COURSE GUIDE

BIO 407
BASIC ENTOMOLOGY

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First Printed 2012

Reprinted 2023

ISBN: 978-978-058-908-0

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Course Guide

Entomology majorly refers to the study of insects and all that surround them. The fact is that today's human population is a drift in a sea of insects. If we look at numbers alone, the estimated ratio of insects to humans is 200 million to 1, and there are about 40 million insects for each acre of land.

Along with humans, insects live in almost every habitable place on the earth, except the ocean depths. Some distinguished entomologists affirm that insects own the land. They are chief consumers of plants; they are the major predators of plant eaters; they play a major role in decay of organic matter and they serve as food for other kinds of animals.
The content of this course shall guide the students and individuals at all levels of educational learning to promote an understanding of major elements of general entomology.

Course Aims

This course aims at providing basic understanding about insects; it throws light into its evolvement, different classification and distribution of insects, organisation of external features, body organs, systems and castes composition of social insects.

Course Objectives

In addition to the aims above, this course set to achieve some objectives. After going through this course, you should be able to:

- explain the evolution of insects, list the general characteristics of insects and align it with factors that contribute to their success in the environment
- assess the beneficial and detrimental effect of insects to plants and animals in their environment
- identify common insect species using their basic features and classify species into their respective families and orders, as well bring out similarities in members of same species
- list the different types of mouth parts, wings and their modifications in the insect body for different functions
- describe the individual organ systems, which function simultaneously to achieve the overall process, including feeding and digestion, respiration, blood circulation, waste excretion and nervous system
- identify the most dread insects pests of human dwellings and other structures, the different caste composition and their

biological role and identify the behavioural adaptations of termites and honey bees to their environment.

Working Through The Course

Huge amount of effort was put together into developing this course and thereby enriching it with a lot of useful information for all categories of individuals in all levels of learning. However, it requires that concerted effort is made in reading through this material for appreciating the effort and in-depth acquisition of the desired knowledge as you spend good time to read through it. You are likewise encouraged to read through and practice all assignments mapped out in this material.

Course Materials

You will be provided with the following course guide (materials) and study units. In addition, the course comes with a list of recommended textbooks which though are not compulsory for you to acquire or indeed read, but are necessary as supplements to the course material.

Study Units

There are two (2) modules in this course broken down as follows:

Module 1

Unit 1 Insect Evolution
Unit 2 Classification and Distribution of Insects

Module 2

Unit 1 Organisation of External Structure
Unit 2 Maintenance and Locomotion
Unit 3 Social Insects

Textbooks And References

The under listed books are recommended for further reading Fabian, O. (1985). *Outlines of Stored Products Entomology.*
Larry, P.P. (2004). *Entomology and Pest Management*. (4th ed.). p.84.

Natural Resources Institute (1996). A Guide to Insect Pest of Nigerian Crops. Identification, Biology and Control. p.101.

Peter Fab and the Editors of Life (1964). The Insects. p.92

Assignment File

There are two components of assessment for this course: The Tutor-Marked Assignment (TMA) and the end of course examination.

Tutor- Marked Assignment

The TMA is the continuous assessment component of your course. It accounts for 30% of the total score. You will be given five TMAs to answer. Three of these must be answered before you are allowed to sit for the end of course examination. The TMAs would be given to you by your facilitator and return after you have done the assignment.

Final Examination And Grading

The examination concludes the assessment for the course. It constitutes 70% of the whole course. You will be informed of the time for the examination.

Presentation Schedule

The *Presentation Schedule* included in your course materials gives you the important dates for the completion of tutor marked assignments and attending tutorials. Remember, you are required to submit all your assignments by the due date. You should guard against lagging behind in your work.

Course Marking Scheme

This Table shows how the actual course marking is broken down.

Assessment	**Marks**
Assignment 1- 4	Four assignments, best three marks of the four count at 30% of course marks
Final Examination	70% of overall course marks
Total	100% of course marks

Course Overview

This course guide tells you briefly what to expect from reading this material which bothers on basic entomology.

The study of entomology, discusses evolution of insect from early ancestors i.e. earthworm, outlines the major characteristics of insects that

contributes to insects in their environment. The details are discussed therein. Insects are known to have beneficial and detrimental effects on living creatures both plants and animals. This course guide shall explain further on this aspect. For adequate scientific understanding of this course, insect classification and distribution was put in place in this course guide. This will enable individuals of all categories of learning to correctly place insects of all kinds in the right, phylum, class, order, family, genus and species. Each insect is given a scientific name, this we refer to as binomial nomenclature. This course guide discusses in detail the right approach to classification and assigning names to individual insects.

The best approach to grouping of segments of insects into functional regions is called Tagmatisation. Features of the various segments and their modifications for their functions in the body of insects are discussed. A representative insect *Periplanetta americanus* (cockroach) was used to highlight all functional features and their modifications in the body of the insect.

Individual organs and systems function simultaneously as a cosmos of interdependent and interacting system, so contribute in part of the success of insects in their environment. Social insects were not underestimated in their functional role in their castes. They live in groups in communal nests and undergo division of labour. The termite society is based on castes with members of each caste differing from those of other castes include primary reproductive's (kings and queens), supplementary reproductive's, workers and soldiers.

How To Get The Most From This Course

Implicit interest and regular culture of reading are of utmost requirements for getting the best out of this course. It is paramount that you should at least purchase one of the textbooks that are recommended for you. More importantly, attending tutorials sessions and completing your assignments on time will certainly assist you to get the best out of this course.

Summary

This course intends to provide you with some underlying knowledge of entomology; the following questions are expected to be adequately answered by the student after completely studying this course:

- What are the beneficial and detrimental effects of insects to us in Nigeria?
- List 5 characteristics of insects that accounts for their success in their environment

- Discuss the major classification of insects
- Outline similarities in members of insects of same species
- What is the binomial nomenclature of cockroach
- Define Tagmatisation in insects
- Classify insect head according to their orientation with mouth parts
- List different types of antenna in insects based on their modifications
- Enumerate the insect leg modifications to their functions
- State 3 types of feeding in insects
- Discuss the different organ-systems in insects
- What are social insects
- Distinguish between termites and ants
- State the behavioural adaptations of termites and bees.

We wish you success in this course. We hope you should be able to appreciate the field of entomology and beneficial and detrimental roles insects play in living organisms and the society at large.

MAIN COURSE

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MODULE 1

UNIT 1 INSECT EVOLUTION

CONTENTS

1.0 INTRODUCTION

This unit on insect evolution presents the evolvement of insect from creatures that probably looked like our present day earthworm. If you look into any Biology text book (see reference at the end of the unit). It will give you quite a number of characteristics of living things that guarantee their successful living in their environment.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- list the characteristics of insect
- discuss the evolvement of insects
- mention the factor that contribute to success of insects in their environment
- state the beneficial effects of insects
- state the detrimental effects of insects.

3.0 MAIN CONTENT

3.1 General Characteristics of Insects

1 Insects like other mandibulates have one pair of pre-oral antenniform appendages
2 The insect body is usually divided into three parts – head, thorax and abdomen
3 The insect head consist of six segments, a pair of mandibles (segment 2), (segment 5) and a pair of 2nd maxillae (segment 6)
4 Compound eyes are present
5 The thorax consists of three segments and three pairs of walking legs ventrally and two pairs of wings dorsally
6 The abdomen consists of eleven segments usually and bears no ambulatory appendages
7 Insects respire by means of trachea which open via segmentally-arranged spiracles.
8 Excretion in insects is by means of Malpighian tubules
9 Insects undergo metamorphosis.

3.2 Success of Insects

The class insecta developed into one of the dominant life forms on earth. They appropriately have been called “conquerors of the land” but what reasons can be advanced for their great success? What characteristics account for their tremendous diversity and numbers?

First, is arthropod body architecture, which emphasises an integument that is light and strong, forming a shell to protect inner tissues and attachment to muscles. Moreover, this shell which usually includes an outermost wax layer helps to prevent water loss from evaporation, a critical problem for small animals living on the land. Arthropod body architecture also includes jointed appendages that, in insects, have been profusely adapted into legs for locomotion, mouth parts for feeding, structures of reproduction and other uses.
Second, insects are also animals of relatively small size. Most vary from about 1/16 inch (about 2mm) to 1 inch (about 3cm). Some may be smaller, however, and a few such as much as 6-inch (about 15cm). The small size of most insects facilitates dispersal, allows them to escape from birds and other predators and enables them to use food present only in small amounts.

Third, is the ability to fly, which makes insects differ from other arthropods and invertebrates. The ability to fly is one of the most important reasons for the success of the whole class. This ability to fly,

aids insects in escaping predators and perhaps more importantly, it enables widespread dispersal of species. This dispersal promotes colonisation of new habitats, which in turn promotes the evolution of new species.

Insects also exhibit great reproductive capacity and several special features of their growth and development have enhanced their ability to persist even in unfavourable environments. The ability to lay large numbers of resistant eggs that can be carried by air, water currents, animals etc, combined with a relatively short generation time, produces a great amount of genetic variability that can be tested against the environment. The result is rapid adaptation of population to changing environmental conditions and formation of new species.

Finally in their adaptability, these major features collectively unique to insects are combined with great changes in physical conditions and habitat on the land.

3.3 Beneficial Effects of Insects

1 Insects pollinate flowers hence, fruit formation depends on them
2 Insects form a source of food for man e.g. honey, termites, caterpillar
3 Useful materials such as silk, bee wax, etc are obtained from insects
4 Insects are important in food chains, e.g. Aquatic insects form food for the fishes
5 Insects are important as scavengers – (decomposition involving cycling of materials)
6 Insects are important tools, e.g. Drosophila is used for research in genetics, physiology etc.
7 Some insects are used to control others that are pests (Biological Control)
8 Insects have aesthetic value (e.g. Butterflies are collected for their beauty).

3.4 Detrimental Effects of Insects

1 Some insects are parasites of animals and plants e.g. Lice, and stem- boring caterpillars.
2 Some insects e.g. mosquitoes and tsetse flies are vectors of parasitic diseases.
3 Some insects e.g. bean weevils destroy crops and stored food.
4 Some insects e.g. termites destroy wooden structures.
5 Some insects e.g. house fly and mosquito are often nuisance to man. The beneficial effects of insects, however, far outweigh their

adverse effects.

3.5 Evolution of Insects

Insects are the most successful group of animals reported to have existed much longer than human beings for more than 350 million years! Insects are the first small animals to inhabit the land with complete success, having evolved from creatures that probably looked like our present day earthworms. The first insects have multiplied and diversified and over 800 species have been reported.

The land had been colonised by low-growing plants, some 100 million years before insects became prominent, and had witnessed a succession of vegetative changes that ultimately resulted in the great coastal forests. It was during this time, the carboniferous period, (about 350 million years ago), when amphibians and reptiles flourished, that, insects gained a firm foothold on the land. During this early period, changes in insect form and the degree of species diversity accelerated rapidly. Some insects then resembled large dragonflies' gigantic forms with wingspans as wide as 29 inches (75cm).

Of the one million or so known species of animals, over 850,000 or 76% are insects. Thousands of species remain to be discovered.

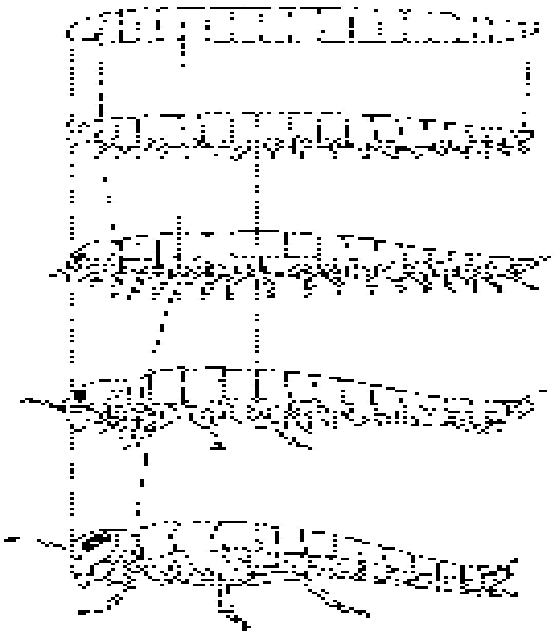


Fig. 1: How Insects Evolved

4.0 CONCLUSION

You have studied the evolution of insects from earthworm and have listed the characteristics of insects that lead to their success on land, without

which they will not be able to survive in their environment.

5.0 SUMMARY

It is evident that insects were the first small animals to inhabit the land with complete success, having evolved from creature that probably looked like our present- day earthworms.

6.0 TUTOR-MARKED ASSIGNMENT

i. List 5 characteristics of insects.
ii. State 5 beneficial effects of insects.
iii. State 5 detrimental effects of insects.
iv. Outline the factors that contribute to success of insects.

7.0 REFERENCES/FURTHER READING

Larry, P. P. (2004). *Entomology and Pest Management.* Fabian, O. (1985). *Outline of Stored Product Entomology.*

Web source:

- https://www.youtube.com/watch?v=NaB--lU1KH0&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D
- https://www.youtube.com/watch?v=o6_C7iRrXzY&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D
- https://www.youtube.com/watch?v=L5DaOlpXtmQ&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D

UNIT 2 CLASSIFICATION AND DISTRIBUTION OF INSECTS

CONTENTS

1.0 INTRODUCTION

In unit 1, you learnt about evolvement and characteristics of insects that led to successful living in their environment. In this unit, you will learn that naming of organisms is referred to as nomenclature and ordering them into a hierarchy of categories which is known as classification. Insects are classified because of the tremendous size of class Insecta.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- order what you know about insects
- compare and contrast their characteristic
- explain similarities in members of the same species
- identify insect specimens when you come across them
- assign a binomial nomenclature to each insect.

3.0 MAIN CONTENT

3.1 Elements of Classification

The naming and ordering of objects into groups is probably the most fundamental step in the development of scientific principles.

Likewise in biology, the naming of organisms is referred to as nomenclature, and ordering them into a hierarchy of categories is known as classification. Taxonomy involves the theoretical basis for classification and the study of the diversity and classification of organisms. Classification allows us to order what we know about insects and to compare and contrast characteristics. We shall expect members of the same species to behave similarly in their food habits, tolerances to environmental extremes, developmental patterns, and other ways.

A group of similar species, put together in a higher category is called a genus, also could be predicted to share somewhat similar ecologies and to have evolved from the same ancestors.

