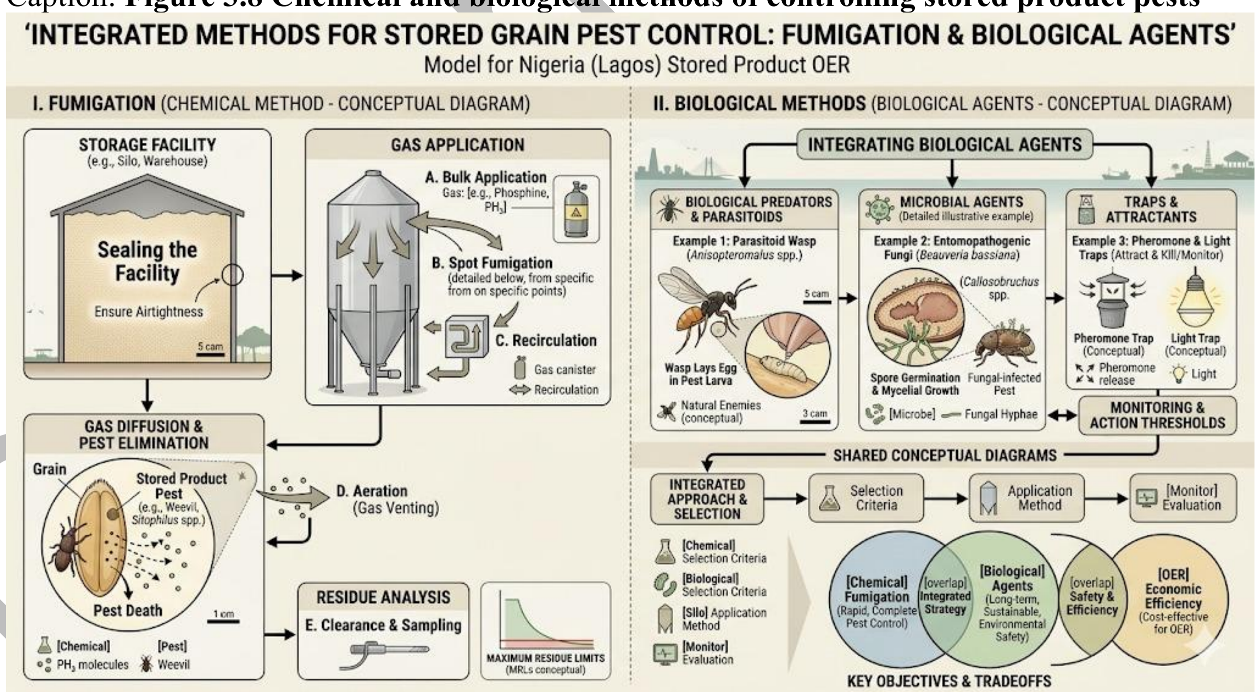
Fill in the blank: Heating grains to specific temperatures can kill insects at all ______ stages.

3.3.3 Chemical and biological methods

Chemical methods for stored product pests include fumigation and the use of insecticides. Fumigation with gases such as phosphine is effective in killing insects inside stored grains. However, it requires careful handling to avoid health risks.

Biological methods involve using natural enemies or microbial agents to control pests. For example, certain parasitoids target moth larvae, while microbial agents such as bacteria and fungi can reduce pest populations. Combining chemical and biological methods often improves effectiveness and sustainability.

Short description: Diagram showing fumigation of stored grains.
Caption: **Figure 3.8 Chemical and biological methods of controlling stored product pests**



Fill in the blank: Fumigation with gases such as ______ is effective in killing insects inside stored grains.

Pilot questions 3.3

What are preventive measures in storage?
Give one example of a preventive measure for stored products.
Name one physical method of controlling stored product pests.
What gas is commonly used in fumigation?
Give one example of a biological method used against stored product pests.

3.4 Integrated Pest Management (IPM)

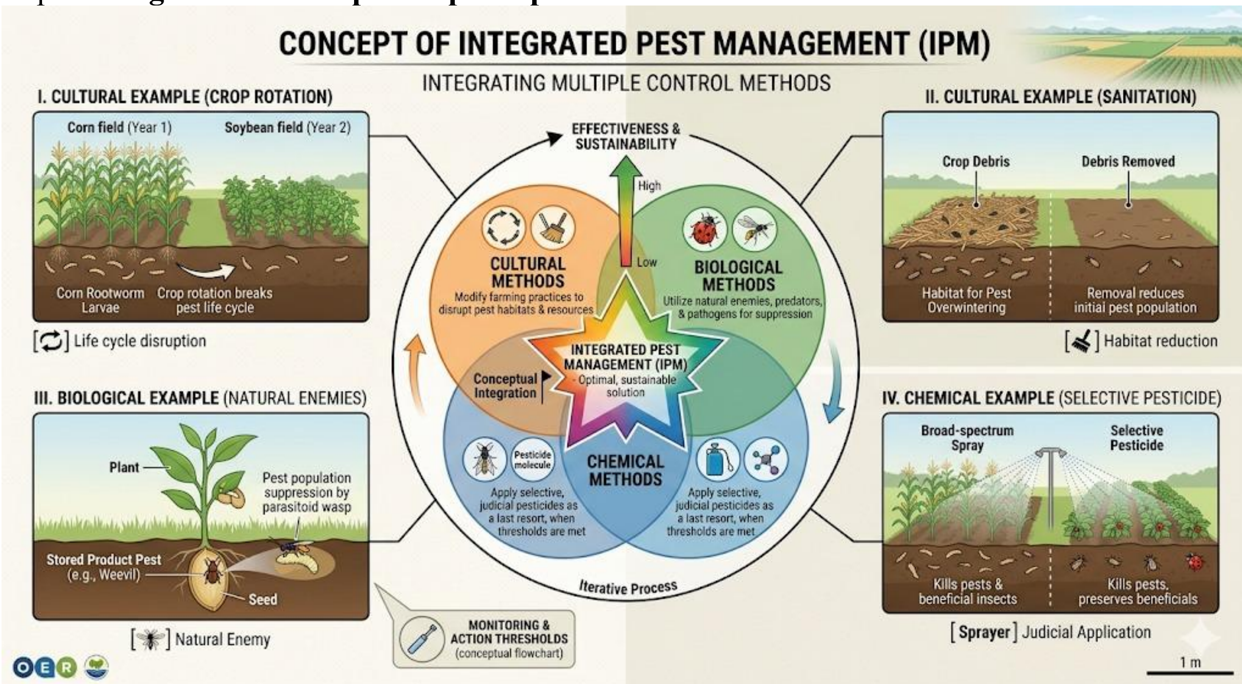
3.4.1 Concept and principles of IPM

Integrated Pest Management (IPM) is a sustainable approach to pest control that combines different methods to manage pest populations effectively while minimising harm to the environment, humans, and beneficial organisms. The principles of IPM include prevention, monitoring, and the use of multiple control strategies such as cultural, biological, and chemical methods in a balanced way.

IPM emphasises decision-making based on pest population thresholds. Instead of applying pesticides routinely, farmers monitor pest levels and act only when populations exceed the economic threshold, meaning the point at which damage would cause significant economic loss.

Short description: Diagram showing the concept of IPM with cultural, biological, and chemical methods integrated.

Caption: **Figure 3.9 Concept and principles of IPM**



Fill in the blank: IPM emphasises action only when pest populations exceed the ______ threshold.

3.4.2 Advantages of IPM in agriculture and storage

IPM offers several advantages over conventional pest control. It reduces reliance on chemical pesticides, thereby lowering risks of resistance, environmental pollution, and harm to beneficial organisms. It also promotes long-term sustainability by encouraging preventive measures and biological control.

In agriculture, IPM helps maintain crop yields while protecting biodiversity. In storage systems, it ensures food safety and reduces contamination. By integrating different methods, IPM provides a holistic and cost-effective solution to pest management.

Box 3.10 Advantages of integrated pest management

Category	Primary Advantage	Mechanical/Biological Basis	Long-Term Outcome
Environmental	**Biodiversity Protection**	Minimizes "off-target" effects on pollinators and natural predators.	Stable ecosystems with natural "checks and

Category	Primary Advantage	Mechanical/Biological Basis	Long-Term Outcome
			balances" on pest populations.
Economic	**Cost-Effectiveness**	Reduces the need for expensive synthetic inputs by using "free" biological services.	Higher profit margins for farmers and lower food prices for consumers.
Biological	**Resistance Management**	Uses chemicals only as a last resort, preventing pests from evolving "immunity."	Extends the useful life of existing pesticides and reduces the "pesticide treadmill."
Human Health	**Reduced Toxicity**	Lowers the chemical residue on food and reduces worker exposure to toxins.	Safer food supplies and improved occupational health for agricultural laborers.
Storage	**Quality Preservation**	Prevents contamination from silk, frass, and odors in stored grains.	Higher market value for exported goods and reduced post-harvest waste.
Regulatory	**Market Access**	Ensures compliance with international Maximum Residue Limits (MRLs).	Facilitates global trade and meets the growing demand for organic/clean produce.

Fill in the blank: One advantage of IPM is that it reduces reliance on ______ pesticides.

Pilot questions 3.4

What does IPM stand for?
What are the main principles of IPM?
Define the term economic threshold in pest management.
Mention one advantage of IPM in agriculture.

Why is IPM considered a sustainable approach?

Series Summary

This Series addressed the control of insect pests of crops and stored products, highlighting practical strategies for safeguarding food security and ensuring sustainable agricultural practices. We began by examining the principles of pest control and the factors influencing pest outbreaks. Then, we explored methods of controlling crop pests, including cultural, biological, and chemical approaches. Following that, we considered methods of controlling stored product pests, focusing on preventive, physical, mechanical, chemical, and biological measures. Finally, we analysed integrated pest management (IPM), emphasising its principles and advantages in agriculture and storage systems.

By completing this Series, you should now be able to define the principles of pest control, analyse factors influencing pest outbreaks, describe and evaluate methods of controlling crop and stored product pests, and explain the concept and advantages of IPM. These achievements align with the Series Learning Outcomes and equip you with practical knowledge for managing insect pests in both field and storage contexts.

Glossary of Terms

Biological control: The use of natural enemies such as predators, parasites, or pathogens to manage pest populations.
Chemical methods: The use of pesticides, fumigants, or repellents to kill or repel pests.
Cultural methods: Farming practices such as crop rotation, intercropping, and sanitation that reduce pest populations.
Economic threshold: The pest population level at which control measures must be applied to prevent economic loss.
Fumigation: The use of gases such as phosphine to kill pests in stored products.
Integrated Pest Management (IPM): A sustainable approach combining multiple pest control methods to minimise harm and maximise effectiveness.
Pest outbreak: A sudden increase in pest populations that causes significant damage.
Preventive measures: Practices such as cleaning, drying, and airtight storage that prevent pest infestations.
Physical methods: Non-chemical techniques such as heating, cooling, sieving, or trapping to control pests.

Concept Check Questions 3

Objective questions

Pest control is important because it reduces agricultural losses and ensures ______ security. (Linked to SLO 3.1)

Monocropping and poor storage conditions are examples of ______ activities that encourage pest outbreaks. (Linked to SLO 3.2)
Crop rotation helps reduce pest populations by disrupting their ______ cycles. (Linked to SLO 3.3)
Ladybird beetles are biological control agents because they feed on ______. (Linked to SLO 3.4)
Excessive use of pesticides can lead to pest ______. (Linked to SLO 3.5)
Drying grains properly before storage reduces the risk of ______ and insect attack. (Linked to SLO 3.6)
Heating grains to specific temperatures can kill insects at all ______ stages. (Linked to SLO 3.7)
Fumigation with gases such as ______ is effective in killing insects inside stored grains. (Linked to SLO 3.8)
IPM emphasises action only when pest populations exceed the ______ threshold. (Linked to SLO 3.9)
One advantage of IPM is that it reduces reliance on ______ pesticides. (Linked to SLO 3.10)

Short-answer questions

11. Define pest control. (Linked to SLO 3.1)
12. Name one environmental factor that influences pest outbreaks. (Linked to SLO 3.2)
13. Give one example of a cultural method of pest control. (Linked to SLO 3.3)
14. Name one predator used in biological pest control. (Linked to SLO 3.4)
15. Why must chemical methods be applied carefully? (Linked to SLO 3.5)
16. Give one preventive measure for stored products. (Linked to SLO 3.6)
17. Name one physical method of controlling stored product pests. (Linked to SLO 3.7)
18. Give one example of a biological method used against stored product pests. (Linked to SLO 3.8)
19. What does IPM stand for? (Linked to SLO 3.9)
20. Mention one advantage of IPM in agriculture. (Linked to SLO 3.10)

Long-answer questions

21. Explain the principles of pest control and why they are important. (Linked to SLO 3.1)
22. Analyse the factors influencing pest outbreaks. (Linked to SLO 3.2)
23. Describe cultural, biological, and chemical methods of controlling crop pests. (Linked to SLO 3.3, 3.4, 3.5)
24. Explain preventive, physical, mechanical, chemical, and biological methods of controlling stored product pests. (Linked to SLO 3.6, 3.7, 3.8)
25. Evaluate the concept and advantages of integrated pest management. (Linked to SLO 3.9, 3.10)

Answers to Concept Check Questions 3

Objective questions

Food.
Human.