The classification of organisms is based on hierarchy of categories, with the most inclusive occurring at the top and the least inclusive at the bottom. Major categories used in animal classification are Phylum, Class, Order, Family, Genus, and Species. A subclass category is commonly present below the class category and a super family category above the family category.

Phylum - Arthropoda
Class - Insecta
Order - Lepidoptera
Family - Pyralidae
Genus - Ostrinia
Species - Ostrinia nubilalis

The scientific name of a species is binomial; it is composed of two names, a genus name and a specific name. The species name is written above as *Ostrinia nubilalis*. The generic name begins with a capital letter while the species name begins with a small letter and both are underlined separately.

3.2 General Classification of Insects

Insects in our environment are numerous, some are yet unidentified, even trained entomologists find it difficult to recognise instantly every insect specimen that comes their way.

There are 28 orders identified and discussed based on their characteristics and biological properties. Out of these orders, 7 constitute the highest population of our pest problems. The list below begins from the most primitive insects to the most highly evolved insects.

Class Insecta

Subclass Apterygota- primitively wingless insects

1	Protura	- Proturans
2	Collembola	- Springtails
3	Diplura	- Diplurans
4	Thysanura	- Bristletails
5	Microcoryphia	- Jumping bristletails

Subclass Pterygota: Winged and secondarily wingless insects.

6	Ephemeroptera	- Mayflies
7	Odonata	- Dragonflies and damselflies
8	Orthoptera	-Grasshoppers,crickets,cockroaches, mantids and walkingsticks
9	Dermaptera	- Earwigs
10	Isoptera	- Termites
11	Embioptera	- Webspinners
12	Plecoptera	- Stoneflies
13	Zoraptera	- Zorapterans
14	Psocoptera	- Psocids
15	Mallophaga	- Chewing lice
16	Anoplura	- Sucking lice
17	Thysanoptera	- Thrips
18	Hemiptera	- Bugs
19	Homoptera	- Aphids,scale insects, hoppers,cicadas, psyllids and whiteflies.

Division Endopterygota - Complex body change during growth

20 Neuroptera - Alderflies, anthions, dobsonflies, fishflies, lacewings, snakeflies and owlflies
21 Coleoptera - Beetles
22 Strepsitera - Twisted-winged parasites
23 Mecoptera - Scorpionflies
24 Trichoptera - Caddisflies
25 Lepidoptera - Butterflies and moths
26 Diptera - Flies and mosquitoes
27 Siphonaptera - Fleas
28 Hymenoptera - Ants, bees, wasps and sawflies

3.3 Subclass Apterygota

This subclass constitutes a group of the most primitive insects in orders Protura, Collembolan, Diplura, Thysanura and Microcoryplia. They are primarily wingless: they lack wings, likewise their ancestors. Internal structures that strengthen the thorax for flight in winged insects are absent. The development shows little changes in form referred to as no metamorphosis.

3.3.1 Order Protura - Proturans

They are unusual insects, small (0.6 to 2.0cm long), whitish with stylet mandibles. They lack eyes and antennae. Front legs emerged out in front of the head. There is presence of numerous sensillae which function like antennae. They live in soil and decomposing plant material, where they feed on organic debris and fungal spores. They are not regarded as pests.

3.3.2 Order Collembola - Spring Tails

Collembola are small (0.2 to 10) mm length. They may be terrestrial or semi-aquatics. They are found most frequently in moist environments including soil, decaying leaves and wood on forest floors, at the edges of ponds. They are microscopic. The common name, spring tail comes from the furcula arising from the underside of the abdomen, near the tip.

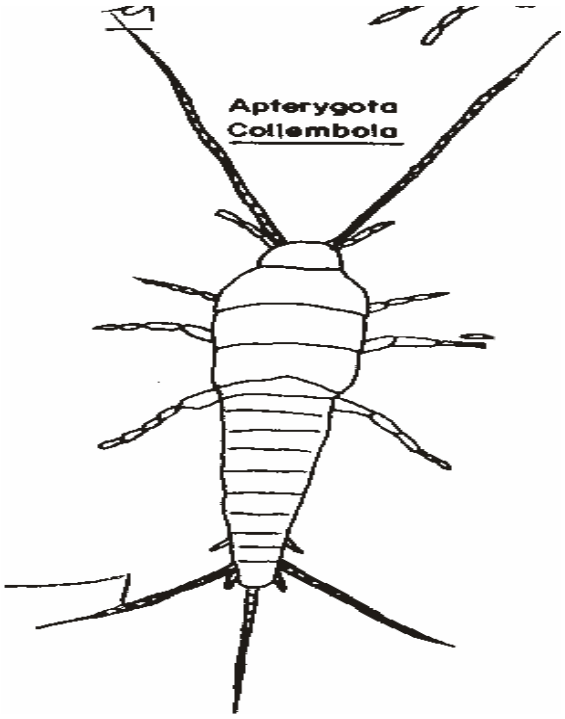


Fig. 2: Collembola

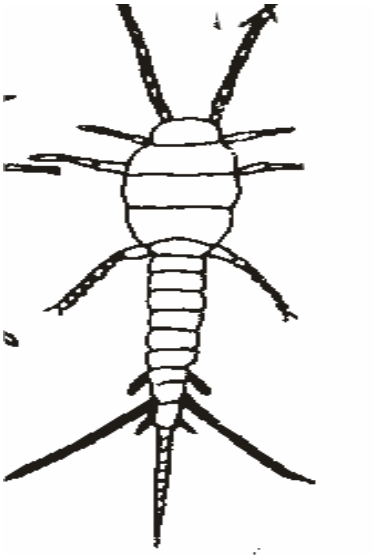
3.3.3 Order Diplura - Diplurans

Diplurans are small, blind, whitish insects, less than 7mm long, with many segmented antennas. Diplurans are small in size, low abundance with secretive habits and are rarely seen, but often exist in soil and soil surface debris. It possesses two prominent cerci at the tip of the abdomen, hence the name diplurans.

3.3.4 Order Thysanura-Bristletails

They are medium-sized insects (7-19) mm long with a flattened body and are mainly terrestrial, found in wood lands, under decaying bark, in termite nests or mammal burrows.

The most distinguishable features of these insects are the two long cerci and a filament at end of abdomen that resembles a tail. A compound eye is present and scales cover the body. The most prominent species are silver fish (*Lepisma saccharina*). They are minor household pests that cause damage to possessions by feeding on starchy substances and on books. They also feed on starched clothing and curtains.



3.3.5 Order Microcoryphia - Jumping Bristle Tails

They resemble bristletails in size and appearance but differ in having a cylindrical body and several abdominal styli arising beneath the abdomen. They have large compound eyes and chewing mouthparts. Their ability to jump (25 to 30)cm when disturbed brings up the name jumping bristle tail. They are found frequently in wooden habitats under leaves, rocks, and bark of decaying logs. They feed mainly on algae and sometimes feed on lichens, mosses and other materials. These species are not regarded as pest.

3.4 Sub Class Pterygota

These are characterised by possession of wings in the adult stage, some adult pterygota wings for example fleas, which evolved naturally in this condition and their ancestors were reported with possession of wings. In essence pterygotes are primarily winged but secondarily wingless. Pterigotes constitutes 25 orders, twelve of which are discussed below:

3.4.1 Order I: Ephemeroptera

They are about 2,000 species and are commonly known as may-flies. The adults live for only a few hours (Ephemeral means living for a short time). The short life of the adult is compensated for by a nymphal life of up to three years. Mayflies are soft bodied insects with large eyes. They have minute antenna. The mouth parts of adult mayflies are atrophied. The wings are membranous with the hind pair smaller than the anterior. The cerci are slender and pointed. The legs of adults are useless for walking and are only used for clinging to vegetation. The nymphs are aquatic. The nymphs are phtophagous, with cylindrical bodies and legs

are modified for burrowing. The nymphs of this order constitute important fish-food.

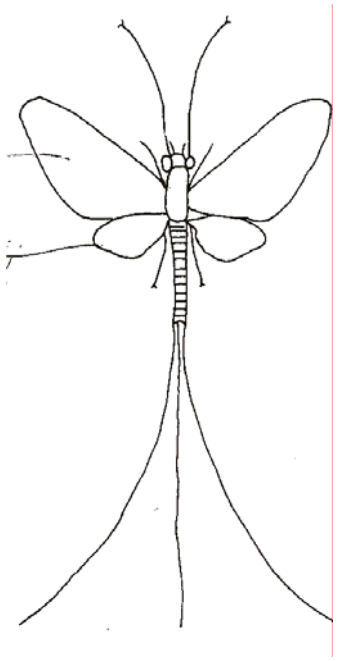


Fig. 4: A Mayfly

3.4.2 Order II – Odonata (Dragon and Damsel Flies)

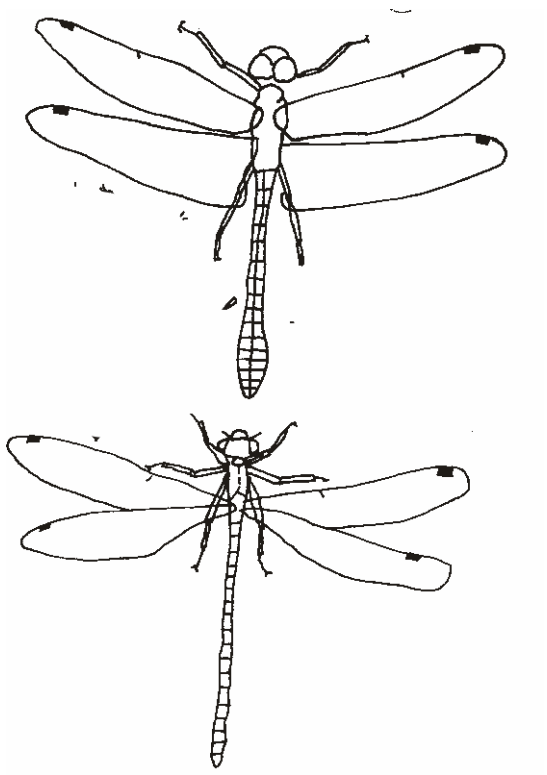
Insects in this order are very large insects with elongated bodies and very large eyes. The antennae are small and have strongly toothed and biting type mouth part. Cerci are very small and have only one segment. The wings are membranous; each wing has a peculiar dark spot called pterostigma.

Dragonflies are predaceous; they feed on insects caught in flight by means of the numerous leg spines. The legs are not used for locomotion. The eggs of odonata are normally laid in water or in aquatic plants and feeds on small crustaceans and insects.

Order odonata consists of two main groups:

(i) The Zygoptera (Damsel flies) which have slender bodies
(ii) The Anisoptera (Dragonflies) which have robust bodies

(a) Dragonflies



(b) Damsel flies

Fig. 5:

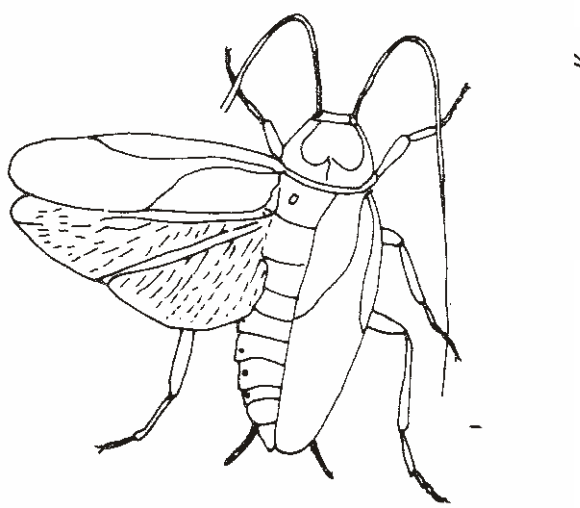
3.4.3 Order III – Dictyoptera

This order includes the cockroaches and praying mantis. They have general biting mouth part. The forewings are narrower and stouter membranous and fan-folding. The cerci are short and jointed. Styles are present in males and eggs are laid in Ootheca.

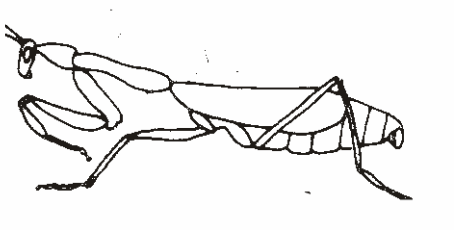
There are two distinct types of insects in this order

(i) Cockroaches - 4,000 species
(ii) Mantids - 2,000 species

The bodies of cockroaches have dorsoventially flattered legs which are strongly developed for running with large coxa. Cockroaches occur in kitchen, toilets and other places with high temperature while mantids are predatory insects. The forelegs are raptorial: the two posterior legs are slender and movement is slow and ungainly.



Cockroaches

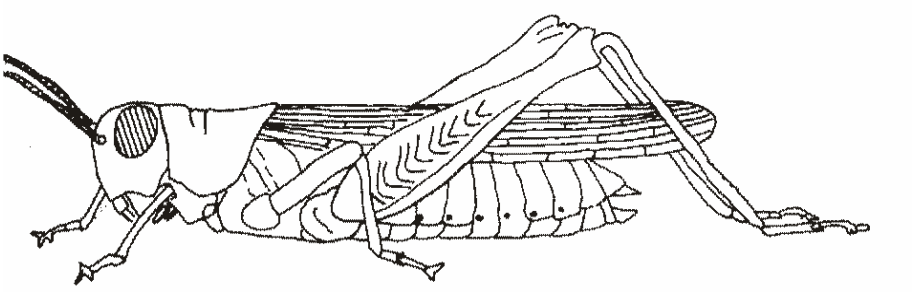


Praying Mantis

3.4.4 Order IV Orthoptera

The term Orthoptera, means: straight wing. The forewings are modified into tegmina which protects the membranous hind wings. The hind wings can be folded to lie at the back and modified for jumping; the femur is enlarged and accommodates the muscles for jumping. The females have well developed ovipositor. The cerci are short. A peculiar feature of this order is possession of special organs for making noise (stridulatory organ). Sound is produced by rubbing the legs against the body or wing. Their auditory organs are also well developed. There are three main groups in this order:

1 Long- horned grasshopper (Tetigonidae): They are vegetarians that destroy valuable crops.
2 Grylidae and grylotalpidae: are crickets and mole crickets which are orthopterans with long but straight ovipositors. Fore limbs are modified for burrowing. They are omnivores and damage the roots off economically important food crops.
3 Acrididiae: are short horned grasshoppers and locusts, with short antenna. This group occurs in large numbers and they destroy crops.



Grasshopper

3.4.5 Order V. Isoptera - The Termites

Example is *Macrotermes nigeriense* (Edible termites): Insects in this order are termites, soft bodied insects that live together in large communities. Primitive species tunnel into wood, others build large ant hills (termitaria) made up of faeces, saliva and mud. Termites have biting mouth parts. The two pairs of elongated wings are very similar, hence the name Isoptera meaning equal wings. They are polymorphic
i.e. exist in different forms or castes. They appear in three basic forms.

1 Reproductive forms
2 The soldiers (sterile males and females)
3 The workers (Sterile males and females).

The winged-reproductive forms usually swarm after heavy rains especially in the mornings and night, they cast off their wings after flying for some time and the workers enclose the queen and king in a royal chamber. There are numerous workers in the colony, who are responsible for building nests, fetching food, nursing the young and cleaning the nest with their mouth parts. The soldiers have highly sclerotised head with well developed mandibles. Some lower termites feed on wood, digested through the help of symbiotic protozoa e.g. Trichonympha in the gut while the higher termites feed on fungi, humus and soil organisms and maintain a garden of fungi to feed the young ones and the queen.

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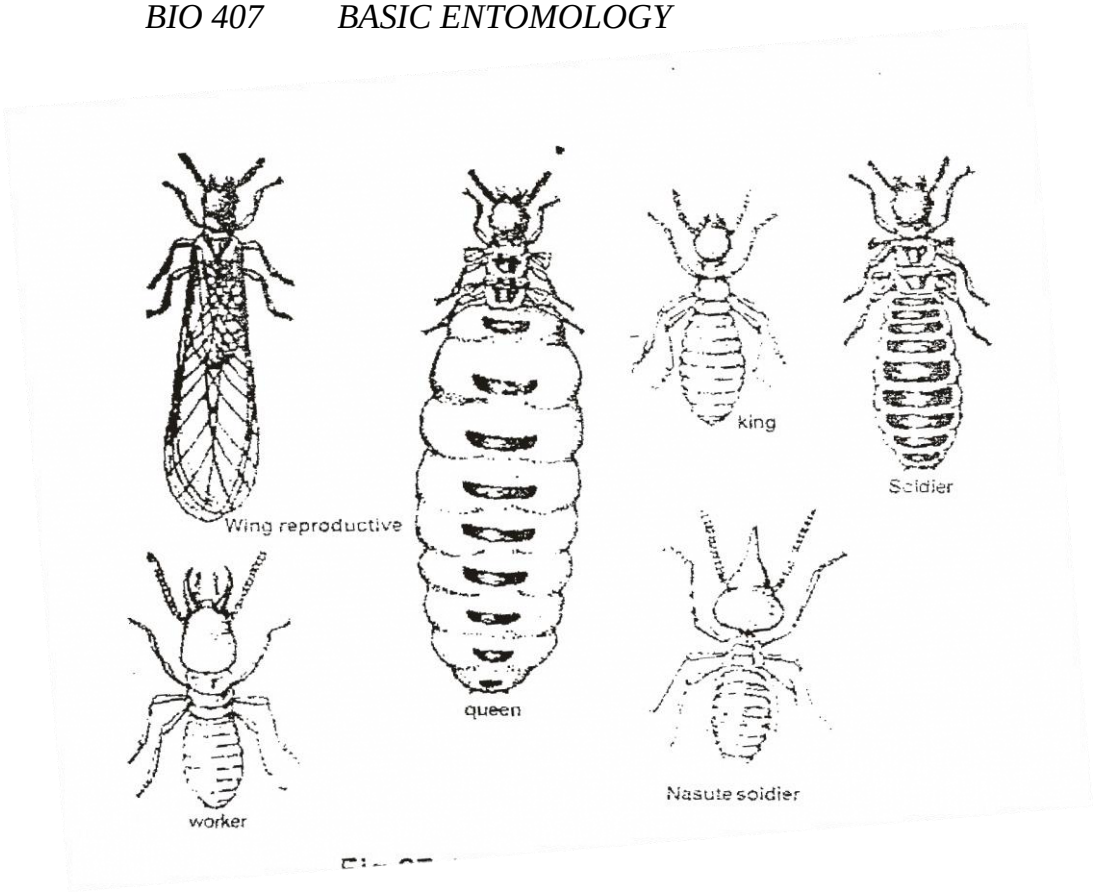
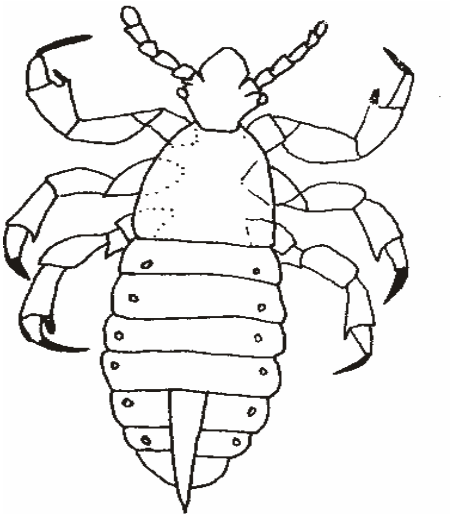


3.4.6 Order VI – Siphunculata (Anoplura) -The Sucking Lice

This order is a small order made up of about 300 species. The Anoplura: sucking lice are blood sucking ectoparasites of mammals, while the order Malophaga contains the biting lice and are birds' ectoparasite. Wings are absent (Apterous), they have poorly developed eyes or eyes are absent. Their mouth parts are modified for piercing and sucking. There are no segmentation on thoracic segments, appear fused together and the body is dorsoventrally flattened.

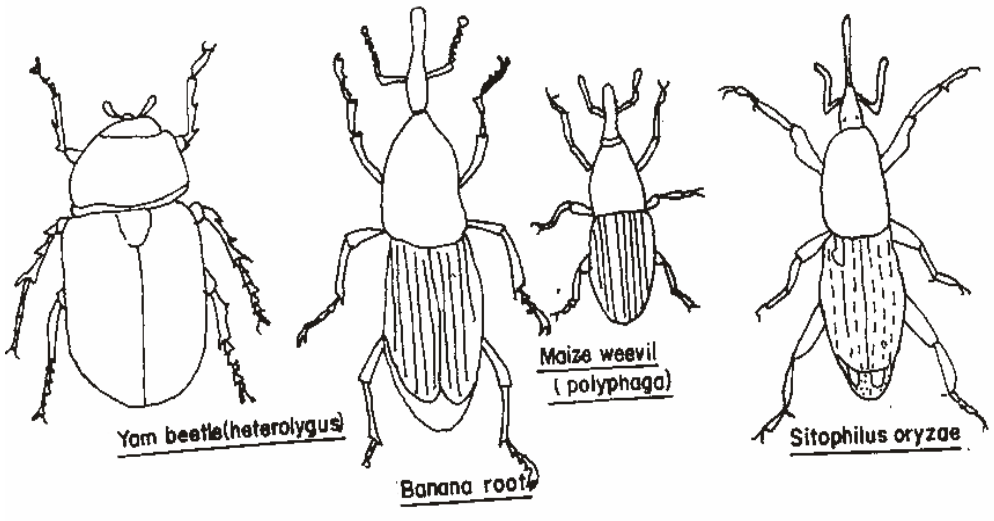
The human louse lives either on the head, body or on the pubic hairs and transmits pathogenic agents that cause typhis, relapsing fever and trench fever. Eggs attached to hair or clothing hatch as nymphs which molt thrice to become adults.



Sucking lice

3.4.7 Order VII-Coleoptera (The Beetles)

This order is the largest order in the animal kingdom. Coleopterans are essentially terrestrial insects, found in soil or decaying matters on soil. Some are aquatic e.g. Dytiscus (water beetle). Most beetles in this order are of economic importance because they destroy farm crops, timber and stored products. Fore wings are modified into hard protective elytra which meet in a line down the back. Hind wings are membranous and folded beneath the elytra (forewings) and sometimes the hind wings may be absent. Mouth parts are biting type legs.

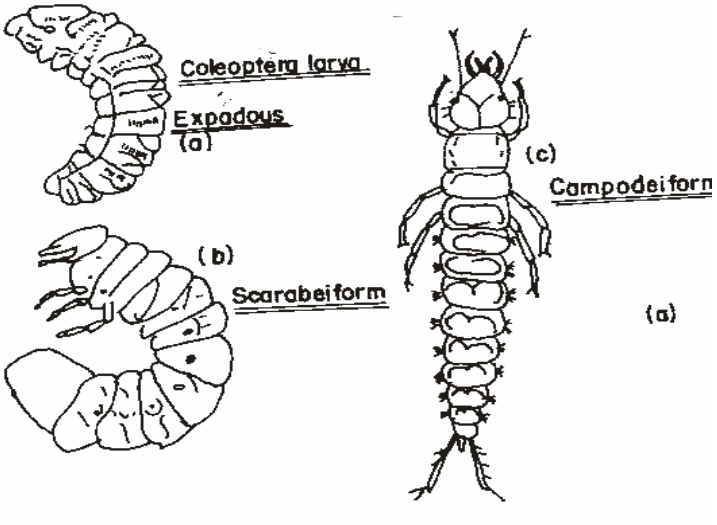


The Beetles

They are adapted for running or burrowing. Beetles undergo complete metamorphosis from egg larva pupa. Hence three types of larva appear

in different members of this order.

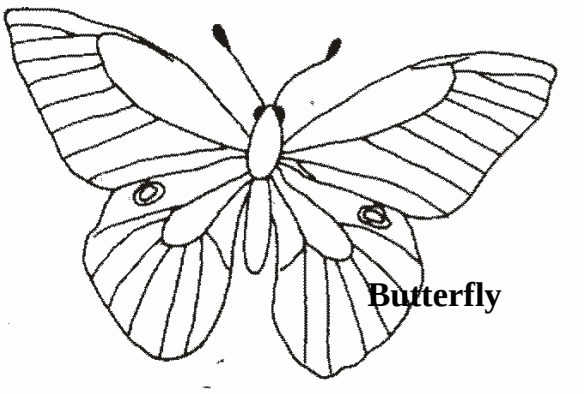
1 **Compodeiform**: Active predatory larva with well developed antenna, legs, and sensory organs.
2 **Eruciform (Scarabeiform**): These are "C Shaped with large sclerotised head. Thoracic legs are well developed and abdomen is inflated, soft and whitish in colour.
3 **Apodous:** (Legs absent): Are crescent shaped and eyeless found in groups living in groups in food e.g. weevils.



3.4.8 Order VIII – Lepidoptera (Butterflies and Moths)

Members are large orders of about 140,000 species and bear the name Lepidoptera because the wings, bodies and appendages are covered with pigmented scales. Adults Lepidoptera feeds on nectar or overripe fruits and the larva are phytophagous. Mouth parts are modified to spiral coiled suctorial proboscis. In some moths, mouth parts degenerates and they do not feed. Lepidopteras undergo complete metamorphosis (Egg

Larva Pupa Adult). The eruciform larva have well developed heads, biting mouth parts, three pairs thoracic of legs and ten abdominal segments, larva of Lepidoptera: caterpillars do much damage to crops and are good source of meat for Nigerians (Yoruba-Kanni/Munimuni).



Butterfly

3.4.9 Order IX- Diptera (The True-Flies)

They are commonly known as true flies, members of this order include mosquitoes, houseflies, midges, and sandflies. A representative feature of this order is presence of a single pair of membranous wings which are borne on the enlarged mesothorax. The hind wings are modified to a pair of halters or balancers. Mouth parts for sucking alone or for piercing and sucking. Many feeds on nectar of flowers or decaying organic matters, examples include mosquitoes, midges; tsetse flies that notably sucks blood.

Three basic types of mouths exist in this order:

1 Housefly type – proboscis are modified for sucking only
2 Female mosquito type-proboscis modified for sucking and piercing
3 Glossina type - mandible and maxillary stylets are lacking. The labium forms the main piercing organ.

Members in this order undergo complete metamorphosis.

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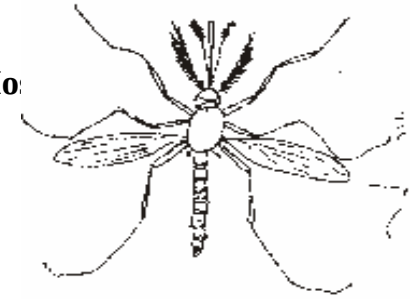

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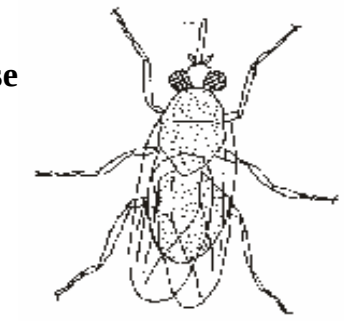


Economic importance of flies

Either as adults or as larvae, the blood sucking flies transmit pathogenic organisms causing various diseases, such as malaria, sleeping sickness elephantiasis, yellow fever and filariasis. Housefly act as mechanical carriers of germs on their legs, hairy body and contaminate food. Their larva cause injuries to crops and their activities result in great financial losses.

This order diptera includes the following families of insects:

1 Culicidae (mosquitoes)
2 Chironomidae (Midges) (Kotonkan)
3 Simulidae - causes river blindness
4 Tabanidae - Horseflies
5 Muscidae - Houseflies
6 Drosophilidae

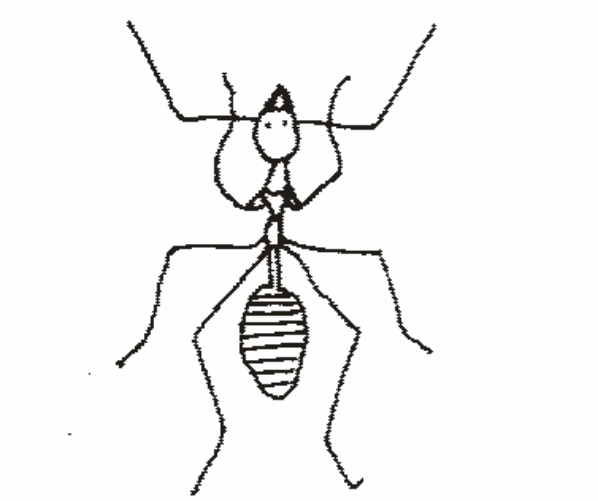
3.4.10 Order X – Hymenoptera

This order constitutes sawflies, bees, ants, wasps. Members are large and about 100,000 species. They exhibit interesting social habit, instinctive behaviour, polymorphism, parasitism and communication. Wings are membranous and have biting mouth type modified for licking and sucking. The larva may be polypodous (with many legs) or Apodous (without legs) like a caterpillar.