Life.
Aphids.
Resistance.
Mould.
Life.
Phosphine.
Economic.
Chemical.

Short-answer questions
11. The management of insect populations that cause damage to crops or stored products.
12. Temperature or humidity.
13. Crop rotation.
14. Ladybird beetle.
15. To avoid pollution, resistance, and harm to beneficial organisms.
16. Cleaning storage facilities.
17. Heating or cooling.
18. Parasitoids or microbial agents.
19. Integrated Pest Management.
20. Reduced pesticide use.

Long-answer questions
21. **Basic response**: Pest control involves managing insect populations to reduce damage and ensure food security.
Value-added response: It also protects livelihoods, reduces disease spread, and supports sustainable agriculture.

Basic response: Pest outbreaks are influenced by environmental conditions and human activities.
Value-added response: Factors such as monocropping, pesticide misuse, and climate change can intensify outbreaks.
Basic response: Cultural methods include crop rotation, biological methods use natural enemies, and chemical methods involve pesticides.
Value-added response: Combining these methods enhances effectiveness and sustainability.
Basic response: Preventive measures include cleaning and drying, physical methods involve heating or cooling, chemical methods use fumigation, and biological methods employ natural enemies.
Value-added response: Integrating these approaches ensures food safety and reduces contamination.
Basic response: IPM combines multiple methods to manage pests sustainably.
Value-added response: It reduces pesticide reliance, prevents resistance, protects biodiversity, and ensures long-term sustainability.

Answers to Pilot Questions 3

Part 3.1

The management of insect populations that cause damage.
It reduces losses and ensures food security.
A sudden increase in pest populations causing damage.
Temperature.
Monocropping.

Part 3.2

Farming practices that reduce pest populations.
Crop rotation.
Ladybird beetle.
Fungus.
To avoid pollution and resistance.

Part 3.3

Practices to prevent pest infestations in storage.
Drying grains.
Heating.
Phosphine.
Parasitoids.

Part 3.4

Integrated Pest Management.
Prevention, monitoring, and combining methods.
The pest population level at which control is needed.
Maintains crop yields.
It reduces pesticide use and promotes sustainability.

References And Attributions 3

Figures and Boxes suggested in Series 3:

Figure 3.1 Importance of insect pest control
Box 3.2 Factors influencing pest outbreaks
Figure 3.3 Cultural methods of controlling crop pests
Box 3.4 Examples of biological control agents
Figure 3.5 Chemical methods of controlling crop pests
Figure 3.6 Preventive measures in storage
Box 3.7 Physical and mechanical methods of controlling stored product pests
Figure 3.8 Chemical and biological methods of controlling stored product pests
Figure 3.9 Concept and principles of IPM
Box 3.10 Advantages of integrated pest management

AI prompt suggestions used for illustration placeholders:

Diagrams showing pest control importance, crop rotation, fumigation, and IPM.
Boxes summarising outbreak factors, biological agents, physical methods, and IPM advantages.

Open Educational Resource (OER) search strings suggested:

"importance of insect pest control diagram OER"
"factors influencing insect pest outbreaks OER"
"cultural methods crop pest control OER"
"biological control agents insect pests OER"
"chemical methods crop pest control diagram OER"
"preventive measures stored product pests OER"
"physical mechanical methods stored product pest control OER"
"chemical biological methods stored product pest control OER"
"integrated pest management concept diagram OER"
"advantages of integrated pest management OER"

General references (APA style):

Pedigo, L. P., & Rice, M. E. (2014). *Entomology and Pest Management*. Waveland Press.
Gullan, P. J., & Cranston, P. S. (2014). *The Insects: An Outline of Entomology*. Wiley Blackwell.
Dent, D. (2000). *Insect Pest Management*. CABI Publishing.
OER Commons. (n.d.). *Entomology resources*. Retrieved from https://www.oercommons.org

ZOO411 Series 4 Control Of Insect Vectors Of Diseases

Part 4.1 Principles of insect vectors and disease transmission
4.1.1 Definition and importance of insect vectors
4.1.2 Mechanisms of disease transmission

Part 4.2 Major insect vectors of human diseases
4.2.1 Mosquitoes and malaria, dengue, and yellow fever
4.2.2 Tsetse flies and trypanosomiasis
4.2.3 Sandflies and leishmaniasis

Part 4.3 Insect vectors of veterinary importance
4.3.1 Flies affecting livestock
4.3.2 Lice, mites, and ticks in domestic animals

Part 4.4 Control strategies for insect vectors

4.4.1 Environmental management and sanitation
4.4.2 Biological and chemical control methods
4.4.3 Integrated vector management (IVM)

Introduction

In the previous Series, we studied the control of insect pests of crops and stored products, focusing on methods to protect food security and reduce economic losses. In this Series, our attention shifts to insect vectors of diseases, which pose serious threats to human and animal health. These insects are not only nuisances but also carriers of pathogens that cause illnesses such as malaria, trypanosomiasis, and leishmaniasis.

The aim of this Series is to explain the principles of insect vectors and disease transmission, describe the biology of major vectors of medical and veterinary importance, and evaluate strategies for their control.

We shall commence this Series by examining the principles of insect vectors and the mechanisms of disease transmission. Next, we will explore major insect vectors of human diseases, including mosquitoes, tsetse flies, and sandflies. Following that, we will consider insect vectors of veterinary importance, such as flies, lice, mites, and ticks. Finally, we will conclude by analysing control strategies for insect vectors, focusing on environmental management, biological and chemical methods, and integrated vector management.

Series Learning Outcomes

Upon completing this Series, you should be able to:

SLO 4.1 define insect vectors and explain their importance in disease transmission,
SLO 4.2 describe the mechanisms by which insect vectors transmit diseases,
SLO 4.3 explain the biology of mosquitoes and the diseases they transmit,
SLO 4.4 describe the role of tsetse flies in transmitting trypanosomiasis,
SLO 4.5 explain the role of sandflies in transmitting leishmaniasis,
SLO 4.6 analyse the impact of insect vectors on livestock health,
SLO 4.7 describe the effects of lice, mites, and ticks on domestic animals,
SLO 4.8 evaluate environmental management and sanitation methods for vector control,
SLO 4.9 explain biological and chemical methods of controlling insect vectors, and
SLO 4.10 analyse the principles and advantages of integrated vector management (IVM).

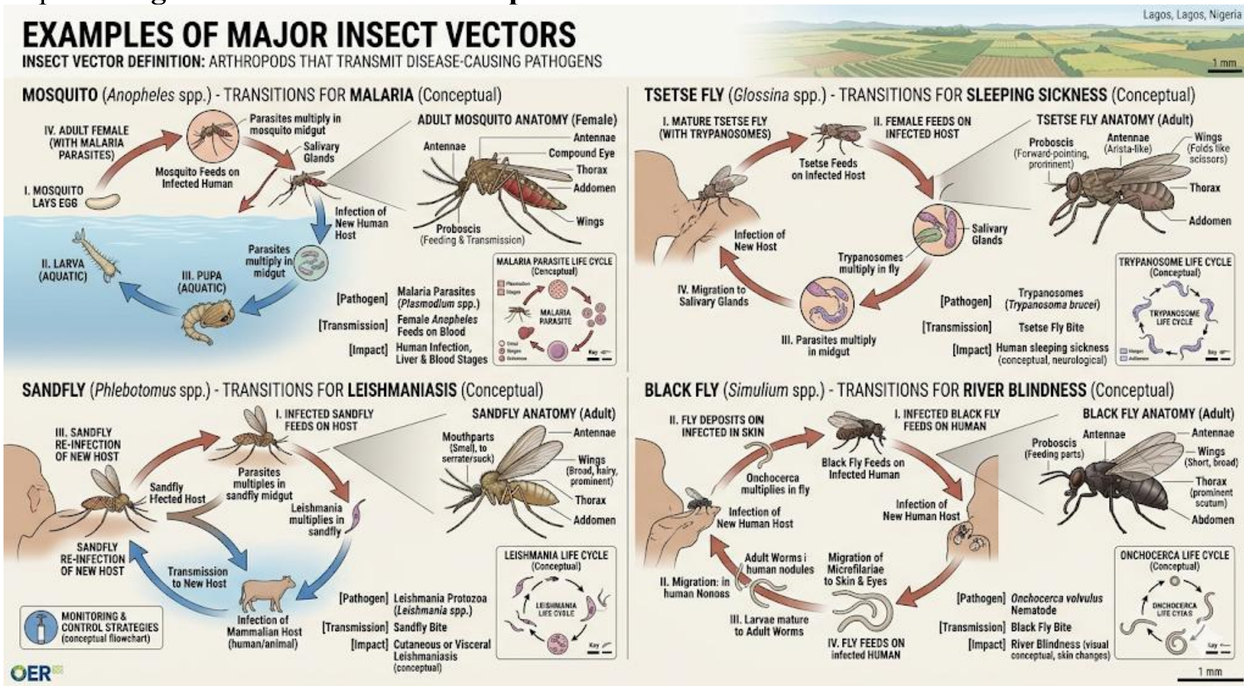
4.1 Principles Of Insect Vectors And Disease Transmission

4.1.1 Definition and importance of insect vectors

Insect vectors are insects that transmit pathogens from one host to another, causing diseases in humans or animals. They are important because they play a central role in public health and veterinary medicine. For example, mosquitoes transmit malaria parasites, while tsetse flies spread trypanosomes.

The study of insect vectors helps us understand how diseases spread and how to design effective control strategies. Without managing vectors, disease prevention becomes extremely difficult, even when treatments are available.

Short description: Diagram showing examples of insect vectors (mosquito, tsetse fly, sandfly).
Caption: **Figure 4.1 Definition and importance of insect vectors**



Fill in the blank: Insect vectors are important because they transmit ______ that cause diseases in humans and animals.

4.1.2 Mechanisms of disease transmission

Insects transmit diseases through several **mechanisms**. These include **mechanical transmission**, where pathogens are carried on the insect's body surface, and **biological transmission**, where pathogens develop or multiply inside the insect before being passed to a host.

Mechanical transmission occurs when flies carry bacteria from faeces to food. Biological transmission is more complex, as seen in mosquitoes transmitting malaria parasites that undergo part of their life cycle inside the insect. Understanding these mechanisms is crucial for designing targeted control measures.

Box 4.2 Mechanisms of disease transmission by insect vectors

Feature	Mechanical Transmission	Biological Transmission
Pathogen Relationship	Passive; no development or multiplication occurs within the insect.	Active; the pathogen must develop, multiply, or both inside the insect.
Transmission Route	External body parts (feet, bristles) or simple regurgitation.	Specialized internal tissues (salivary glands, midgut, or feces).
Incubation Period	None; transmission can occur immediately after contamination.	**Extrinsic Incubation Period:** A required delay while the pathogen matures.
Specificity	Non-specific; many different insects can carry the same bacteria.	Highly specific; usually requires a specific genus or species of insect.
Primary Examples	House Flies (*Salmonella*), Cockroaches (*E. coli*).	Mosquitoes (Malaria), Tsetse Flies (Sleeping Sickness), Ticks (Lyme).
Control Strategy	Focus on sanitation and physical barriers (screens/nets).	Focus on breaking the life cycle (larvicides/insecticides).