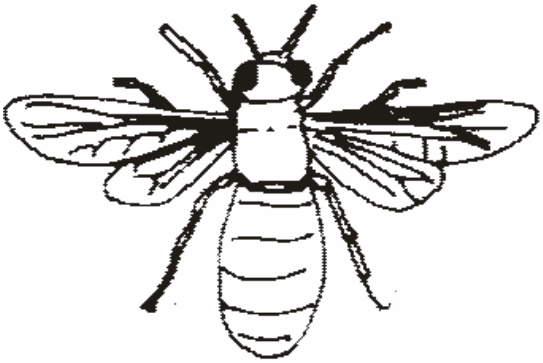
Species of hymenoptera are economically important:

1 Honey bees yield honey and wax
2 Bees are important pollinators of flower
3 Parasitic hymenoptera are helpful in the biological control of injurious insects
4 Family Vespoidea – wasps are carnivorous, they paralyse caterpillars with their sting and store them in the nests for young ones to feed on.
5 Family Apoidea – bees hind legs are highly modified for pollen collection stored in their nest for their larva, while workers function as nurses, ventilators, cleaners foragers depending on their age.

Red ant



Bees

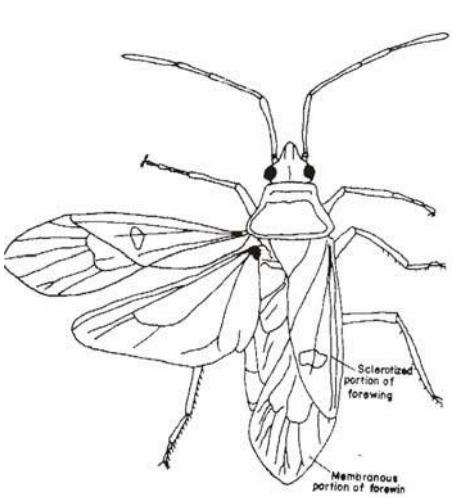


Wasps

3.4.11 Order XI Hemiptera

They are large group of about 56,000 species, constitute 2 groups:

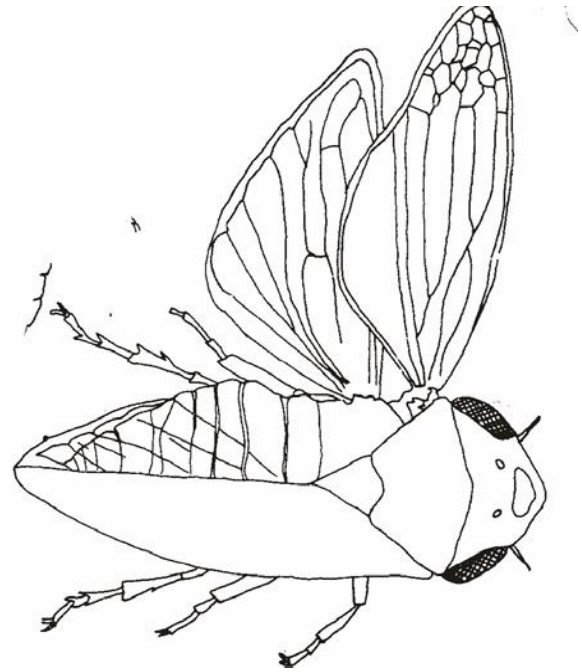
1 Heteroptera – (true bugs) see diagram below



2 Homoptera – Cicadas, Aphids, scale insects.

Cicadas

The mouth parts of hemiptera are modified for piercing and sucking.



Economic importance of hemipterans

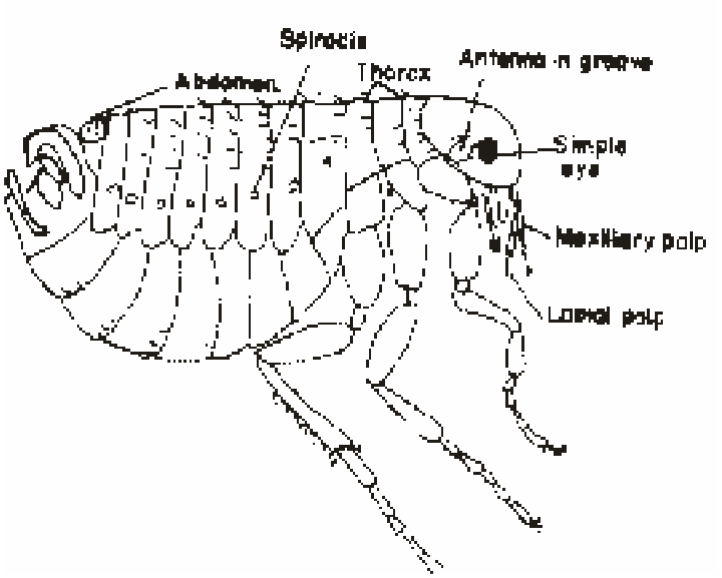
1 Cause direct and indirect injury to cultivated plants e.g. bugs transmits

diseases to economic crops such as potato, tobacco, citrus, fruits, sugarcane, maize and cocoa.

2. The heteropterans are plant feeders hence the name plant bugs.
3. The scale insects are parasitic infect cocoa and plants in general.

3.4.12 Order XII – Siphonaptera (Fleas/Aphaniptera)

Members are small order of about 1,000 species, small wingless (Apterous). A characteristic feature of this order is that, they are laterally compressed. Adult flea mouth parts are modified for piercing and sucking. They lack compound eyes, but many species have two ocelli on either side, many fleas are blind. Legs are modified for jumping. There is presence of claws for holding to the host.



Fleas

Economic Importance

1 Are ectoparasite of warm- blooded animals (respond to warmth), they leave the host when it dies.
2 Transmit bacteria e.g. bubonic plague bacillus
3 Fleas called Jigger (*Tunga penestrans*) are common in the tropics, burrow into the toes and become completely embedded in flesh.

IN TEXT QUESTIONS

Define the following; compodeiform, Eruciform, Apodous

Answer:

1 **Compodeiform**: Active predatory larva with well developed antenna, legs, and sensory organs.
2 **Eruciform (Scarabeiform**): These are "C Shaped with large sclerotised head. Thoracic legs are well developed and abdomen is inflated, soft and whitish in colour.
3 **Apodous:** (Legs absent): Are crescent shaped and eyeless found

in groups living in groups in food e.g. weevils.

4.0 CONCLUSION

In the unit, you have learnt the various classification of insect into subclass Apterygota, subclass Ptergtota and division Endopterygota.

5.0 SUMMARY

Insects have been classified into 28 suborders based on structural similarities for correct identification. Without identification, we have no basis for predicting injury and advising action.

6.0 TUTOR-MARKED ASSIGNMENT

i. What is binomial nomenclature?
ii. Outline the characteristics of order coleopteran
iii. Discuss the economic importance of flea.

7.0 REFERENCE/FURTHER READING

Larry, P. P. (2004). *Entomology and Pest Management.*

- https://www.youtube.com/watch?v=NaB--lU1KH0&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D
- https://www.youtube.com/watch?v=o6_C7iRrXzY&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D
- https://www.youtube.com/watch?v=L5DaOlpXtmQ&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D

MODULE 2

Unit 1 Organisation of External Structure
Unit 2 Maintenance and Locomotion
Unit 3 Social Insects

UNIT 1 ORGANISATION OF EXTERNAL STRUCTURE

CONTENTS

1.0 INTRODUCTION

Insects have segmented bodies as had their earlier wormlike ancestors. Twenty segments were reported to exist in these ancestors. Today's, insects show a reduction in this number, with certain segment fusing to form three well- defined regions head, thorax and abdomen. The grouping of this segment into functional regions is called Tagmatisation. In this unit, you learn the features on the various segments and their modifications for their functions in the body of the insects. Your tutor will help you to look at a representative insect e. g cockroach on a Petri- dish and observe the head, thorax and abdominal segment and other features.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define tagmatisation in insects
- state the three body segments in insects

- draw and discuss the main features on the insect head
- classify the insect head according to basis of their orientation with mouth parts
- describe the features of the thoracic segments
- mention the segments on the abdominal region.

3.0 MAIN CONTENT

3.1 Tagmatisation

The specialisation and grouping of adjacent metameric segments into region called tagma or tagmata is tagmatisation.

These regional specialisation result in supra-segmental organisation such as the head, thorax and the abdomen. In primitive metamerically segmented animals, the structure and function of the segment that makes up the body are nearly the same. In advanced Arthropods, groups of adjacent segment called tagmata are structurally marked off and specialised to perform particular functions. This results in division of labour that leads to better efficiency.

Insects show three distinctive tagmata:

1 The head which has six segments
2 The thorax which has three segments
3 The abdomen which has at most eleven segments.

Thorax bears the legs and the wings and the abdomen lack ambulatory appendages.

3.2 The Head

The insect head bears the mouthparts and sense organs. It is modified for feeding and detection of external stimuli. The mouth parts are varied in form and the nature of the mouth parts usually indicating the feeding habits of a particular insect. The mouth parts are, however, composed of certain basic units, which may be modified in particular situations to suit the mode of feeding and detection of external stimuli.

Representative Head Capsule of Insect

The head is an anterior-like capsule like heavily sclerotids body region with varying shapes. It is believed to have been formed by the fusion of six (6) segments. The head can be classified into 3 types on the basis of the orientation with the mouth part.

It is classified into:
i. Hypognathous
ii. Prognathous
iii. Opisthorhynchous

Hypognathous: The mouth parts have the same orientation with the leg. It is primitive arrangement and occurs in vegetarians e.g. grasshoppers. Prognathous: The mouth parts point forward, it occurs in carnivorous and burrowing species e.g. coleoptera (the weevils).

Opisthorhynchous: This is made-up of an elongate proboscis which shape downward and backward in between the legs e.g. homoptera.

The basic units of the head are:

i. The median labrum or upper lip, a flap-like lobe in front of the head
ii. The paired mandible which is highly sclerotinised structures hinged to the other edge of the head by a kind of ball-socket arrangement. They are true teeth for chewing
iii. The hypopharynx: are fleshy, tongue-like lobe situated below the mandible in the mid-ventral position
iv. The maxillae are paired structures situated beneath the mandibles, at the sides. Each maxilla is made up of several parts: a toothed inner to be (lacinia) used for food manipulation and a soft, flap- like outerlobe, the galea. The central plate to which each is attached is called the stipes. Each maxilla bears a segmented palp.
v. The labium is a single basal plate which closes the cavity of the mouth from below. It bears segmented palps which are presumably sensory in function.

The head capsule is divided into the number of sclerites by sulcus and this enable us to name the various of the head, variations however exist in the medial part of a transversed sulcus extending across the lower part of the face above the mouth marked at its lateral and by a cleared anterior tentorial pit, it is known as epistomal sulcus.

The lateral part of this sulcus above the mouth part starting from the anterior tentorial pit is the subgina sulcus, below the epistomal sulcus are two (2) sclerites, the upper one is the clypeus, the lower one is the labium which forms the upper pit.

A pair of sulcus extends perpendicularly upwards from the epistomal sulcus towards either the antenna or the compound eyes this is known as Subocular or Subantenna Sulcus respectively. They are sometimes called

frontogenal sulcus, because the region between the paired sulcus is called or known as front and genal laterally.

The area dorsal to the front between the compound eyes is known as vertex, and the gena are limited by the occipital sulcus and post occipital sulcus.

The posterior occipital sulcus forms a paired tentorial pit at a point where it meets the sub occipital sulcus sometimes on the vertex and then invertex Y shape sulcus occur called Ecdysial cleavage line. Considerable variation however exists from this typical sulcus and regional arrangement, the head capsule maintains its rigidity due to the possession of apodin. The two (2) pairs of tentorial pits marks the internal braces of the head, the tentorium consist of two (2) anterior end two (2) posterior apodin forming an internal skeleton which braces the head capsule and provide attachment surfaces for muscles.

Various structure are located in the various region of the head, prominent among them is the eyes, antenna and mouth part.

Eyes

This is the first structure that is located in the head, insects have two (2) types of eyes:

i. Simple eyes
ii. Compound eyes Simple eyes are of 2 types:
i. The dorsal ocellus
ii. The lateral ocellus (called also stemmata).

The dorsal ocellus

The dorsal ocellus is located from the front or the vertex of the head of some winged insects. They are absent in wingless insect and varied in detailed structure. But the following features are recognise in them.

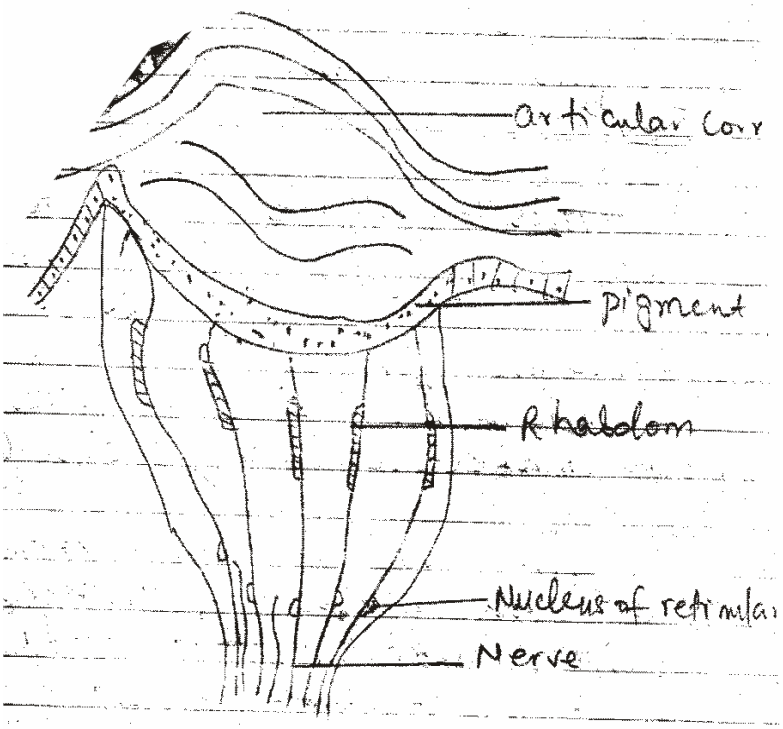
Features

i. **Cornea**: This is a thickened transparent layer overlying the ocellus to form a lens.
ii. **Corneagen layer**: This is made up of colourless transparent epidermal cell which secretes the cornea.
iii. **Retina**l: This is made-up of numerous senses located in a shallow cup arranged in groups of two or more, they formed rhabdomere distally and its fibres pass out of the side of the ocellia and make several syhaptic

junctions with asorn of other sensory cell which connect the central nervous system.

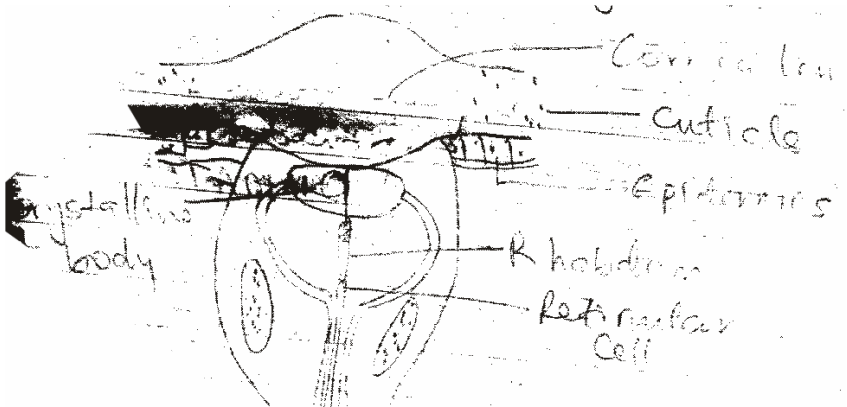
Functions of dorsal ocellus

1 It is a stimulatory organ which varies the excitory level of insect with respect to the visual stimuli passive by the compound eyes.
2 It is believed that dorsal ocellia and the compound eyes interact in mediating photostactic behaviour in insect.



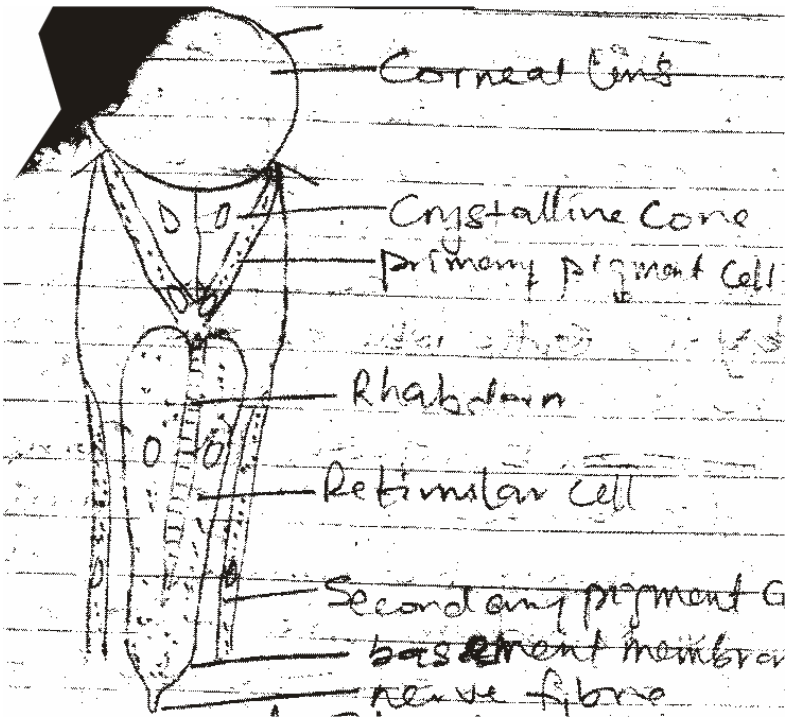
Lateral ocellus

These are only visual organ present in the larva of the holometabolous insects, they occur on the side of the head and the number varies, they are different from dorsal ocellus in being innervated by the optic lobe of the brain, it also have crystalline refractive body developed beneath the cornea lens, the lenses of the stemata produces an innervated image which falls on the rhabdom irrespective of the distance of the object.



Stemmata

Lateral Ocellus



Compound eyes

The adult insect head bears paired large compound eyes made up of many hexagonal units or lenses. Adult insects may bear single (simple) eyes or ocelli, usually three in number. Immature insects do not bear compound eyes but groups of ocelli located at each side of the head.
These are paired structure building out of the head giving a wide field of viewed they are formed from the aggregation of separate visual element known as OMMATIDIUM each of this correspond with one single facet of the ocellus like the stemmata they are innervated by the optic lobe of the brain.

The number and size of the facet in the compound eyes vary in insect, each ommatidium consist of two (2) parts.

(i) An optic gathering part known as IRIS.

(ii) And a sensory part known as RETINA.

Iris

The iris has a transparent, colourless cuticular lens, which forms the cornea at its outer region. This cornea is secreted by epidermal cells known as CORNEAGEN CELLS, this cells are later withdrawn to the site to form the primary pigment cell.

Beneath the cornea, are four (4) semper cells which produce crystalline cones the cones are hard, clear, intracellular structures bothered laterally by the primary pigment cell.

Retina

This is made-up of elongated sensory cells, known as Retinular Cells, each of which has microvilli known collectively as rhabdomials, this are corrected together to form a RHABDOM.
The Rhabdomia contains Rhodopsin – Rhodopsin a pigment sensitive to light thereby aiding visual perception.

Function of ommatidia

Ommatidia function independently with each subtending a very small part of the total visual field which overlapped considerably, the overlap is resolve by the brain, and this eye has been observed to be able to produce colours in some insects as well as different wavelength.

3.3 The Antenna

These are the sense organs borne on the insect head, are paired segmented antennae (feelers). They vary greatly in form: see fig 1 below:

i. Setaceous (threadlike)
ii. Filiform (linear)
iii. Moniliform (headlike)
iv. Geniculate (elbowed)
v. Clavate (chibbed)
vi. Capitate (with head)
vii. Lamellate (with leaflike folds)
viii. Serrate (toothed)
ix. Pectinate or hipectinate (Comblike)
x. Plumose (Feathery). See figure 2 below

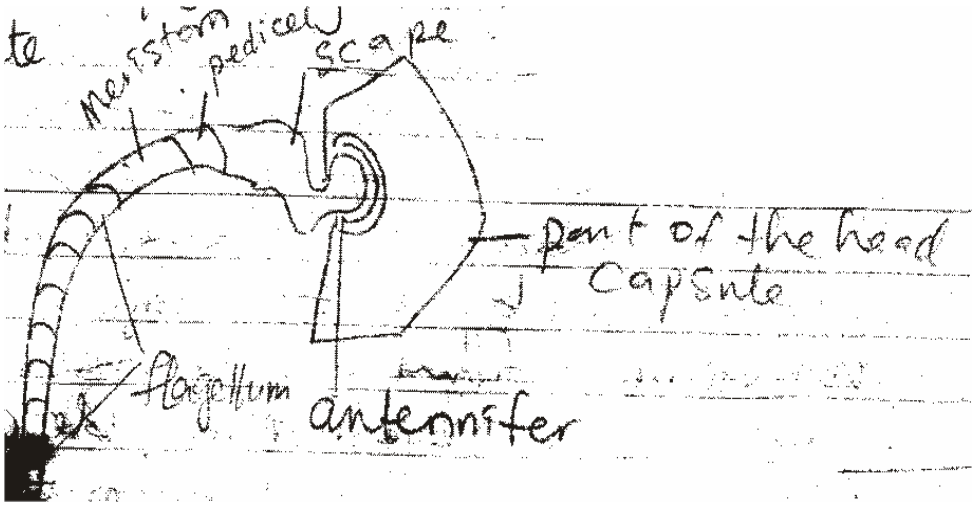


Fig 1:

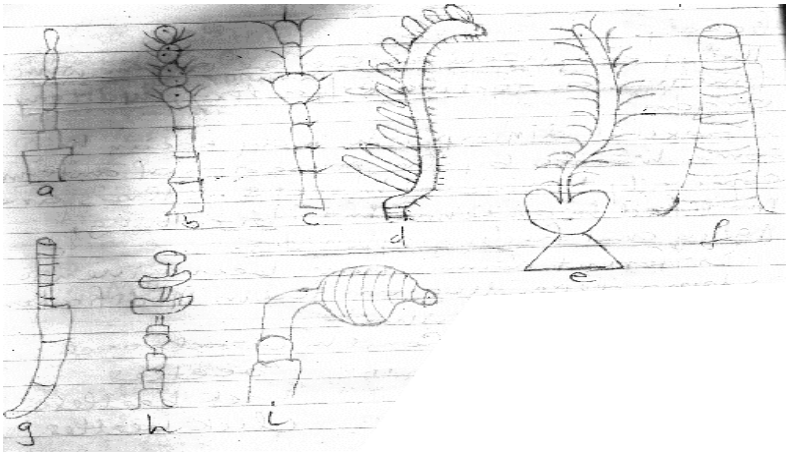


Fig 2:

The possession of one pair of antenna is a diagnostic feature of all insect and is characteristics of each family, genus, species of insects and of great importance in identification of sensory functions ascribed to the antennae depend on the type of sensilla (sensory receptors) present in them.

They may bear:

i. Chemoreceptors (sensitive to chemical substances in solution)
ii. Hygroreceptors (sensitive to humidity)
iii. Auditory (hearing)
iv. Olfactory (smell)
v. Gastatory (taste) receptors

The antenna vary in sizes and forms, depending on their functions and

efficacy:

i. They are used as sense organs, which function as tactile, olfactory, auditory organ.
ii. Sexual dimorphism may occur in some insects by the possession of antenna especially in social insects. Others are modified in antenna into breathing, mating and feeding apparatus.

3.4 The Mouth Part

The mouth part is an organ essentially appendages and jaws, made-up of an unpaired labrum and followed by an epipharynx and hypopharynx in front and behind. Has paired mandible and maxilla and unpaired labium forming the lower lib, this structures are modified in various insects on dietary bases.

Two bases types were recognised:

i. Mandibulate type i.e. (biting and chewing type)
ii. Haustellate type (sucking mouthpart)

Mandibulate type: Upper Lip or labrum

It is a broad- loped sterile hanging from the clypeus; it is raised from other mouth part by two (2) muscles arising from the head and inserted medically to the anterior merging of the sclerite. It is however lowered by another paired muscles inserted on the torma(e) which are thickened portion of the sclerite located on the posterior lateral merging of the labrum.

Mandible

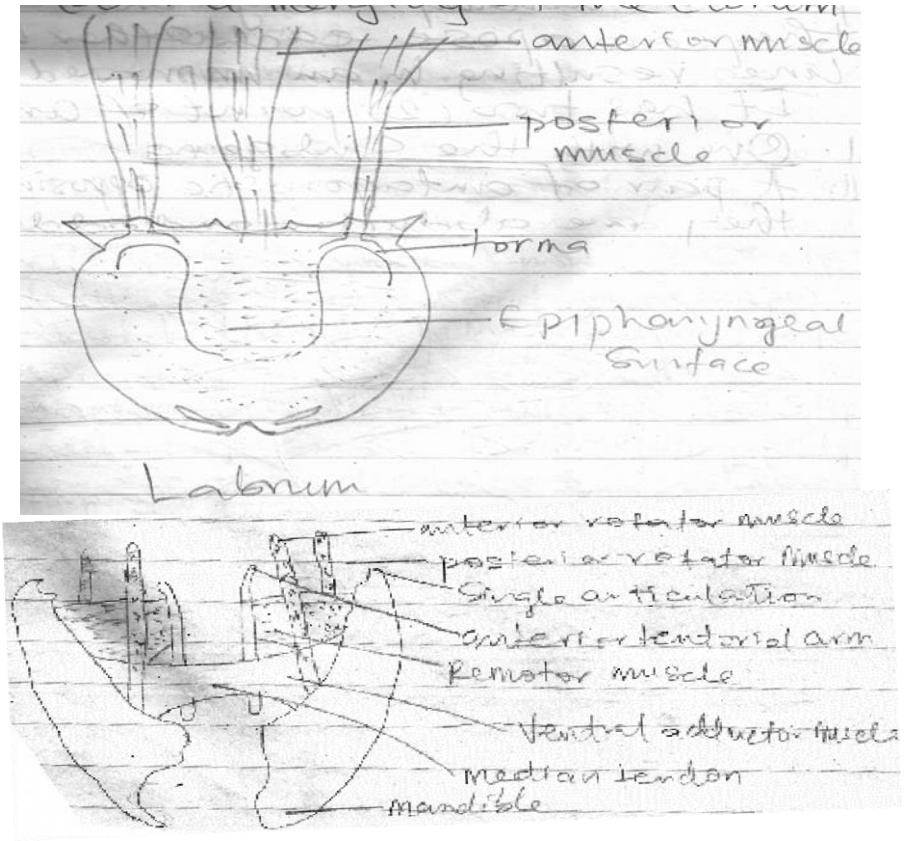
Mandible was highly sclerotized, paired, muscles representing the pair of appendage of the forth segment of the head, it moves sideways, resulting in the biting, chewing or crushing of food variation exist in its shape and complexity. See diagram below.

In apterygotes, they are usually long and slendered with only one point of articulation to the head capsule, it therefore rotates about this point with the action of anterior and posterior muscle, however in the pterygotes mandibles are short and strong sclerotiles with its biting surface differentiated into small distal inscissors region and its proxima lower region, such pair are usually asymmetrical so that they can apose each other in the mid-line resulting in an improved efficiency.