Fill in the blank: When pathogens multiply inside an insect before being passed to a host, this is called ______ transmission.

Pilot questions 4.1

What is an insect vector?
Why are insect vectors important in public health?
Name one insect vector and the disease it transmits.
What is mechanical transmission?
Give one example of biological transmission.

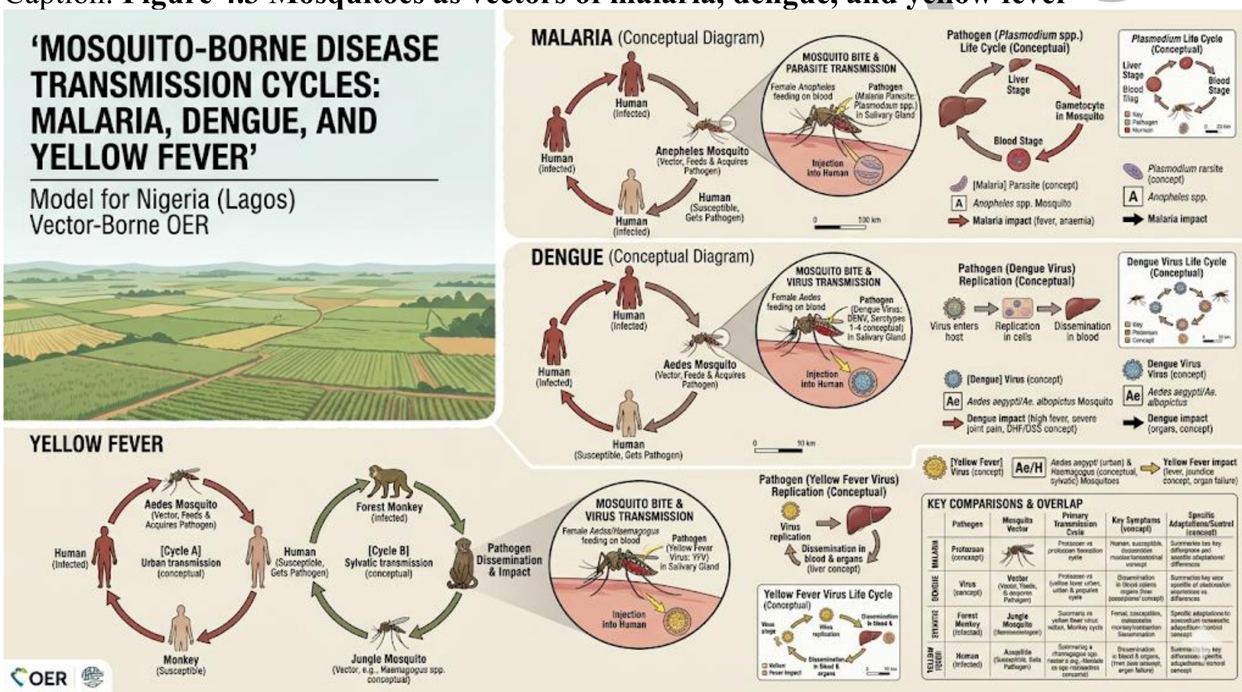
4.2 Major Insect Vectors Of Human Diseases

4.2.1 Mosquitoes and malaria, dengue, and yellow fever

Mosquitoes are among the most significant insect vectors of human diseases. They transmit pathogens such as *Plasmodium* parasites (causing malaria), dengue virus, and yellow fever virus. Their importance lies in their widespread distribution and their close association with humans.

Mosquitoes transmit diseases biologically, as pathogens undergo part of their life cycle inside the insect before being passed to humans. For example, malaria parasites develop in the mosquito gut before being transmitted through a bite.

Short description: Diagram showing mosquito transmission of malaria, dengue, and yellow fever.
Caption: **Figure 4.3 Mosquitoes as vectors of malaria, dengue, and yellow fever**



Fill in the blank: Malaria parasites develop inside the ______ before being transmitted to humans.

4.2.2 Tsetse flies and trypanosomiasis

Tsetse flies are vectors of trypanosomes, the parasites that cause African trypanosomiasis (sleeping sickness). These flies transmit the parasites biologically, as the trypanosomes multiply inside the fly before being passed to humans or animals.

Sleeping sickness is a serious disease that affects the nervous system, leading to severe illness if untreated. Control of tsetse flies is therefore critical for protecting communities in endemic regions.

Box 4.4 Tsetse flies and trypanosomiasis

Feature	Human African Trypanosomiasis (HAT)	Animal African Trypanosomiasis (Nagana)
Primary Pathogen	*Trypanosoma brucei gambiense / rhodesiense*	*Trypanosoma congolense / vivax / brucei*
Vector Species	*Glossina palpalis* group (Riverine)	*Glossina morsitans* group (Savannah)
Transmission Type	**Cyclo-propagative:** Parasite multiplies and changes form.	**Cyclo-propagative:** Parasite multiplies and changes form.
Site of Development	Midgut $\rightarrow$ Salivary Glands (20–35 days).	Midgut $\rightarrow$ Proboscis / Salivary Glands.
Clinical Impact	"Sleeping Sickness": Fever, tremors, coma, and death.	Wasting, anemia, and "unthriftiness" in livestock.
Economic Effect	High mortality and loss of human labor.	Prevents the use of cattle for milk, meat, and plowing.
Key Control Tool	Targeted blue/black cloth traps and screens.	Insecticide-treated "target" screens and livestock dips.

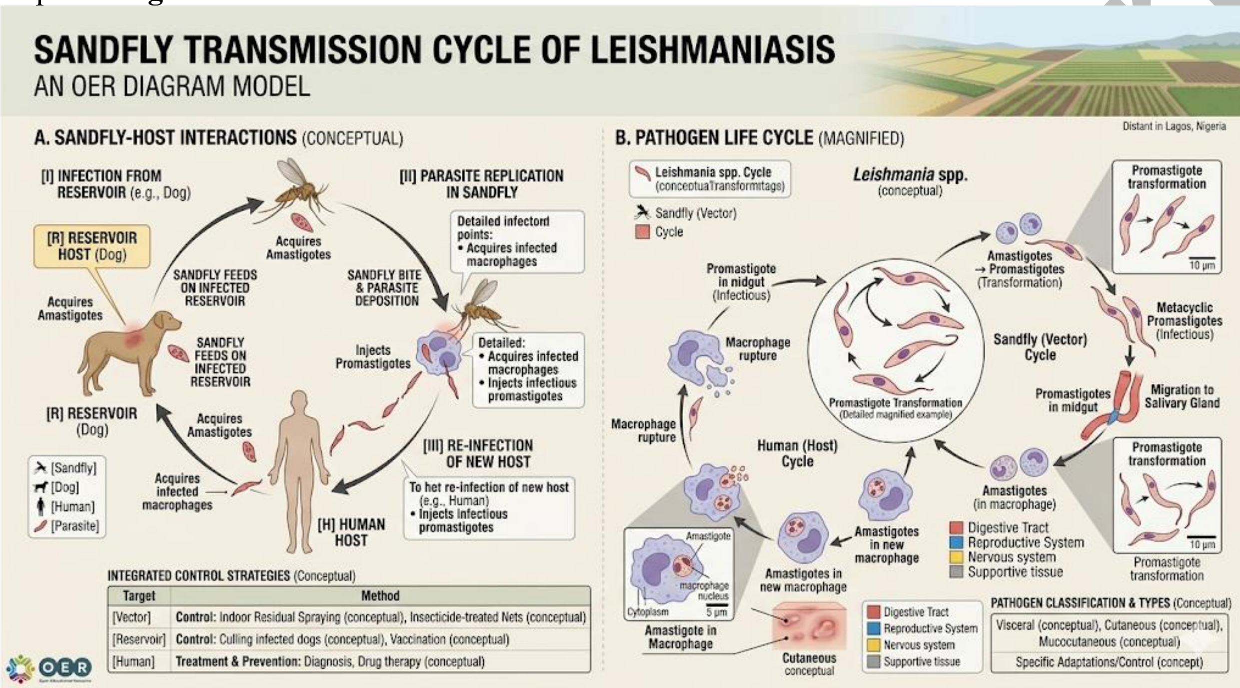
Fill in the blank: Tsetse flies transmit parasites that cause ______ sickness.

4.2.3 Sandflies and leishmaniasis

Sandflies are small insects that transmit *Leishmania* parasites, causing leishmaniasis. This disease can present in different forms, including cutaneous leishmaniasis (skin lesions) and visceral leishmaniasis (affecting internal organs).

Sandflies are particularly dangerous because they are difficult to detect due to their small size and silent flight. Their biology and feeding habits make them effective vectors in tropical and subtropical regions.

Short description: Diagram showing sandfly transmission of leishmaniasis.
Caption: **Figure 4.5 Sandflies as vectors of leishmaniasis**



Fill in the blank: Sandflies transmit *Leishmania* parasites that cause ______.

Pilot questions 4.2

Name three diseases transmitted by mosquitoes.
What parasite causes malaria?
Which insect transmits trypanosomes?
What disease is caused by trypanosomes?
Name one form of leishmaniasis transmitted by sandflies.

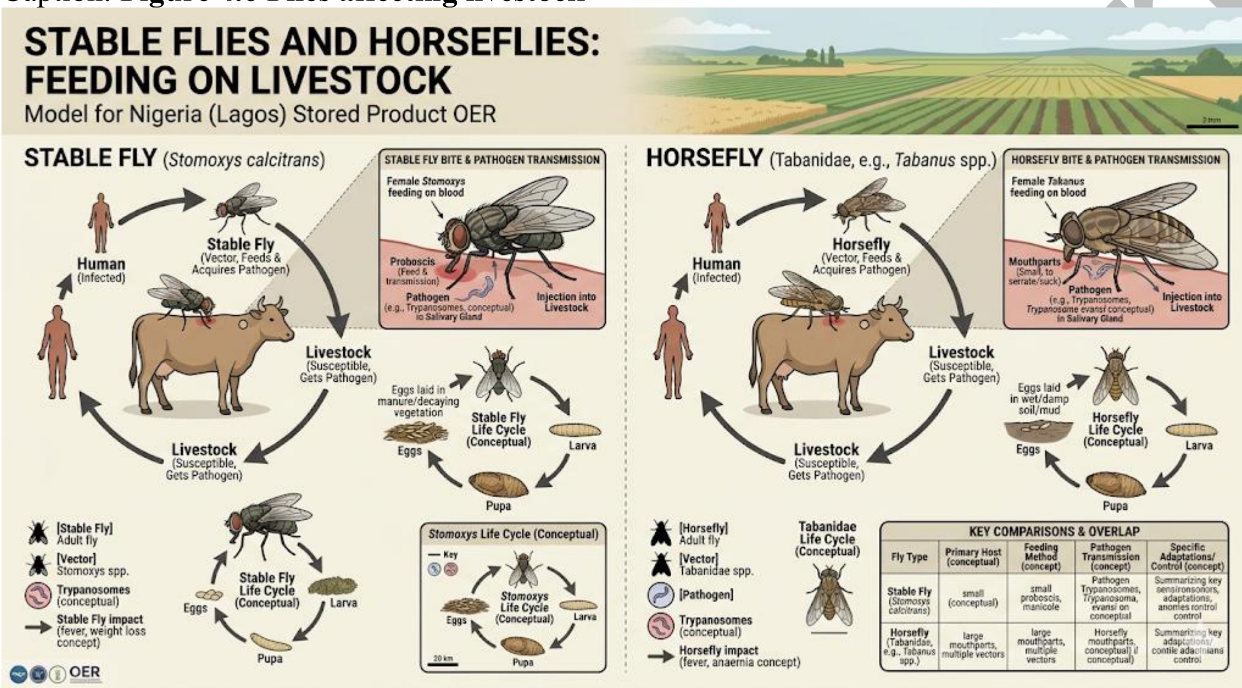
4.3 Insect Vectors Of Veterinary Importance

4.3.1 Flies affecting livestock

Certain **flies** are major vectors of veterinary importance because they affect livestock health and productivity. Stable flies and horseflies feed on the blood of cattle, horses, and other animals, causing irritation, anaemia, and reduced weight gain. Their bites can also serve as entry points for secondary infections.