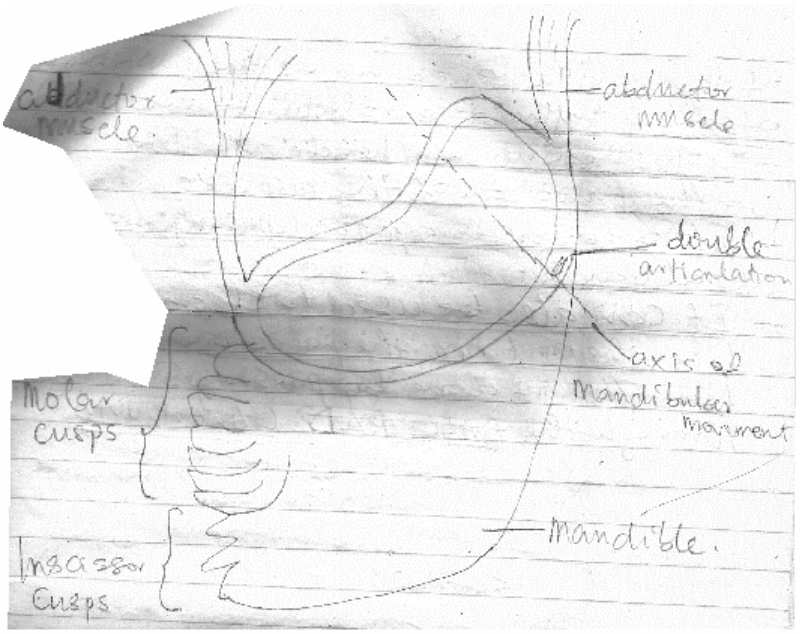
It has two (2) points of articulation:

i. One with the subgena

ii. A pair of antagonistic opposing muscle they are abductor and adductor muscles.



Apterygote Muscle



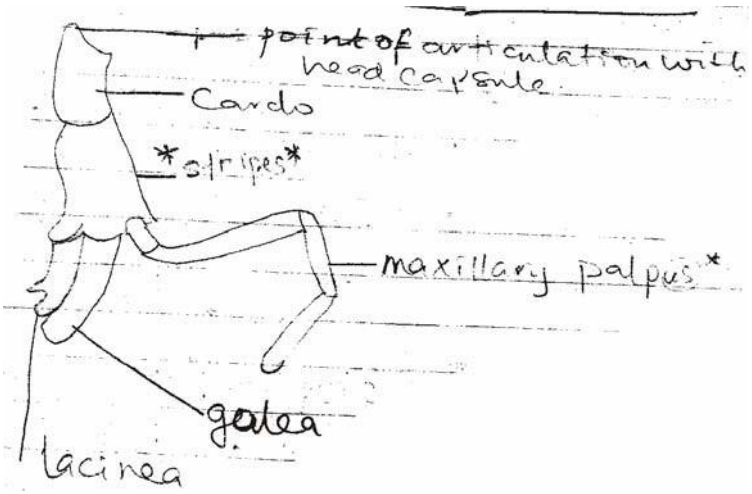
Pterygote Mandible

Maxilla: A pair of maxilla, representing a pair of appendage on the fifth segment of the head occupied a lateral position behind the mandible, it has a single articulation with the head and this is by means of a based cardo with a flat plate known as STIPE following both segments (cardo and stipe) is capable of independent movement. Distal to the stipe are 2 lopes, (i) Inner lacina and (ii) Outer Galea; located lateral on the stipe is a jointed palp known as Maxillary palp. These are sensory in function and used in testing food. The muscular arrangement of the maxilla encourages the movement of every segment in relation to each other and to the cranium/head.

The Function of the Maxilla: It is to encourage food passage into the oral cavity.

It can also be used to clean up structure like the antenna, the palps and the front leg. This is done by passing such structure through the GALEA PAD. See diagram below

Labium

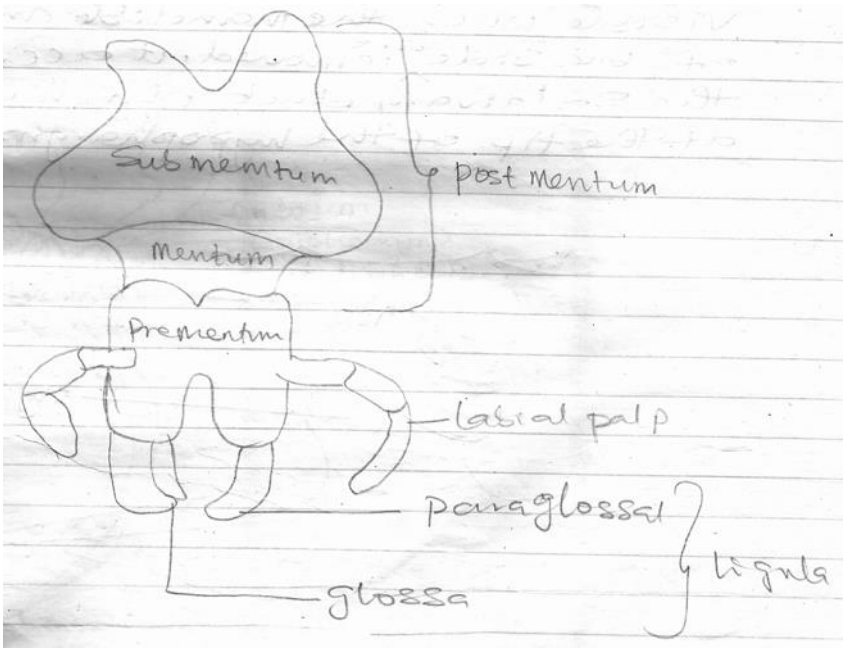


This forms the lower limb and is similar to the maxilla, hence it is called second maxilla. It represents the pair of appendage of the sixth segments they are however fused in the midline. Its basal part is called postmentum. This could be divided into a proximal

(i) Submentum (ii) Distamentum

Distal to this is the second (2nd) segment, the PREMENTUM which carries (4) four lobes terminally, 2 inner glossal 1&2 outer para glossa. These are collectively known as LIGULA. It may however be absent or fused in some insects. A pair of 3 segmented palps arises from the REMEMTUN known as LABIAL PALP/PALPIGIERS. They are

sensory in function. See diagram below

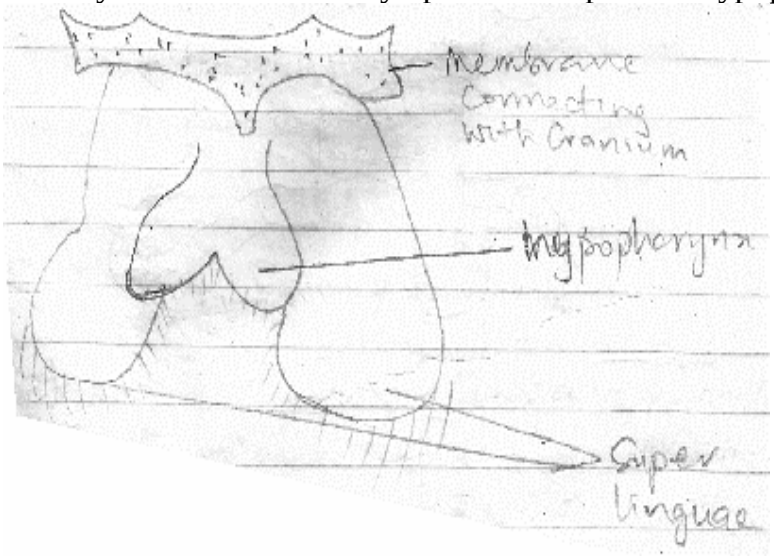


Epipharynx

This is not a sclerite but membranous and form the upper part of the oral opening (mouth). This structure, in most cases is attached to the labrum and if this is the case, the labrum is referred to as Labrum Epipharynx.

Hypopharynx

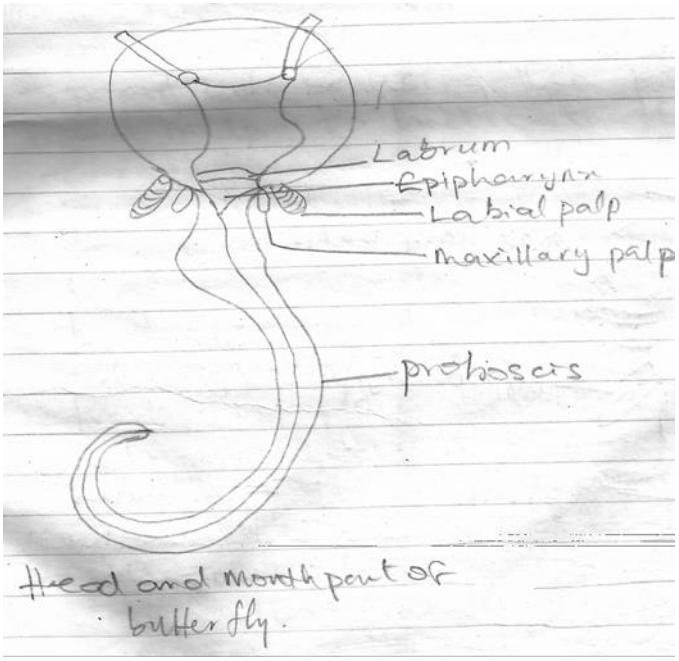
Also membranes and usually distinct, it is tongue-like and located immediately infront/above the labrum. It is only visible when the mandible and maxillae of one side are removed. It accommodates the salivary ducts which usually open at the tip of the hypopharynx.



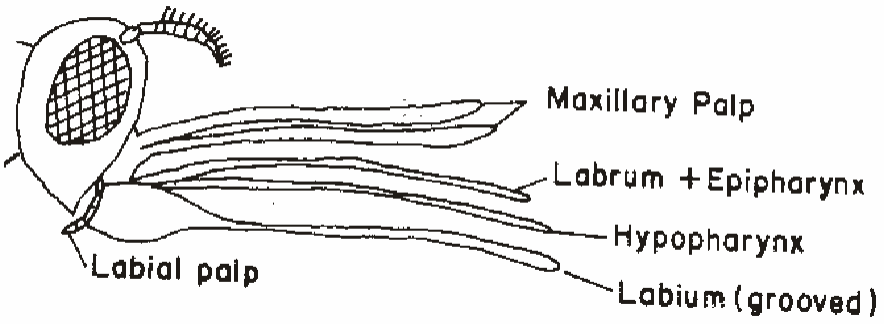
Haustellate sucking mouth part

This is more advanced, elongated and beak-like. It is generally involve modification of the basic mouth part into elongated stylets. Various modifications depending on the diet have been observed.

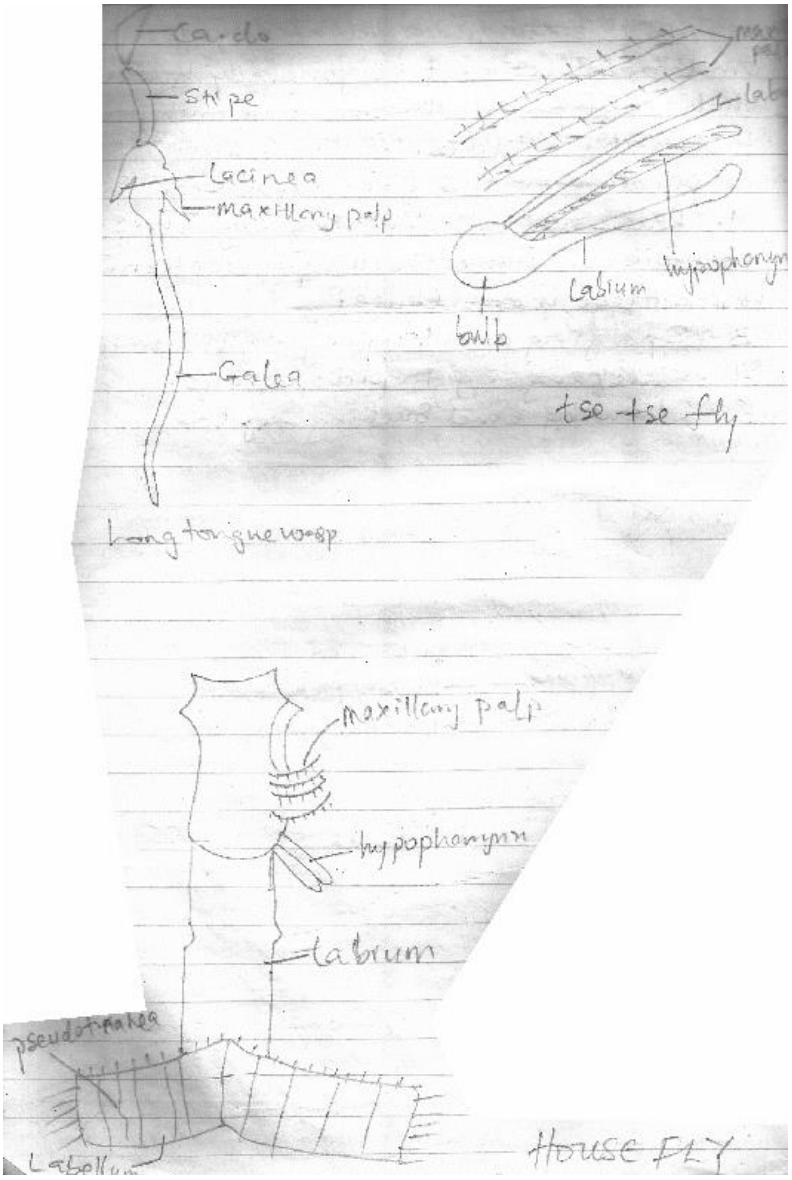
1 Rasping and sucking e.g. thrips.
2 Piercing and sucking e.g. dipterans (mosquito) hemapterans (fleas, head louse).
3 Sponging and lapping e.g. housefly.
4 Sucking e.g. lepidopterans.
5 Chewing and sucking e.g. bees.



Head and mouth part of butterfly



Mouth Path of Tsetse Fly



Mouth Part of Housefly

3.5 The Thorax

The thorax constitutes the chest region of the insect body. It is a comparatively short box-like region, specialised for participation in locomotory activity. The wings and legs which are veritable organs of locomotion are attached to thorax. The thorax is subdivided into three regions:

i the prothorax (in front)
ii the mesothorax (in the middle)
iii the metathorax (behind) the thoracic segment

The region is connected to the head by a membranous neck known as

Cervix. This allows freedom of movement of the head each segment of the thorax has three (3) group of sclerite.

i. Dorsal mortum
ii. A paired plate
iii. Ventral sternum

Each of this plate could be referred to specifically by using the prefix (pro, meso, and meta) to indicate the segment of each they occur example (e.g.) pronortum i.e. nortum of the prothorax each segment carries a pair of legs except in some lumature form. Insects therefore have three (3) pair of legs HEXAPODA each leg emanate from the pleurosternal junction, while wings are borne on the meso thoracic and metathoracic segment. If only one pair of wing is present, it occurs on the mesothorax on each side of the thorax are 2 (two) slit-like occurring between the pro and meso thoracic segment and then also between the meso and metathoracic segment known as **Spiracles**. The dorsal (upper) part of the thorax is the notum, the ventral (lower) part the sternum and each side is a pleuron. Each thoracic regions bears a pair of jointed legs while on the mesothorax and metathorax bear a pair of wings each. Thus there are three pairs of legs (hence Hexapoda) and two pairs of wings.

3.6 Insect Legs

The legs are found on the thoracic segment, all insects legs typical consists of six (6) segments which articulate with each other by monocondylic articulate or dicondylic articulation, these segments are:

i Coxa
ii Trochanter
iii Femur
iv Tibia
v Tarsus
vi Pretarsus

Coxa

This is the basal segment, it articulate with the pleurosternal wall of the thorax such articulations are usually single, this makes the coxa very free, but a second articulation with the trochanter reduces the freedom of the coxa.

Tarsus

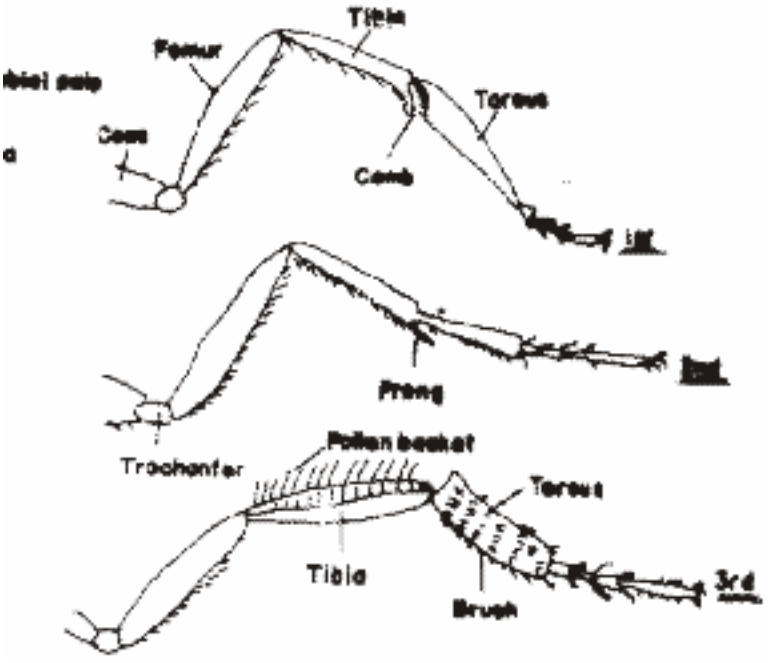
The tarsus may be divided into segment typically 5 in number with non of the segment acquiring its own muscle and hence movement of the tarsus is effected by elevator and depressor muscle arising from the apex of the tibia.

The pretarsus

Consist of the claw which may be paired or single. It has other structure like pad or arolium in between the claw.

Legs are primary organ for walking, but have been variously modified for different mode of movement and indeed other activities. Examples of insect's legs:

i Walking/ambulatorial legs/limb e.g. cockroach. ii Jumping/saltatorial e.g. grasshopper.
iii Grasping/raptorial/predatorial e.g. praying mantis. iv Swimming/natatorial e.g. backswimmers
v Digging/for sorial e.g. Mole cricket vi Grooming e.g. Bees
vii Clinching e.g. Head louse viii Rasping e.g. Housefly



Insect legs

The legs of an insect consist of a series of tagma separated by joints. The basal segment, the coxa is short and inserted into the cavity of the thorax in which it rotates in a sort of ball and socket joint. The second segment,

the trochater is a smaller and more or less tubular or triangular piece which articulates with the coxa behind it. The third segment is the femur which is large, usually long and sometimes thickened and spined. The femur is attached by a knee-like joint to the fourth segment the tibia which is generally long and slender. The rest of the leg is called the tarsus consisting of one to five segments and ending in a pair of claws. The number of tarsal segments is often a very important taxonomic character. Insect legs may be modified for various functions such as:

i running
ii jumping
iii clinging
iv grasping
v swimming
vi digging.

Insect legs may also bear various sensory structures specialised for hearing or for sound production (stridulation).

3.7 Insect Wings

Insects owes some part of their success as terrestrial organism to the possession of wings, being the only part of organisms apart from aves or birds that possess this character, the wings are dorsolateral outgrowth of the body wall emanating between the northum and the pleuron, they are thin plate-like expansion of the integument and are strengthen by a frame-work of holochitinous tubes known as VAILS.

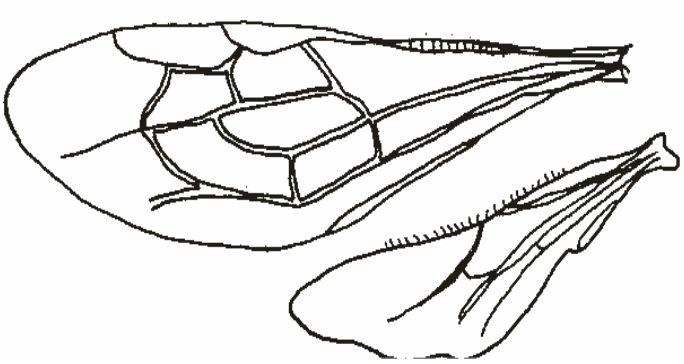
The vail is membranous with small sclerites to which muscles for wing movement we attached.

The mobility of the wing is further enhanced by the capability of the thorax to change shape. Insect wings vary in number, shape, size, variation and disposition.

When insect are at rest, the wings are folded back on the body, most adult insects have two pair of wings which are independent of each other, and hence ineffective (not effective) most insect therefore, tend to become functionally two (2) winged, either by coupling the wing on each side, so that they function as one or by modifying the second pair to form sense organs. Example – Halteres (Insect with 2 wings).

In most insects, wings are membranous and may carry tiny scales. In some however the forewing are thickened to form Elytra or they may become Leathery to form TAGMINA both of which are harder than the normal

membraneous wings, veins of wings vary in distribution with species but are quite constant with species and so the character of veins have been used extensively in insects classification. The complete system of wing on the wings is called or known as VEINATION.



Wing Veination

The fore wings (borne on the mesothorax) are more sclerotised and serve as protective covering to the hind wings (on the metathorax) which are usually membraneous and used for flight. Some insects (e.g. adult flies) bear only one pair of wings (on the mesothorax), whole in a few others (lice, fleas etc) wings are absent stored product insects bear two pairs of wings, but in some cases, the insects are flightless. The nature of the wings, their colour, sculpturing, venation, etc may be very useful features in insect identification.

3.8 The Abdomen

The abdomen is usually made-up of 11 segments. The eleventh one being very reduced and represented by appendages in most cases, the number of segment may however be reduced due to fusion or telescopic of the segment into each other.

During development other segment are added in ANAMORPHIC INSECT e.g. proturans. But in EPIMORPHIC insect especially the holometabolous forms, no such development is observed.
The abdominal segment have pronounced stergal , sternal and sclerite. But the pleural plate is reduced to membranous materials on which the spiracle is borne.

The spiracle may occur on the stergal or sternal plate of some insect. The pregenital segment will not carry appendages except in some immature forms and adult apterygote in some pterygote such segment may carry appendages that function as gills in aquatic animals, lateral

filament or pro-legs. The posterior segment are modified for ovipositor

and mating (the no 8 -10th abdominal segment).

The reproductive opening of the male insect is usually on the 9th segment and it is concerned with copulation and transference of spermotheca to the female while the female opening of the oviduct is usually on or behind segment 8or 9.

This is concerned primarily with oviposition and such structure may be withdrawn into the organism when not in use. The external genitalia of insect are extremely variable even within species of the same genera and it is strictly adapted to the habit involved in copulation and egg laying. The terminal segment in some aquatic insect are modified for respiration e.g. mosquito larva while the cerci is a primitive appendage which occur in apterygote and hemimetabolous orders.

- It functions as a sense organ sensitive to tactile stimulation, air movement and sometimes sounds.
- The structure may also show sexual dimorphism which suggests that they play a role in copulation.

Some insect abdomen of the more posterior segments tends to be hidden under those in front, of them, thus reducing the number of segments visible externally. Except in certain primitive insects, such as the Collembola and Thysanura, locomotory appendages are absent in the abdomen, but other structures such as cerci, styles and those associated with the external genitalia are usually present. Female adults bear ovipositors which assist in egg-laying and may be modified in shape and form for digging, piercing and stinging.

3.9 Spiracles

Insects, like many other terrestrial arthropods, respire by means of trachea which are branched, tube-like structures supplying oxygen directly to the tissues and opening and closing as desired, so as to reduce water loss through them. Paired spiracles are located at the sides of the thoracic and abdominal segments.

IN TEXT QUESTION
Briefly explain the abdomen of insect
Answer:
The abdomen is usually made-up of 11 segments. The eleventh one being very reduced and represented by appendages in most cases, the number of segment may however be reduced due to fusion or telescopic of the segment into each other

4.0 CONCLUSION

In this unit you have learnt about the insect body segments, leg modification insect wings and types of antenna based on their modifications.

5.0 SUMMARY

The three body segments of insect have some modificational features for their functions that is the insect legs, antenna and wings,

6.0 TUTOR-MARKED ASSIGNMENT

i. Mention the major antenna types found in insects.
ii. List the major wing-types found in insects.
iii. Describe the adaptive radiation in insect legs and antenna.
iv. What is tagmatisation.

7.0 REFERENCES/FURTHER READING

Natural Resources Institute (1996). *A Guide to Insect Pests of Nigerian Crops Identification, Biology and Control.*

Peter Fab and the Editors of Life (1964). *The Insects*.

- https://www.youtube.com/watch?v=NaB--lU1KH0&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D
- https://www.youtube.com/watch?v=o6_C7iRrXzY&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D
- https://www.youtube.com/watch?v=L5DaOlpXtmQ&pp=ygUgZXZvbHV0aW9uIG9mIGluc2VjdHMgZG9jdW1lbnRhcnk%3D

UNIT 2 MAINTENANCE AND LOCOMOTION

CONTENTS

1.0 INTRODUCTION

In unit 3, you studied the external morphology and learnt the head comprises of sense organs you leant that the insect body is segmented and the thorax region bears three jointed appendages, with a pair of membranous wings. In this unit, you will learn about insect body as a cosmos of interdependent and interacting system. Individual organs, systems, which function simultaneously to achieve the over- all life process will be discuss.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain feeding in insects
- explain the functioning of the excretory system in insects
- describe the functioning of tracheal system in gaseous exchange of insects
- outline the blood composition in insects
- describe the role of insect sense organ in perceiving the realities of their environment
- discuss male and female reproductive structures in insects.

3.0 MAIN CONTENT

3.1 Digestive System

Virtually all organic substance available in nature can be utilised as food by insect, hence their digestive system exhibit diverse variation. This is, however, built on the same general plan which can be described as a tube running from the mouth to the anus with three(3) distinct regions:

Foregut - (Stomodaeum) Midgut - (Mesenteron) Hindgut - (Proto Daeum)

Each of these are specialised to perform different functions. They are separated by valves sphincters which regulate food passage within them. Aside from the tube, there are accessory glands which secrete materials into the alimentary canal to aid digestion.

Foregut

This section is concerned with storage and fragmentation of food. It is ectodermal in origin and therefore lined internally by a cuticle known. The wall is musculated with external longitudinal muscle and opposing internal circular muscle. The section is divided into four (4) regions.

(i) **The Pharynx**: This consist of a series of dialator muscles inserted into the apodin of the head, it encourages suction of food in fluid feeder and passing food backward to the esophagus in solid feeders.
(ii) **The esophagus:** This is an undifferentiated channel responsible for the passage of food to the crop.

(iii) **The Crop**: The crop is enlarged for food storage due to the presence of INTIMA, secretions are not observed in the crop, just like

other sections of the foregut, but digestion may proceed in this sub-region due to enzyme produced by the salivary gland or those regurgitated.
(iv) **The Proventriculus**: This region prevents back flow of food but does not prevent regurgitation it may be absent in fluid feeders.

Midgut

This section is refer to as the stomach or ventriculus, it is endodermal in origin and primarily concerned with enzyme production and absorption of product of digestion. Cell within the mid-gut are usually COLUMNAR. The musculature of this region is poorly developed and opposes the arrangement in the fore-gut. This region may bear the gastric caecum at the anterior and epithelia membranes are permeable hence, permitting exchange of digestive enzymes and products. The lumen may have finger-like projection which increases the surface-area available for digestion and absorption.

In fluid feeder, this section also facilitates rapid expulsion of water from the body.

Hindgut

It is ectodermal in origin, it is lined with INTIMA. It is meant to conduct undigested food to the exterior via the anus. Musculature is like that of the midgut, it is differentiated into two (2) sub-regions (i) AN ANTERIOR INTESTINE made up of ileum and (ii) POSTERIOR INTESTINE made up rectum and anus.

The ileum is undifferentiated inmost insects but in termites its stored flagellate (small organism like euglena) which aid cellulose digestion.
The malpighian tubules arise from the proxima part of the anterior intensive i.e. The pylorus. The posterior area of the intestine i.e. the arms and rectum is enlarged and important in the reabsorption of water, salt and amino acid. It has a thin wall in certain regions with columnar epithelium.

The length of the alimentary canal varies with the type of food consumed

- Carnivores have the shortest
- Herbivores have the longest
- Omnivorous have the moderately sized alimentary canal

3.2 Excretory System

Maintenance of salt and water and osmotic level in the haemolymph and the elimination of nitrogenous waste is ensured by the malpighian tubules

which are the excretory structures insects are anatomically associated with the alimentary canal. They nate tiny yellowish tubes from the junction between the midgut and hindgut.

Malpighian tubules are long, thin and this arises from the gut near the junction of the mid and hind gut, this lies freely in the body cavity. The walls are one celled thick and the number varies with insect.

Excretory products such as water and salt pass into the Malpighian tubules from the haemolymph. The gland of the rectum also partake in excretory system since they remove water and salt which gets to them by means of controlled reabsorption.

3.3 Respiratory System

Respiratory ventilation are accomplished by means of the trachea system. This is the system of internal tube lined with cuticle on INTINA since they are ECTODERMAL in origin.