These flies are particularly problematic in farming systems where animals are kept in open fields or poorly managed enclosures. Control measures often include sanitation, traps, and in some cases, insecticides.

Short description: Diagram showing stable flies and horseflies feeding on livestock.
Caption: **Figure 4.6 Flies affecting livestock**



Fill in the blank: Stable flies and horseflies affect livestock by causing irritation, blood loss, and reduced ______.

4.3.2 Lice, mites, and ticks in domestic animals

Lice, mites, and ticks are external parasites that infest domestic animals. Lice feed on blood or skin debris, causing itching and discomfort. Mites burrow into the skin, leading to mange, which results in hair loss and skin lesions. Ticks, although not insects but arachnids, are often studied alongside them because of their veterinary importance. They transmit diseases such as babesiosis and anaplasmosis in cattle.

These parasites reduce animal productivity and may lead to severe health problems if not controlled. Preventive measures include regular inspection, treatment with acaricides, and maintaining clean housing conditions.

Box 4.7 Lice, mites, and ticks in domestic animals

Feature	Lice (Insects)	Mites (Arachnids)	Ticks (Arachnids)
Taxonomy	Class Insecta (6 legs)	Class Arachnida (8 legs)	Class Arachnida (8 legs)
Visibility	Visible to the naked eye; usually found at the base of hairs.	Microscopic; usually requires a "skin scraping" to diagnose.	Macroscopic; easily seen once engorged with blood.
Primary Condition	**Pediculosis:** Irritation, hair loss, and "unthriftiness."	**Mange/Scab:** Severe dermatitis, crusting, and intense pruritus.	**Tick Worry/Paralysis:** Blood loss and toxicosis from saliva.
Host Specificity	Highly specific (e.g., Cattle lice only live on cattle).	Moderate specificity; some can cross between related species.	Low specificity; many ticks feed on birds, rodents, and livestock.
Disease Vectoring	Minor; mostly nuisance and blood loss.	Rare; primarily causes skin-level pathology.	**High:** Primary vector for **Babesiosis**, **Anaplasmosis**, and **Lyme**.
Economic Loss	Damaged hides and "wool break" due to scratching.	Loss of fleece and leather quality; high mortality if untreated.	Reduced milk/meat yield and the cost of treating systemic diseases.

Fill in the blank: Mange is caused by ______ burrowing into the skin of animals.

Pilot questions 4.3

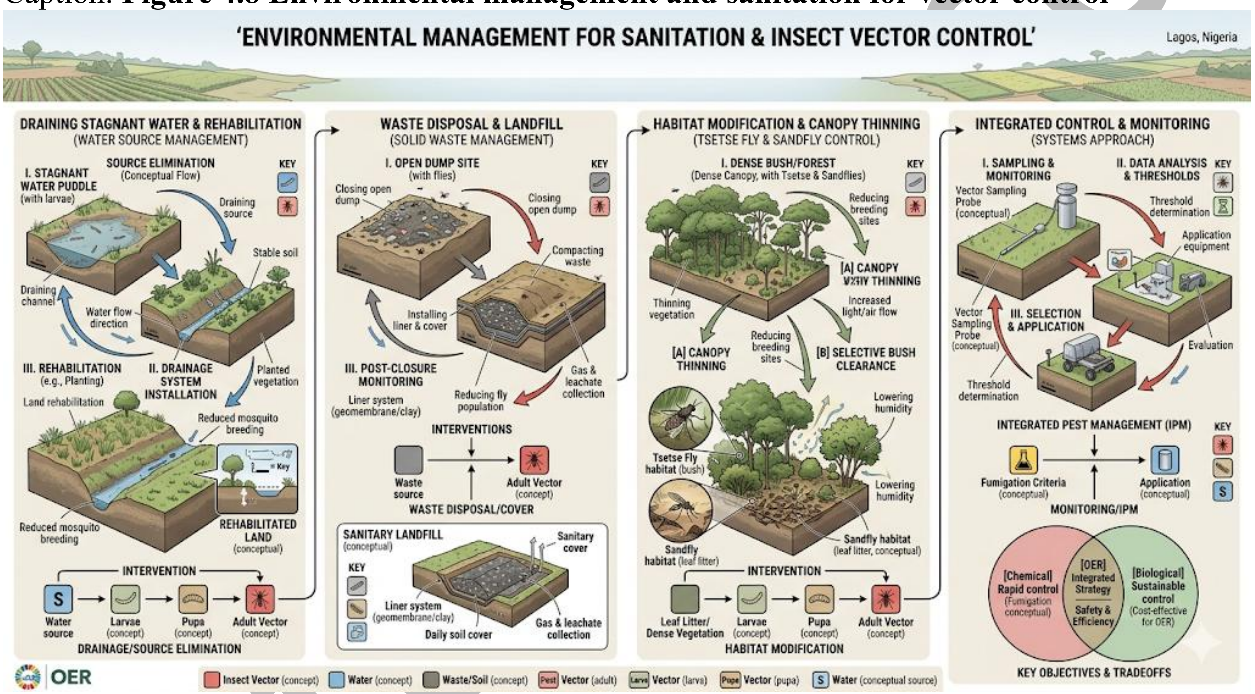
Name two flies that affect livestock.
What problems do stable flies cause in cattle?
What parasite causes mange in animals?
Why are ticks studied alongside insects in veterinary entomology?
Mention one disease transmitted by ticks in cattle.

4.4 Control Strategies For Insect Vectors

4.4.1 Environmental management and sanitation

Environmental management refers to modifying habitats to reduce vector breeding sites. For example, draining stagnant water prevents mosquitoes from reproducing, while proper waste disposal reduces fly populations. **Sanitation** involves keeping surroundings clean to minimise contact between humans, animals, and vectors. These measures are cost-effective and sustainable, especially in rural communities.

Short description: Diagram showing environmental management practices such as draining stagnant water and proper waste disposal.
Caption: **Figure 4.8 Environmental management and sanitation for vector control**



Fill in the blank: Draining stagnant water is an example of ______ management used to control mosquitoes.

4.4.2 Biological and chemical control methods

Biological control methods use natural enemies or microbial agents to reduce vector populations. For instance, fish that feed on mosquito larvae can be introduced into water bodies. Similarly, bacteria such as *Bacillus thuringiensis israelensis* (Bti) are used to kill mosquito larvae without harming other organisms.

Chemical control methods involve the use of insecticides, repellents, and fumigants. These are effective but must be applied carefully to avoid resistance, environmental pollution, and harm to non-target species. Combining biological and chemical methods often improves effectiveness.

Box 4.9 Biological and chemical control methods for insect vectors

Feature	Biological Control	Chemical Control
Primary Agents	Predators (Fish), Pathogens (Bacteria), or Genetic modifiers (*Wolbachia*).	Adulticides (Pyrethroids), Larvicides (Temephos), or Growth Regulators (Methoprene).
Target Stage	Primarily the **Larval** stage in aquatic habitats.	Both **Adult** (flying/resting) and **Larval** stages.
Persistence	High; once established, a predator population or bacteria can self-sustain.	Low to Moderate; chemicals degrade over time or wash away with rain.
Environmental Impact	Minimal; generally non-toxic to humans and non-target wildlife.	Higher; can affect pollinators (bees) or aquatic life if not used precisely.
Resistance Risk	Very Low; it is difficult for insects to evolve "immunity" to being eaten.	**High:** Overuse leads to "Super-Mosquitoes" that can survive standard sprays.
Speed of Action	Slow; takes time for the biological agent to reduce the overall population.	**Fast:** Provides immediate reduction in biting insects during an outbreak.

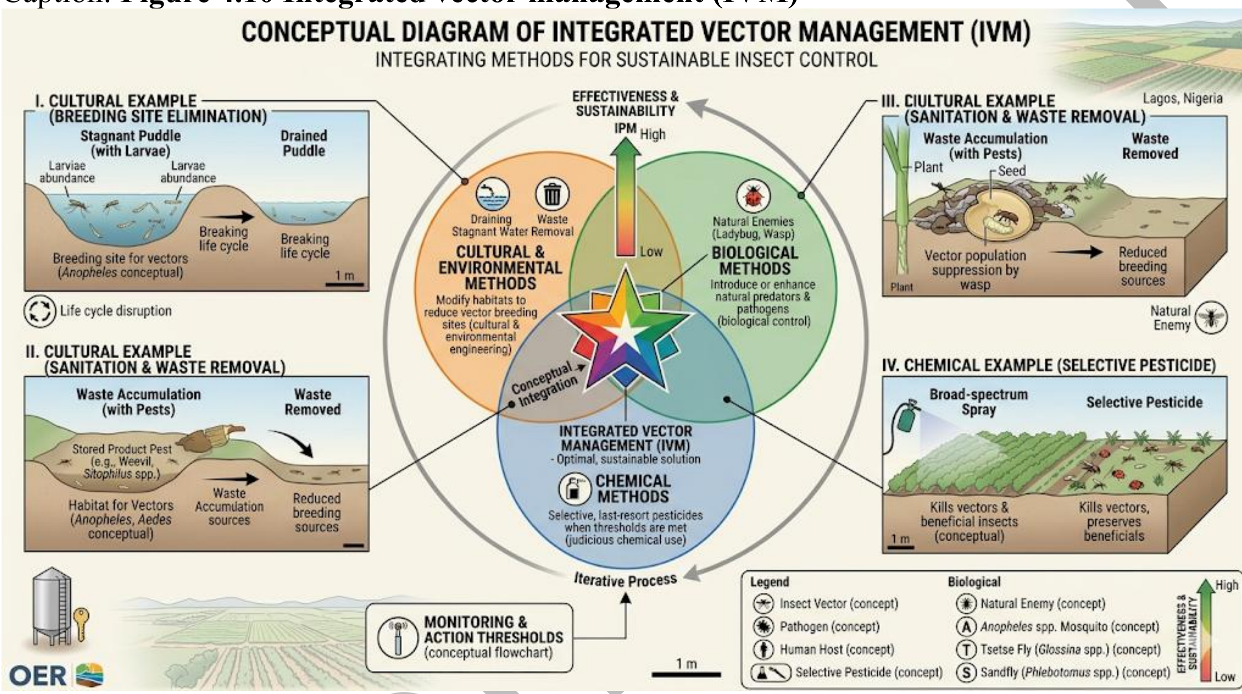
Fill in the blank: *Bacillus thuringiensis israelensis* is a microbial agent used to kill mosquito ______.

4.4.3 Integrated vector management (IVM)

Integrated Vector Management (IVM) is a comprehensive approach that combines environmental, biological, and chemical methods to control vectors in a sustainable way. It emphasises evidence-based decision-making, community participation, and the use of multiple strategies to reduce reliance on chemicals.

IVM is particularly important in regions where multiple vector-borne diseases occur simultaneously. By integrating different methods, IVM ensures long-term effectiveness and reduces the risks associated with single-method control.

Short description: Diagram showing integrated vector management combining environmental, biological, and chemical methods.
Caption: **Figure 4.10 Integrated vector management (IVM)**



Fill in the blank: Integrated vector management combines multiple strategies to reduce reliance on ______.

Pilot questions 4.4

What is environmental management in vector control?
Give one example of sanitation used to reduce vector populations.
Name one biological method of controlling mosquito larvae.
Why must chemical methods be applied carefully?
What does IVM stand for?

Series Summary

This Series focused on the control of insect vectors of diseases, highlighting their importance in public health and veterinary medicine. We began by examining the principles of insect vectors and the mechanisms of disease transmission. Then, we explored major insect vectors of human diseases, including mosquitoes, tsetse flies, and sandflies. Following that, we considered insect vectors of veterinary importance such as flies, lice, mites, and ticks. Finally, we analysed control strategies for insect vectors, emphasising environmental management, biological and chemical methods, and integrated vector management.

By completing this Series, you should now be able to define insect vectors, explain how they transmit diseases, describe the biology of major vectors of medical and veterinary importance, and evaluate strategies for their control. These outcomes align with the Series Learning Outcomes and provide you with practical knowledge for managing vector-borne diseases in both human and animal contexts.

Glossary of Terms

Acaricides: Chemicals used to kill ticks and mites.
Biological transmission: When pathogens develop or multiply inside an insect before being transmitted to a host.
Economic threshold: The pest population level at which control measures must be applied to prevent economic loss.
Environmental management: Modifying habitats to reduce vector breeding sites.
Insect vector: An insect that transmits pathogens causing diseases in humans or animals.
Integrated Vector Management (IVM): A comprehensive approach combining multiple strategies to control vectors sustainably.
Mechanical transmission: When pathogens are carried on the insect's body surface without development inside the insect.
Mange: A skin disease in animals caused by mites burrowing into the skin.
Parasite: An organism that lives on or inside another organism, often causing harm.
Sanitation: Practices that keep surroundings clean to reduce vector populations.

Concept Check Questions 4

Objective questions

Insect vectors are important because they transmit ______ that cause diseases. (Linked to SLO 4.1)
When pathogens multiply inside an insect before being passed to a host, this is called ______ transmission. (Linked to SLO 4.2)
Mosquitoes transmit malaria, dengue, and ______ fever. (Linked to SLO 4.3)
Tsetse flies transmit parasites that cause ______ sickness. (Linked to SLO 4.4)
Sandflies transmit *Leishmania* parasites that cause ______. (Linked to SLO 4.5)
Stable flies and horseflies affect livestock by causing irritation, blood loss, and reduced ______. (Linked to SLO 4.6)
Mange is caused by ______ burrowing into the skin of animals. (Linked to SLO 4.7)
Draining stagnant water is an example of ______ management. (Linked to SLO 4.8)
Bacillus thuringiensis israelensis is a microbial agent used to kill mosquito ______. (Linked to SLO 4.9)
Integrated vector management reduces reliance on ______. (Linked to SLO 4.10)

Short-answer questions
11. Define an insect vector. (Linked to SLO 4.1)
12. What is mechanical transmission? (Linked to SLO 4.2)
13. Name one disease transmitted by mosquitoes. (Linked to SLO 4.3)
14. Which insect transmits trypanosomes? (Linked to SLO 4.4)
15. Mention one form of leishmaniasis. (Linked to SLO 4.5)
16. Name two flies that affect livestock. (Linked to SLO 4.6)
17. What parasite causes mange in animals? (Linked to SLO 4.7)
18. Give one example of sanitation used to reduce vector populations. (Linked to SLO 4.8)
19. Name one biological method of controlling mosquito larvae. (Linked to SLO 4.9)
20. What does IVM stand for? (Linked to SLO 4.10)

Long-answer questions
21. Explain the importance of insect vectors in public health and veterinary medicine. (Linked to SLO 4.1)
22. Describe the mechanisms of disease transmission by insect vectors. (Linked to SLO 4.2)
23. Explain the biology of mosquitoes, tsetse flies, and sandflies as vectors of human diseases. (Linked to SLO 4.3, 4.4, 4.5)
24. Analyse the impact of flies, lice, mites, and ticks on livestock and domestic animals. (Linked to SLO 4.6, 4.7)
25. Evaluate environmental, biological, chemical, and integrated strategies for controlling insect vectors. (Linked to SLO 4.8, 4.9, 4.10)

Answers to Concept Check Questions 4

Objective questions

Pathogens.
Biological.
Yellow.
Sleeping.
Leishmaniasis.
Productivity.
Mites.
Environmental.
Larvae.
Chemicals.

Short-answer questions
11. An insect that transmits pathogens causing diseases.
12. Pathogens carried on the insect's body surface without development inside the insect.
13. Malaria.
14. Tsetse fly.
15. Cutaneous leishmaniasis.
16. Stable fly and horsefly.
17. Mites.

18. Proper waste disposal.
19. Using fish or microbial agents such as Bti.
20. Integrated Vector Management.

Long-answer questions
21. **Basic response**: Insect vectors spread diseases in humans and animals, making them important in health and veterinary contexts.
Value-added response: They influence disease epidemiology, economic productivity, and require targeted control strategies for sustainable health systems.

Basic response: Transmission occurs mechanically or biologically.
Value-added response: Mechanical transmission involves pathogens on body surfaces, while biological transmission involves pathogen development inside the insect.
Basic response: Mosquitoes transmit malaria, dengue, and yellow fever; tsetse flies transmit trypanosomes; sandflies transmit *Leishmania*.
Value-added response: Their biology, feeding habits, and life cycles make them effective vectors and determine disease distribution.
Basic response: Flies cause irritation and blood loss, while lice, mites, and ticks infest animals and transmit diseases.
Value-added response: These parasites reduce productivity, cause secondary infections, and highlight the need for veterinary pest management.
Basic response: Environmental, biological, chemical, and integrated strategies are used to control vectors.
Value-added response: Integrated approaches reduce reliance on chemicals, promote sustainability, and ensure long-term effectiveness in vector control.

Answers to Pilot Questions 4

Part 4.1

An insect that transmits pathogens.
They spread diseases in humans and animals.
Mosquito – malaria.
Pathogens carried on the insect's body surface.
Malaria parasites developing inside mosquitoes.

Part 4.2

Malaria, dengue, yellow fever.
Plasmodium.
Tsetse fly.
Sleeping sickness.
Cutaneous leishmaniasis.

Part 4.3

Stable flies and horseflies.
Irritation and blood loss.
Mites.
Because they transmit diseases affecting livestock.
Babesiosis.

Part 4.4

Modifying habitats to reduce breeding sites.
Proper waste disposal.
Fish feeding on larvae.
To avoid resistance and pollution.
Integrated Vector Management.

References And Attributions 4

Figures and Boxes suggested in Series 4:

- Figure 4.1 Definition and importance of insect vectors
- Box 4.2 Mechanisms of disease transmission by insect vectors
- Figure 4.3 Mosquitoes as vectors of malaria, dengue, and yellow fever
- Box 4.4 Tsetse flies and trypanosomiasis
- Figure 4.5 Sandflies as vectors of leishmaniasis
- Figure 4.6 Flies affecting livestock
- Box 4.7 Lice, mites, and ticks in domestic animals
- Figure 4.8 Environmental management and sanitation for vector control
- Box 4.9 Biological and chemical control methods for insect vectors
- Figure 4.10 Integrated vector management (IVM)

AI prompt suggestions used for illustration placeholders:

- Diagrams showing insect vectors, transmission mechanisms, mosquito diseases, tsetse flies, sandflies, and IVM.
- Boxes summarising transmission mechanisms, tsetse flies, lice and ticks, and control methods.

Open Educational Resource (OER) search strings suggested:

- "insect vectors definition diagram OER"
- "mechanisms of disease transmission insect vectors OER"
- "mosquito malaria dengue yellow fever transmission diagram OER"
- "tsetse flies trypanosomiasis transmission OER"
- "sandfly leishmaniasis transmission diagram OER"
- "stable flies horseflies livestock diagram OER"
- "lice mites ticks domestic animals OER"
- "environmental management sanitation insect vector control OER"
- "biological chemical methods insect vector control OER"
- "integrated vector management insect control OER"

General references (APA style):

Gullan, P. J., & Cranston, P. S. (2014). *The Insects: An Outline of Entomology*. Wiley Blackwell.
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World Health Organization. (2017). *Vector-borne diseases*. Retrieved from `https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases` (who.int in Bing)
OER Commons. (n.d.). *Entomology resources*. Retrieved from https://www.oercommons.org

ZOO411 Series 5 Techniques For Collection, Preservation, And Identification Of Insects Of Economic Importance

Part 5.1 Techniques for collection of insects
- 5.1.1 Field collection methods
- 5.1.2 Use of traps and nets
- 5.1.3 Safety considerations during collection

Part 5.2 Techniques for preservation of insects
- 5.2.1 Dry preservation methods
- 5.2.2 Wet preservation methods
- 5.2.3 Labelling and storage practices

Part 5.3 Techniques for identification of insects
- 5.3.1 Morphological features used in identification
- 5.3.2 Use of taxonomic keys
- 5.3.3 Modern tools and technologies in identification

Part 5.4 Importance of collection, preservation, and identification

5.4.1 Role in research and education
5.4.2 Applications in agriculture, medicine, and veterinary science

Introduction

In the last Series, we explored the control of insect vectors of diseases, focusing on strategies to protect human and animal health. In this Series, our attention turns to the practical techniques used to collect, preserve, and identify insects of economic importance. These skills are fundamental for entomologists, agricultural scientists, and health professionals who rely on accurate identification and preservation to study insect behaviour, manage pests, and harness beneficial species.

The aim of this Series is to equip you with practical knowledge and techniques for collecting, preserving, and identifying insects, while highlighting their relevance to research, education, and applied sciences.

We shall commence this Series by examining techniques for collecting insects, including field methods, traps, and safety considerations. Next, we will explore techniques for preserving insects, focusing on dry and wet methods as well as proper labelling and storage. Following that, we will consider techniques for identifying insects, using morphological features, taxonomic keys, and modern technologies. Finally, we will conclude by discussing the importance of these techniques in research, education, and applications in agriculture, medicine, and veterinary science.

Series Learning Outcomes

Upon completing this Series, you should be able to:

SLO 5.1 describe field collection methods for insects,
SLO 5.2 demonstrate the use of traps and nets in insect collection,
SLO 5.3 explain safety considerations during insect collection,
SLO 5.4 describe dry preservation methods for insects,
SLO 5.5 explain wet preservation methods for insects,
SLO 5.6 demonstrate proper labelling and storage practices for preserved specimens,
SLO 5.7 identify insects using morphological features,
SLO 5.8 apply taxonomic keys in insect identification,
SLO 5.9 evaluate modern tools and technologies used in insect identification, and
SLO 5.10 analyse the importance of collection, preservation, and identification in research, education, and applied sciences.

5.1 Techniques For Collection Of Insects

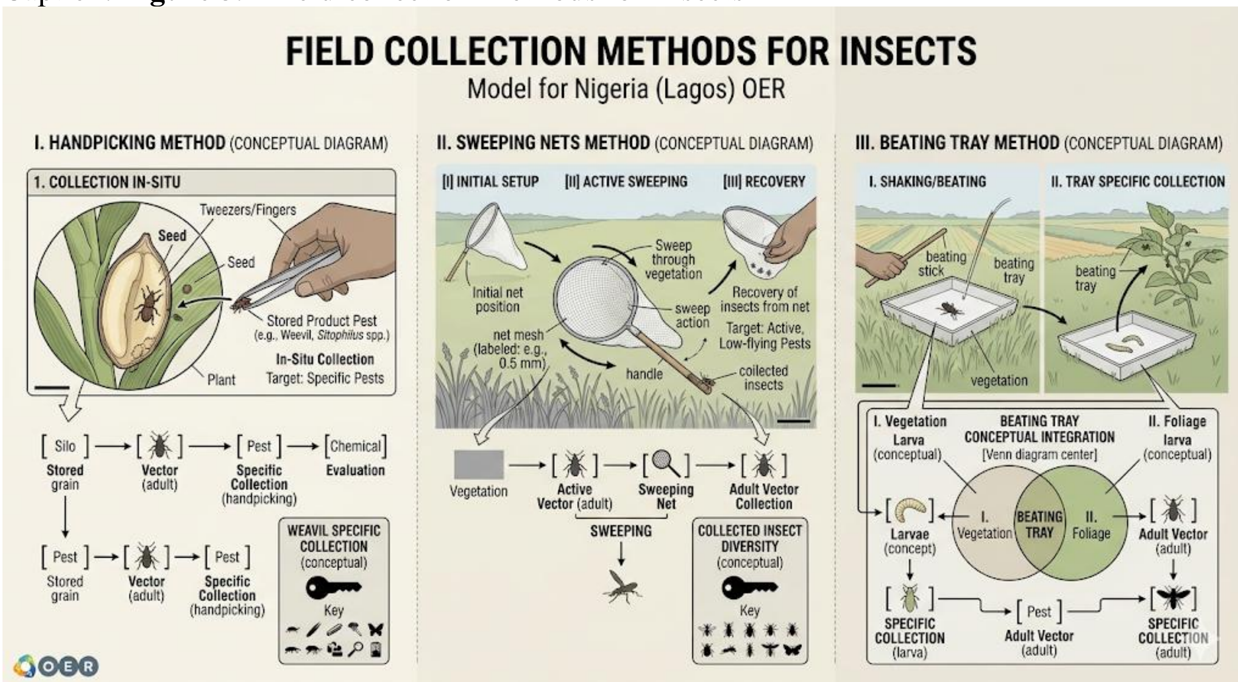
5.1.1 Field collection methods

Field collection methods refer to techniques used to gather insects directly from their natural habitats. These include handpicking, sweeping vegetation with nets, and beating plants over a tray or cloth to dislodge insects. Each method is chosen based on the type of insect and the environment. For example, handpicking is effective for larger insects such as beetles, while sweeping nets are useful for small flying insects in grasslands.

It is important to select the right method to avoid damaging specimens and to ensure accurate representation of insect diversity in the area.

Short description: Diagram showing handpicking, sweeping nets, and beating tray methods of insect collection.

Caption: **Figure 5.1 Field collection methods for insects**



Fill in the blank: Sweeping nets are particularly useful for collecting small ______ insects in grasslands.

5.1.2 Use of traps and nets

Traps and nets are specialised tools designed to capture insects efficiently. Common traps include light traps, which attract nocturnal insects, and pitfall traps, which capture ground-dwelling species. Nets are of different types, such as aerial nets for flying insects and aquatic nets for insects living in water.

These tools allow entomologists to collect large numbers of insects with minimal effort, making them essential for surveys and research.

Box 5.2 Common traps and nets used in insect collection

Tool Category	**Specific Tool**	**Primary Target Insects**	**Collection Mechanism**
Active	**Aerial Net**	Butterflies, Dragonflies, Wasps.	**Capture in flight:** Lightweight mesh for fast-moving, delicate insects.

Tool Category	Specific Tool	Primary Target Insects	Collection Mechanism
Active	**Sweep Net**	Grasshoppers, Beetles, Hemiptera.	**Dislodgement:** Brushing through vegetation to catch "hiding" insects.
Active	**Aspirator (Pooter)**	Ants, Aphids, Small Parasitoids.	**Suction:** Used for precise, non-destructive pick-up of tiny specimens.
Passive	**Pitfall Trap**	Ground beetles, Ants, Spiders.	**Gravity:** Insects walking on the surface fall into a buried container.
Passive	**Malaise Trap**	Flies, Bees, Ichneumonid wasps.	**Intercept/Ascent:** Insects fly into a "tent" and crawl upward into a jar.
Passive	**Light Trap**	Moths, Nocturnal beetles, Lacewings.	**Phototaxis:** Attraction to UV or mercury vapor light at night.
Extraction	**Berlese Funnel**	Mites, Springtails, Soil larvae.	**Desiccation:** Heat/light drives insects out of leaf litter into a preservative.
Visual	**Pan Trap**	Aphids, Hoverflies, Small wasps.	**Color Attraction:** Insects are lured by bright colors (usually yellow) and drown.

Fill in the blank: Light traps are commonly used to attract and capture ______ insects.

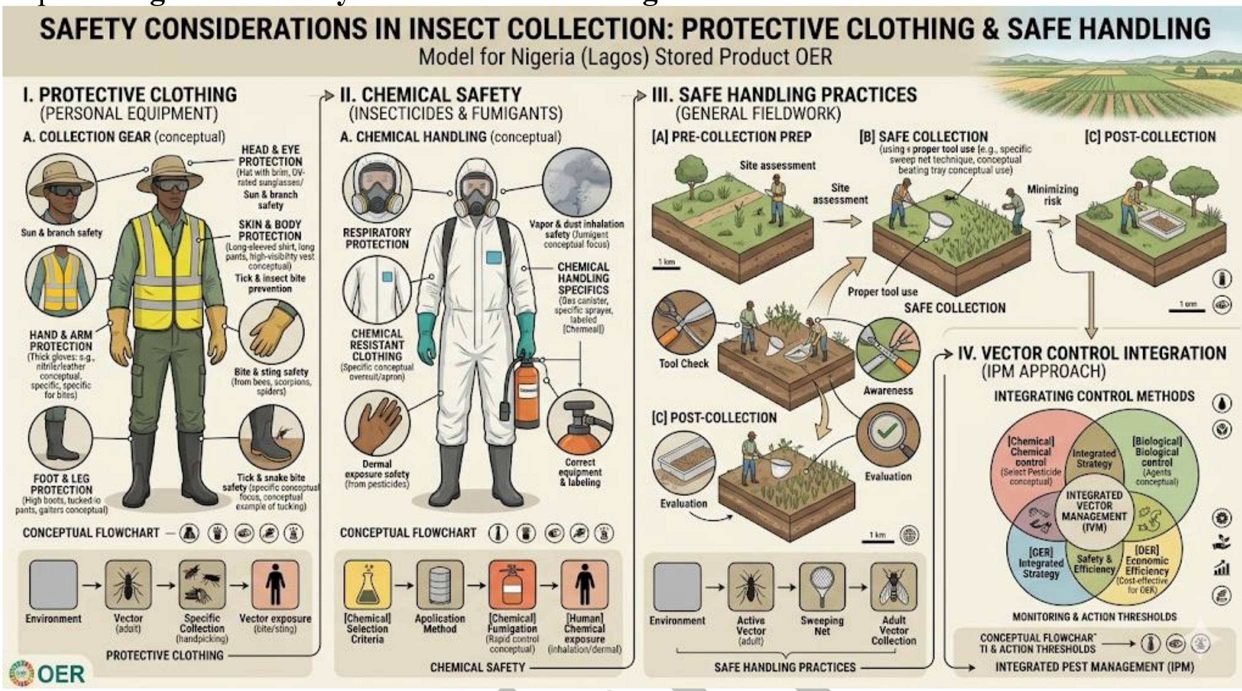
5.1.3 Safety considerations during collection

Safety considerations are vital when collecting insects, as some species may bite, sting, or transmit diseases. Collectors should wear protective clothing, use gloves when handling potentially harmful insects, and avoid areas with high risks such as stagnant water where mosquitoes breed.

Additionally, ethical considerations are important. Collectors should avoid over-collecting and ensure that their activities do not disrupt ecosystems.

Short description: Diagram showing protective clothing and safe handling during insect

collection.
Caption: **Figure 5.3 Safety considerations during insect collection**



Fill in the blank: Wearing protective ______ is important when handling insects that may bite or sting.

Pilot questions 5.1

What are field collection methods?
Name one method used to collect insects from vegetation.
Give two examples of traps used in insect collection.
What type of net is used for aquatic insects?
Why are safety considerations important during insect collection?

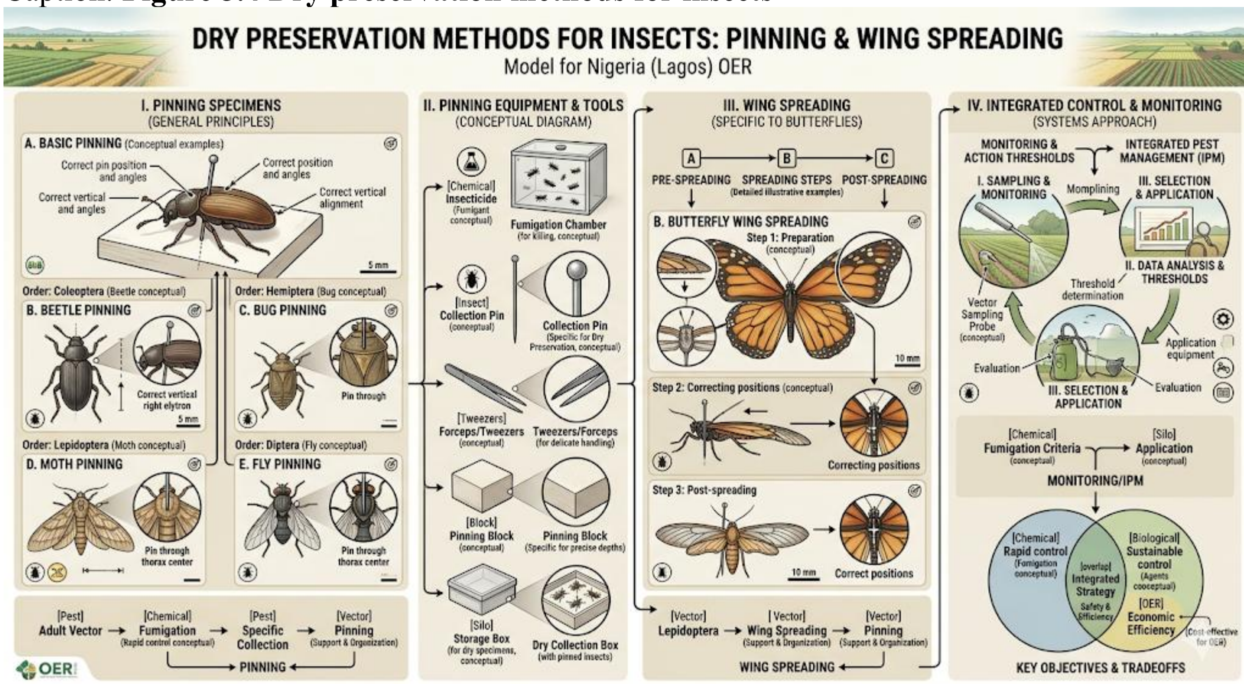
5.2 Techniques For Preservation Of Insects

5.2.1 Dry preservation methods

Dry preservation methods involve keeping insect specimens in a dry state to maintain their structure and appearance. Common techniques include pinning insects on boards, spreading wings for butterflies and moths, and storing small insects in paper envelopes. These methods are widely used because they allow specimens to be studied for long periods without significant deterioration.

Care must be taken to position insects correctly during pinning to preserve key features used in identification.

Short description: Diagram showing pinned insects and wing spreading for butterflies.
Caption: **Figure 5.4 Dry preservation methods for insects**



Fill in the blank: Pinning insects correctly helps preserve their ______ features for identification.

5.2.2 Wet preservation methods

Wet preservation methods involve storing insects in liquids such as alcohol or formalin. This technique is particularly useful for soft-bodied insects like larvae, which may shrivel or lose shape if dried. Specimens are usually placed in vials filled with 70% alcohol to maintain their form and prevent decay.

Wet preservation is essential for maintaining delicate structures that are critical for identification, especially in immature stages of insects.

Box 5.5 Wet preservation methods for insects

Preservative	Concentration	Primary Use Case	Key Advantages	Major Disadvantages
Ethyl Alcohol (Ethanol)	**70%–80%**	General curation and museum storage.	Excellent tissue penetration; keeps specimens flexible.	Can cause color fading over many years.
Absolute Ethanol	**95%–100%**	**Molecular/DNA** research and sequencing.	Preserves genetic material by preventing hydrolysis.	Makes specimens extremely brittle and fragile.
Isopropyl Alcohol	**70%**	Field collection when Ethanol is unavailable.	Inexpensive and easily accessible globally.	Harsher on tissues; can cause "clearing" (transparency).
Formalin	**4%–10%**	Initial **"Fixing"** of large, fleshy larvae.	Hardens tissues by cross-linking proteins.	**Destroys DNA**; toxic fumes; makes specimens too stiff.
Kahle's Solution	Mixed*	Internal anatomy and larval micro-dissection.	Prevents internal decay better than plain alcohol.	Contains acetic acid and formalin; requires careful handling.
Pampel's Fluid	Mixed*	General soft-bodied insect preservation.	Maintains natural body shape and limb flexibility.	More complex to mix than standard alcohol solutions.

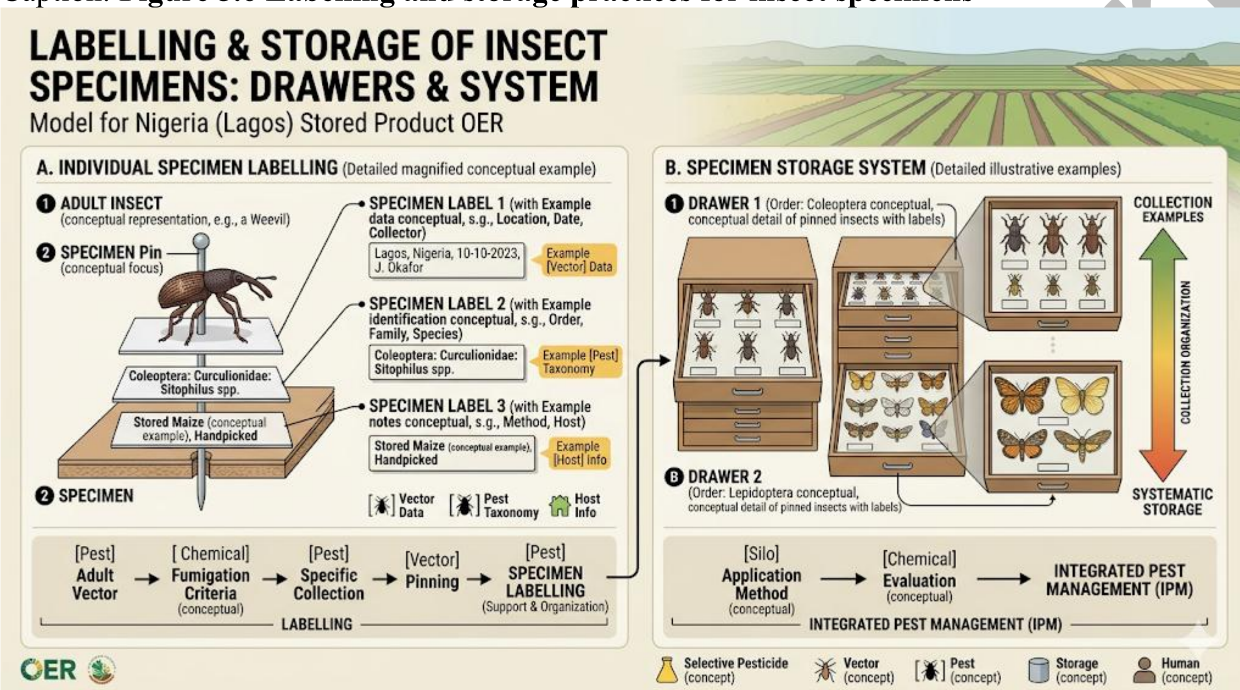
Fill in the blank: Wet preservation is particularly useful for soft-bodied insects such as ______.

5.2.3 Labelling and storage practices

Labelling and storage practices are critical for ensuring that preserved specimens remain useful for research and education. Labels should include information such as the date, location, and method of collection. Proper storage involves keeping specimens in insect cabinets or drawers, protected from light, dust, and pests.

Accurate labelling ensures that specimens can be traced back to their origin, which is vital for scientific studies. Good storage practices also extend the lifespan of collections and make them accessible for future reference.

Short description: Diagram showing labelled insect specimens stored in drawers.
Caption: **Figure 5.6 Labelling and storage practices for insect specimens**



Fill in the blank: Labels should include the date, location, and ______ of collection.

Pilot questions 5.2

What are dry preservation methods?
Name one technique used in dry preservation.
Why is wet preservation important for larvae?
What liquid is commonly used in wet preservation?
What information should be included on specimen labels?

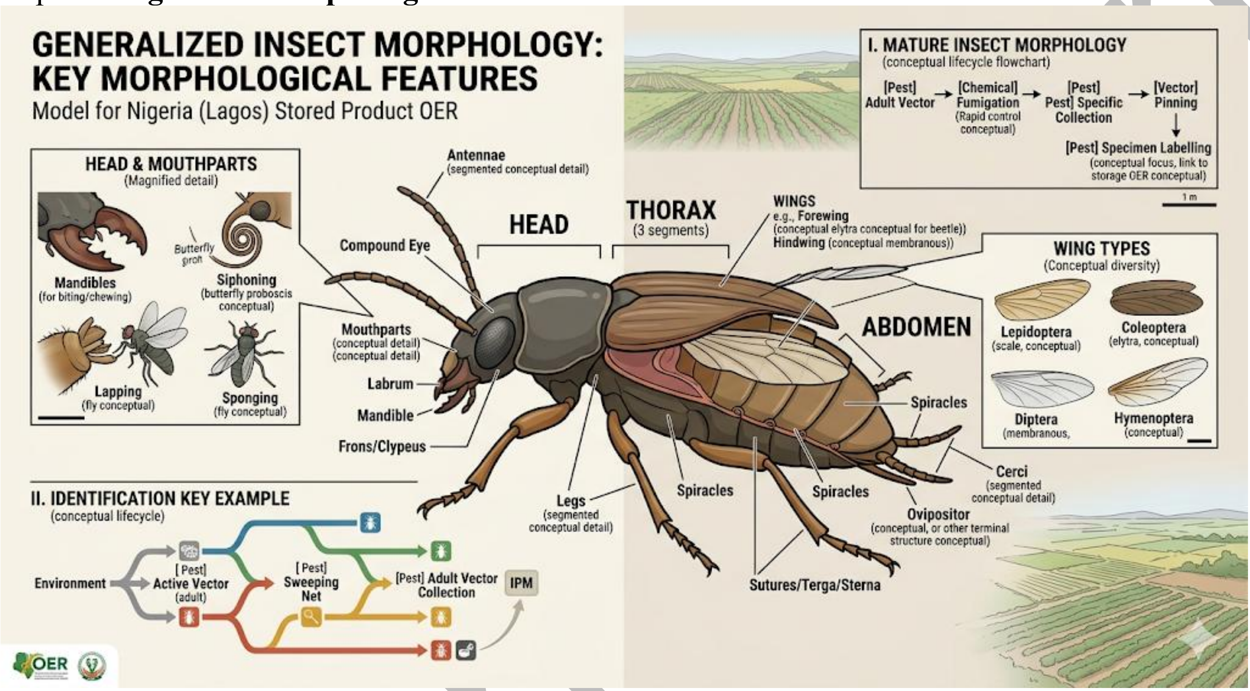
5.3 Techniques For Identification Of Insects

5.3.1 Morphological features used in identification

Morphological features are the physical characteristics of insects that help in distinguishing one species from another. These include body segmentation, wing structure, antenna shape, mouthparts, and leg adaptations. For example, beetles can be identified by their hardened forewings (elytra), while butterflies are recognised by their scaled wings.

Careful observation of these features is the first step in insect identification, and it requires practice to notice subtle differences between closely related species.

Short description: Diagram showing key morphological features such as wings, antennae, and mouthparts.
Caption: **Figure 5.7 Morphological features used in insect identification**



Fill in the blank: Beetles can be identified by their hardened forewings, also known as ______.

5.3.2 Use of taxonomic keys

Taxonomic keys are tools that guide users step by step in identifying insects based on observable features. The most common type is the dichotomous key, which presents paired statements that lead to the correct identification. For instance, a key may ask whether the insect has wings or not, and depending on the answer, direct the user to the next step.

Taxonomic keys are essential for systematic identification and are widely used in research and education.

Box 5.8 Example of a dichotomous taxonomic key

Couplet	Morphological Feature	Character State A (Identify/Go To)	Character State B (Identify/Go To)
1	**Presence of Wings**	**No Wings:** Go to 2	**Wings Present:** Go to 3
2	**Abdominal Appendages**	**3 Long Tail Filaments:** *Zygentoma* (Silverfish)	**No Tails; Flat Body:** *Phthiraptera* (Lice) or *Siphonaptera* (Fleas)
3	**Number of Wings**	**One Pair (2 Wings):** *Diptera* (True Flies)	**Two Pairs (4 Wings):** Go to 4
4	**Forewing Texture**	**Hard/Veinless (Elytra):** *Coleoptera* (Beetles)	**Membranous or Leathery:** Go to 5
5	**Wing Covering**	**Covered in Micro-Scales:** *Lepidoptera* (Moths/Butterflies)	**Transparent or Hairs only:** Go to 6
6	**Mouthpart Type**	**Sucking Beak (Rostrum):** *Hemiptera* (True Bugs)	**Chewing or Lapping:** *Hymenoptera* (Bees/Wasps/Ants)

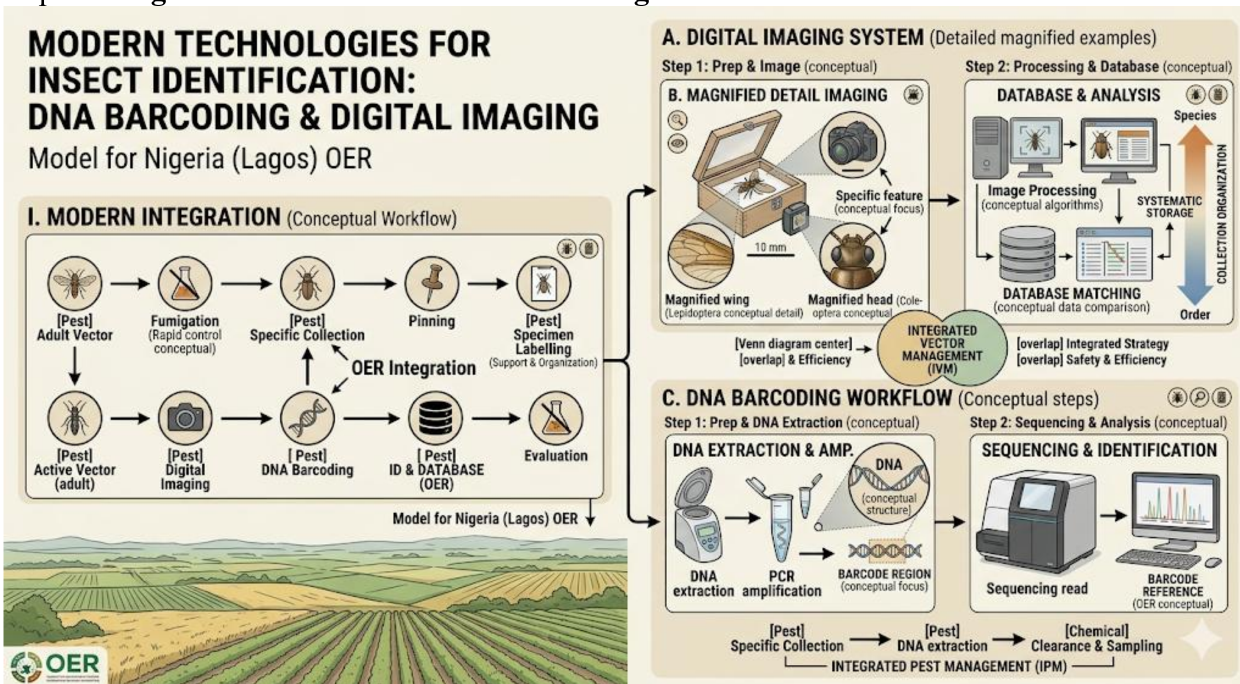
Fill in the blank: The most common type of taxonomic key used in insect identification is the ______ key.

5.3.3 Modern tools and technologies in identification

Modern tools and technologies have greatly improved insect identification. These include digital imaging, DNA barcoding, and computer-based identification software. DNA barcoding uses genetic sequences to distinguish species, while imaging tools allow detailed examination of insect structures.

These technologies complement traditional methods and provide more accurate results, especially for species that are difficult to differentiate morphologically.

Short description: Diagram showing DNA barcoding and digital imaging used in insect

identification.
Caption: **Figure 5.9 Modern tools and technologies in insect identification**


Fill in the blank: DNA barcoding distinguishes insect species using their genetic ______.

Pilot questions 5.3

What are morphological features in insect identification?
Name one morphological feature used to identify beetles.
What is a taxonomic key?
Which type of taxonomic key is most commonly used?
Mention one modern technology used in insect identification.

5.4 Importance Of Collection, Preservation, And Identification

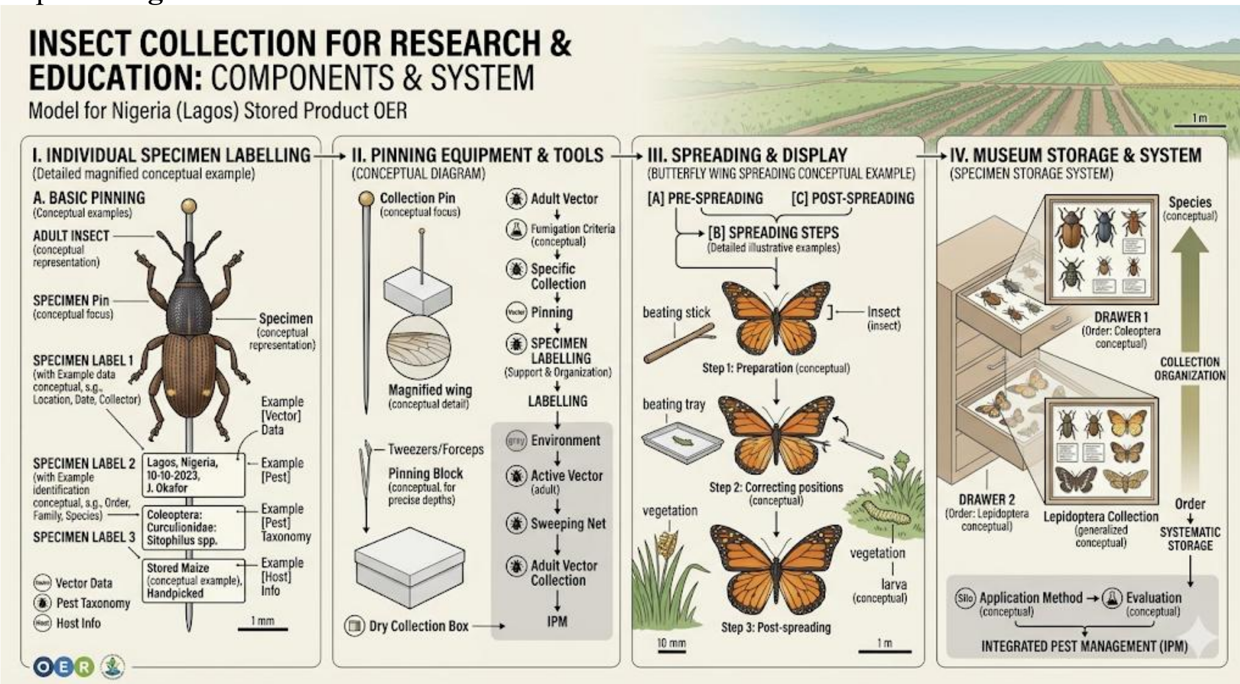
5.4.1 Role in research and education

The **collection, preservation, and identification of insects** play a vital role in research and education. By collecting specimens, scientists can study insect diversity, behaviour, and ecological roles. Preserved specimens serve as reference materials in museums and laboratories, allowing students and researchers to learn about insect morphology and classification.

Educational institutions rely on well-preserved collections to train future entomologists, while researchers use them to compare species across regions and time periods. This ensures continuity of knowledge and supports scientific discovery.

Short description: Diagram showing insect specimens in a museum collection used for teaching and research.

Caption: **Figure 5.10 Role of insect collections in research and education**



Fill in the blank: Preserved specimens serve as reference materials in museums and ______.

5.4.2 Applications in agriculture, medicine, and veterinary science

Insects of economic importance are not only studied for academic purposes but also for their practical applications. In **agriculture**, identifying pest species helps farmers design effective control strategies. In **medicine**, accurate identification of insect vectors is essential for managing diseases such as malaria and leishmaniasis. In **veterinary science**, recognising parasites like ticks and mites aids in protecting livestock health.

Thus, collection, preservation, and identification techniques provide the foundation for applied entomology, ensuring that insects are managed effectively in ways that benefit society.

Box 5.11 Applications of insect collection, preservation, and identification

Field of Application	Key Technique Used	Purpose of the Application	Real-World Impact
Agriculture	**Sweep Netting & Pheromone Traps**	Monitoring for the **Economic Threshold (ET)**.	Prevents "calendar spraying" and saves farmers money on pesticides.
Public Health	**Malaise & Light Traps**	Mapping hotspots for **Malaria** or **Dengue** vectors.	Coordinates life-saving **Indoor Residual Spraying (IRS)** programs.
Veterinary Science	**Skin Scraping & Microscopic ID**	Diagnosing **Mange (Mites)** or **Tick-borne** parasites.	Protects livestock productivity and prevents mass animal mortality.
Biosecurity	**Morphological Identification**	Inspecting international cargo for "hitchhiker" pests.	Prevents the introduction of invasive species like the **Khapra Beetle**.
Forensics	**Berlese Funnel Extraction**	Collecting larvae from a scene to determine age.	Provides legal evidence for the **Post-Mortem Interval (PMI)**.
Conservation	**Wet & Dry Curation**	Maintaining a historical "DNA library" of species.	Tracks the impact of **Climate Change** on pollinator populations.

Fill in the blank: Accurate identification of insect vectors is essential for managing ______ such as malaria.

Pilot questions 5.4

Why are insect collections important in research?
How do preserved specimens support education?
Give one application of insect identification in agriculture.
Mention one medical application of insect identification.
Why is identification important in veterinary science?

Series Summary

This Series focused on techniques for collecting, preserving, and identifying insects of economic importance, providing learners with practical skills essential for entomological work. We began by exploring field collection methods, traps, and safety considerations. Then, we examined preservation techniques, including dry and wet methods, as well as proper labelling and storage practices. Following that, we studied identification techniques, highlighting morphological features, taxonomic keys, and modern technologies such as DNA barcoding. Finally, we discussed the importance of these techniques in research, education, and applications in agriculture, medicine, and veterinary science.

By completing this Series, you should now be able to describe and demonstrate methods of insect collection, explain preservation techniques, apply identification tools, and analyse the importance of these practices in both academic and applied contexts. These achievements align with the Series Learning Outcomes and provide you with a strong foundation for practical entomology.

Glossary of Terms

Aerial net: A net used to capture flying insects.
Alcohol preservation: A wet preservation method using alcohol to store soft-bodied insects.
Dry preservation: Techniques such as pinning or storing insects in envelopes to keep them in a dry state.
Dichotomous key: A taxonomic tool that uses paired statements to guide identification.
DNA barcoding: A modern identification method using genetic sequences to distinguish species.
Morphological features: Physical characteristics such as wings, antennae, and mouthparts used in identification.
Pitfall trap: A trap placed in the ground to capture crawling insects.
Taxonomic key: A tool used to identify organisms based on observable features.
Wet preservation: Techniques involving liquids such as alcohol or formalin to store specimens.

Concept Check Questions 5

Objective questions

Sweeping nets are useful for collecting small ______ insects. (Linked to SLO 5.1)
Light traps are commonly used to attract and capture ______ insects. (Linked to SLO 5.2)
Wearing protective ______ is important when handling insects that may bite or sting. (Linked to SLO 5.3)
Pinning insects correctly helps preserve their ______ features. (Linked to SLO 5.4)
Wet preservation is particularly useful for soft-bodied insects such as ______. (Linked to SLO 5.5)
Labels should include the date, location, and ______ of collection. (Linked to SLO 5.6)
Beetles can be identified by their hardened forewings called ______. (Linked to SLO 5.7)

The most common type of taxonomic key is the ______ key. (Linked to SLO 5.8)
DNA barcoding distinguishes insect species using their genetic ______. (Linked to SLO 5.9)
Preserved specimens serve as reference materials in museums and ______. (Linked to SLO 5.10)

Short-answer questions
11. Define field collection methods. (Linked to SLO 5.1)
12. Name one trap used in insect collection. (Linked to SLO 5.2)
13. Why are safety considerations important during insect collection? (Linked to SLO 5.3)
14. Give one example of dry preservation. (Linked to SLO 5.4)
15. What liquid is commonly used in wet preservation? (Linked to SLO 5.5)
16. What information should be included on specimen labels? (Linked to SLO 5.6)
17. Name one morphological feature used in insect identification. (Linked to SLO 5.7)
18. What is a taxonomic key? (Linked to SLO 5.8)
19. Mention one modern technology used in insect identification. (Linked to SLO 5.9)
20. Give one application of insect identification in agriculture. (Linked to SLO 5.10)

Long-answer questions
21. Describe field collection methods and their importance. (Linked to SLO 5.1)
22. Explain the use of traps and nets in insect collection. (Linked to SLO 5.2)
23. Analyse dry and wet preservation methods for insects. (Linked to SLO 5.4, 5.5)
24. Explain how morphological features and taxonomic keys are used in insect identification. (Linked to SLO 5.7, 5.8)
25. Evaluate the importance of insect collection, preservation, and identification in research, education, and applied sciences. (Linked to SLO 5.10)

Answers to Concept Check Questions 5

Objective questions

Flying.
Nocturnal.
Clothing.
Morphological.
Larvae.
Method.
Elytra.
Dichotomous.
Sequences.
Laboratories.

Short-answer questions
11. Techniques used to gather insects from natural habitats.
12. Pitfall trap.
13. To protect collectors from bites, stings, or disease transmission.
14. Pinning insects.

15. Alcohol.
16. Date, location, and method of collection.
17. Antennae.
18. A tool that guides identification based on observable features.
19. DNA barcoding.
20. Identifying pest species for control strategies.

Long-answer questions

21. **Basic response**: Field collection methods include handpicking, sweeping nets, and beating trays.
Value-added response: They are important for studying insect diversity and ensuring accurate representation of species.

Basic response: Traps and nets capture insects efficiently.
Value-added response: Light traps attract nocturnal insects, pitfall traps capture ground dwellers, and nets are specialised for flying or aquatic species.
Basic response: Dry methods include pinning, while wet methods use alcohol or formalin.
Value-added response: Each method preserves different types of insects and ensures specimens remain useful for identification.
Basic response: Morphological features such as wings and antennae are observed, and taxonomic keys guide identification.
Value-added response: Dichotomous keys provide systematic steps, while modern tools complement traditional methods.
Basic response: These techniques support research, education, and applied sciences.
Value-added response: They enable pest management in agriculture, disease control in medicine, and livestock protection in veterinary science.

Answers to Pilot Questions 5

Part 5.1

Techniques used to gather insects from natural habitats.
Sweeping nets.
Light trap and pitfall trap.
Aquatic net.
To protect collectors and ecosystems.

Part 5.2

Methods that keep insects in a dry state.
Pinning.
Larvae shrivel if dried.
Alcohol.
Date, location, and method of collection.

Part 5.3

Physical characteristics used to distinguish species.
Elytra.
A tool for systematic identification.
Dichotomous key.
DNA barcoding.

Part 5.4

They allow study of insect diversity and behaviour.
They serve as reference materials for teaching.
Identifying pest species.
Identifying disease vectors.
Protecting livestock health.

References And Attributions 5

Figures and Boxes suggested in Series 5:

- Figure 5.1 Field collection methods for insects
- Box 5.2 Common traps and nets used in insect collection
- Figure 5.3 Safety considerations during insect collection
- Figure 5.4 Dry preservation methods for insects
- Box 5.5 Wet preservation methods for insects
- Figure 5.6 Labelling and storage practices for insect specimens
- Figure 5.7 Morphological features used in insect identification
- Box 5.8 Example of a dichotomous taxonomic key
- Figure 5.9 Modern tools and technologies in insect identification
- Figure 5.10 Role of insect collections in research and education
- Box 5.11 Applications of insect collection, preservation, and identification

AI prompt suggestions used for illustration placeholders:

- Diagrams showing insect collection methods, preservation techniques, morphological features, and modern identification tools.
- Boxes summarising traps and nets, wet preservation methods, dichotomous keys, and applications in agriculture, medicine, and veterinary science.

Open Educational Resource (OER) search strings suggested:

- “field collection methods insects diagram OER”
- “traps nets insect collection OER”
- “safety considerations insect collection diagram OER”
- “dry preservation methods insects diagram OER”
- “wet preservation methods insects OER”
- “labelling storage insect specimens diagram OER”
- “morphological features insect identification diagram OER”
- “dichotomous key insect identification OER”
- “modern tools technologies insect identification diagram OER”
- “insect collections research education diagram OER”
- “applications insect collection preservation identification OER”

General references (APA style):

Borror, D. J., Triplehorn, C. A., & Johnson, N. F. (1989). *An Introduction to the Study of Insects*. Saunders College Publishing.

Gullan, P. J., & Cranston, P. S. (2014). *The Insects: An Outline of Entomology*. Wiley Blackwell.

Pedigo, L. P., & Rice, M. E. (2014). *Entomology and Pest Management*. Waveland Press.

Dent, D. (2000). *Insect Pest Management*. CABI Publishing.

OER Commons. (n.d.). *Entomology resources*. Retrieved from https://www.oercommons.org