Spiral thickening known as Taenidia gives rigidity to this tube. The principle tube of this system is the trachea which has a diameter of 2 m it opens to the outside via spiracles which are guided by valves and are segmentally located in pairs. The spiracle varies in size and shape. The trachea system is divided into 2 (two) on the basis of spiracles into:

i. **Open System**: In which case the spiracle open directly to the outside and it occurs mostly in terrestrial insects.
ii. **Closed System**: The spiracle is permanently closed but a network of trachea tube wrist just underneath the integument. This are widely distributed but the opening is restricted to certain surfaces. This system is common to aquatic and parasitic insect.

Internally, the tracheas ramify into finer tracheae which terminate into very fine tracheoles the tracheoles lack the cuticular lining they are filled with fluid and permeate various tissue.

Lateral trunk of the trachea usually occur on each side of the body, tracheae from neighbouring spiracle also anastomose to form dorsal and ventral longitudinal trucks. Such longitudinal trachea runs the length of the body while transverse smaller branches extend to various tissues.

The arrangement of trachea varies with insect but usually in heart and dorsal muscles are supplied by the dorsal longitudinal trunk. The alimentary canals, gonads, legs and wings are supplied by the lateral trunk, while the central nervous system supplied the ventral longitudinal

trunk.
The conventional current produced by the changes in volume of the trachea system improves the ventilation rates, which otherwise is solely dependent on diffusion, the presence of thin walled air-sac at some point or the trachea also encourages ventilation.
In a very active insect however, dorso ventral movement of the abdomen couple with the withdrawal of fluid. In fluid filled tracheole region ensures improved ventilation.

3.4 Circulatory System

The insect circulatory system is described as operation that it does not consist of defines blood vessels familiar in no-arthropods. Instead, blood flows through a system of open for various parts of the body. The "heart" is a pulse tube in the abdominal region, and pumps blood in forward direction.

Insects have open circulatory system. The blood occupies body cavity known as HAEMOCOEL, the only blood vessel present in insect is located dorsal to the alimentary canal and it extends over the whole length of the organism.

The vessel comprises of a posterior heart overlying the abdomen and an interior aorta. The heart is divided into series of chamber by valve, each chamber has a series of paired slit-like opening known as OSTIA through which blood drains into the heart, the number of ostia vary with insect. The maximum number of ostia is 12, 3 pairs in the thorax, 9 pairs in the abdomen. The anterior and posterior lips of the ostia open into the heart to permit the flow of blood into the heart at diastole but prevent the outward flow at systole.

The anterior part of the vessel i.e. the dorsal aorta is simple and unperforated tissue. It opens anteriorly and has a contractible wall. The values are held back by unicellular thread attached to the inner lining of the heart and this prevents the values from turning out inside during systole. The dorsal aorta lies in the dorsal pericardial sinus along with the heart. This is cut off from the ventral body cavity containing the viscerals or visceral organs by the dorsal diaphragm. The dorsal diaphragm extends from the lower surface of the heart to the lateral position of the tergal plate. Closely associated with the heart are the alary muscles which stretche from one part of the body to other just below the heart and stretching out to the restricted region of the tergin.

This structure therefore forms an integral part of the dorsal diaphragm.

The blood of insects

The blood is a clear fluid suspending a number of cells basically LEUCOCYTE. They are often greenish or yellowish but seldom red. It makes up of about 5 – 40% of the body weight of an insect (usually 25 percent or less).

Blood circulation

This is generated by pumping of the heart at systole, this ensures that blood passes through the dorsal aorta. The valve of the incurrent ostia prevent the blood from going out of the heart from the dorsal aorta, it goes to the anterior portion of the pericardial sinus, pressure therefore mount at this region. Blood is then encouraged to flow into the visceral and ventral sinus with a net backward flow. Movement of the ventral diaphragm assists blood supply to the nervous system. The dorsal diaphragm which is convex above contracts due to the muscles and it flattens out to increase the volume of the pericardial sinus and decrease the volume of the pervisceral sinus. This has a net effect of encouraging blood flow into the pericardial sinus. At this time, the heart is undergoing diastole and so blood available in the mepericardial sinus are allowed into the heart through the incurrent ostia. During the circulation, most are bath directly and some nutrients transported by the blood is deposited by the aid of diffusion.

3.5 Nervous System

This forms an elaborate connecting network linking sense organs to effector organs and bringing about co-ordinated response. They are made up of numerous neurons and neuroglia cells. Neuroglia cells are supportive and nutritive in function, they also encourage rapid generation and conduction of electrochemical impulse. The central nervous system consists of two main centre head, one of which is designated as the brain united with a ventral nerve cord. The nerve cord has ganglia from which paired segmental nerves originate in the thorax and abdomen.

They occur around the neuron and form a layer of cell called PERINEURION. They are modified to form MYELIN SHEATH or THE SCHWANN CELL.

Nervous system of an insect is divided into 3, they are:

1 Central Nervous System
2 Peripheral Nervous System
3 Visceral Nervous System

3.5.1 Central Nervous System

This consists of three parts:

i. The brain
ii. Suboesophageal ganglion
iii. Ventral nerve cord.

The brain is located in the head above the esophagus and it is connected to the sub esophageal ganglion by circum mesopagea connectives. While the sub esophageal ganglion is connected to the ventral nerve cord directly. The size of the brain varies but it is larger in insect with complex behaviour.

3.5.2 Visceral Nervous System

This is divided into:

i esophageal sympathetic
ii Ventral sympathetic iii Caudal sympathetic

i. **The esophageal sympathetic**: It connects the brain and the fore and mid intestine, the heart and the anterior parts of the insect.
ii. **The ventral sympathetic**: It connects each ganglion to each other and the spiracle.
iii. **The caudal sympathetic**: It connects the reproductive system and the hind gut.

3.5.3 Peripheral Nervous System

This includes all nerves mediating between receptors and the central nervous system. Receptors include:

Mechanoreceptor - e.g. Sensillar Audioreceptor - Tympanal organ Chemoreceptor - Maxillary palp Thermoreceptor - Leg pads Humidity receptor - Antenna
Photoreceptor - Compound eyes and ocelli

It also connects nerves that link the central nervous system to effector organs such as muscles.

3.6 Insect Reproduction

Insects are usually in separate sexes parthenogenesis have been reported in some species. In such species, there may not be a record of male.

Reproductive organs generally consist of paired GONAD connected to a GONOPHORE via a median duct with a lot of accessory organs.

3.6.1 Male Reproductive System

This consists of a paired testes placed above or below the gut within the abdomen. Each of these consists of a group of follicle surrounded by peritoneal sheath in which sperms develop posteriorly. They are connected to a median ejaculatory duct by a period vas deferens. The ejaculatory duct opens outside on a penis or an AEDEGUS.

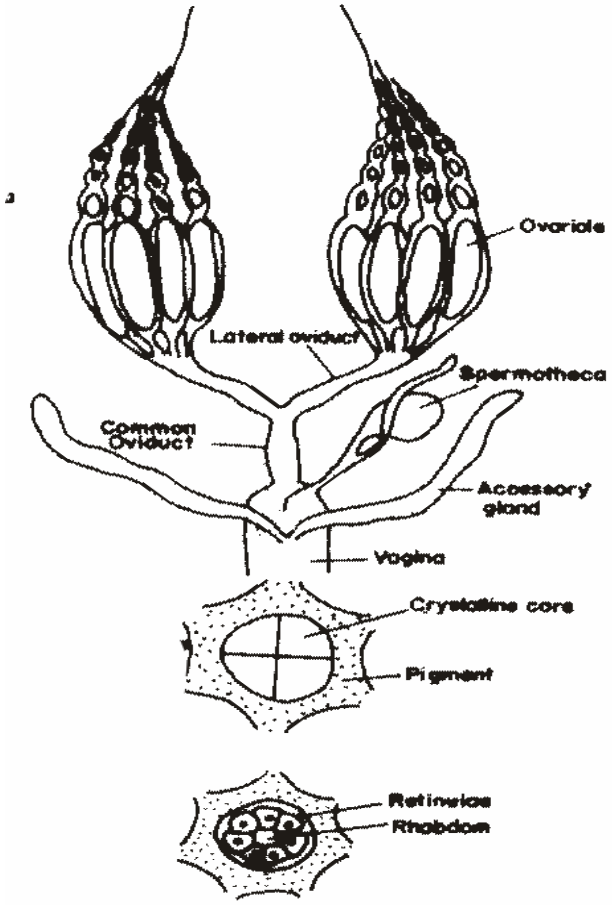
In some insects, each vas deferens may be enlarged to form a sac or sperm storage known as **Seminal Vessicle.**

An accessory gland may be connected to the vas deferens at its distal end. The secretion of such gland mixes with the sperm to form a seminal fluid and produce Stermatophores i.e. a sperm containing capsules. Modification however exists in insects.

3.6.2 Female Reproductive System

A pair of ovary each consisting of a group of ovaries about 1-200 leads into the oviduct posteriorly and uniting anteriorly in a suspensory ligament attaching it to the abdominal wall. Egg moves down from the upper part of the ovaries connect a pair of lateral oviduct and jointed to form a medial oviduct which opens into the genital chamber. It is sometimes closed to form a vagina which often developed into a **Bursa Copularis** for the reception of the penis. Connected to the vagina is a sac in which sperms could be stored known as **Spermatheca**. A group of various accessory glands may be present to secrete adhesive materials to fastened the egg to some objects or provide efficient coverage for the egg. The genital organs of female insects exhibit remarkable similarity. In each consists of a small number of lobes which open into the each side. The two vasa deferential unite posteriorly to form duct which then opens exteriorly to the penis. Seminal vesicles are present as simple swellings on the vasa deferens, which may also have accessory glands associated with them.

In the female, each ovary consists of ovarioles similar to the lobes of the testis, oviduct leading from the ovaries unite posteriorly to form a common ova which continue backwards as the vagina. A median sperm are paired accessory (collaterail) glands are also located on the vagina.



Insect Reproductive System

3.7 Growth in Insects

Due to the presence of exoskeleton, growth in insects like other arthropod, is achieved by ecdysis or moulting, this usually involve growth in phrases a stadium is the time interval between successive moult and luster is formed assure by insects during a particular stadium. Moulting in some insectsis usually associated with visible transformation or changes in external morphology. This is visible transformation in external morphology.

Moulting and metamorphosis are controlled by hormone located in the head and the thorax, the corpora allata and the prothoracic gland.

Corpora allata is responsible for the production of juvenile hormone which maintains the lumative form of an insect during early moult. It stops production at the end of maturity and becomes functional stage after the adult stage is reached. Prothoracic gland produces hormone responsible for moulting.

3.7.1 Ecdyis or Moulting

Largely on account of this rigid cuticle, the insect can only increase in size when it sheds its skin. Growth, therefore, occurs in another discontinuous fashion, in jerks, so to speak. During moult or ecdysis, the insect sheds its old skin, and a new one is subsequently reformed. While the cuticle is still soft, new tissues are formed leading to considerable growth in size. The form assumed by the immature insect in between moults is called an instar, and the intervening period, a stadium. Since insects pass through several larval instars during their development. Ecdysis and larval growth are subject to profound physiological and neuro-secretory control.

Insects are a very important group of animals because of their beneficial and adverse effects on the life of man. Insects have made a tremendous impact on the environment and on human activities and health medical economic and agricultural Entomology are important branches of science.

3.7.2 The Process of Moulting

The process by which an arthropod shed its old cuticle and secretes a new one is called moulting/ecdysis.

During the process of moulting, the hypodermis separate from the endocuticle and secret a new epicuticle, enzymes such as chitinases and proteases are secreted by the hypodermis and passed to the new epicuticle to accumulate as a moulting fluid in the sub-cuticular space below the old cuticle. The endocuticle of the old cuticle is gradually digested or eroded most of the product of this digestion are absorbed by the epidermal cells and used to synthesis the new cuticle below the old one.

Waxes and other lipid in the epicuticle of the new exoskeleton prevent the new cuticle from being digested by enzymes in the moulting fluid. The digestion of the old cuticle and secretion of the new cuticle occur simultaneously, eventually the old cuticle ruptures along lines where the endocuticle is very thin and the animal comes out of the old encasement.

The new cuticle is soft and pliable for some time and it is stretch to accommodate the increased size of the animal, the stretching is facilitated by the uptake of water or air by the animal.

Some arthropods such as crab continue to moult throughout their life.

3.7.3 Metamorphosis

This is one of the most characteristic features of insects, one striking facts of metamorphosis is that insect are always hatching in a condition morphologically different from that assured by the adult.

In order to reach the latter inster i.e. the adult stage they consequently have to pass through changes of form called Metamorphosis.

Four (4) clear cut stages with varying structures and habit have been identified in insects, this are the egg, larva, pupa and adult.

1 The egg stage ensures embryonic development.
2 The larva stage ensures growth

Nymph and larva are both immature stages of insects but a nymph is a young insects different from the adult in that the wings and genitals are incompletely developed, also the growth from nymph to adult is simple and unaccompanied by a pupa stage.

A larva differs from the adult in the mouthpart. No compound eyes and growth is accompanied by a pupa stage.

3 The pupal stage is the resting stage for reorganisation.
4 The adult stage is basically for reproduction

Insects has been classify generally into 3 groups due to the metamorphosis.

i. **Ametabola** (They don't undergo metamorphosis
ii. Paurometabola/hemimelabola
iii. Holometabola

3.7.4 Insect Larva

Types of Insect Larva

1 Protopod larva

This is found in the order hymenoptera and they are parasitic. The larva is devoid of segmentation in the abdomen. This is a primitive type of larva, encountered among parasitic Hymenoptera. A protopod larva has only rudimentary head and thoracic appendages. Its abdomen lacks segmentation. It is perhaps best regarded as a prematurely hatched embryo.

2 Polypod larva

This are found in the order lepidoptera and they are also called eruciform larva.

- They have well defined segmentation.
- There is presence of abdominal limb or proleg.
- Thoracic leg is present, but not well developed. Oligopod larva

This type of larva has well developed thoracic appendage, but no abdominal ones. The head and mouthparts are well developed.

3 Oligopod Larva

- This is characterised by well developed thoracic leg.
- Absence of abdominal appendages except a pair of cerci.

There are 2 types of oligopod

i. **Compodeiform**: They are active predators with a well developed sense organ. They are mainly found in the exopterygota order: which is elongate, with depressed, highly sclerotised body; bears well developed mouthparts, cephalic and thoracic appendages as well as acute sense organs. No abdominal legs are present, except for conspicuous, many-jointed caudal filaments. The larva is typically active and predatory. Some ground beetles as well as a few stored gain beetles have compodeiform larvae.

ii. **Scarabeiform**: This is a curved, stout, cylindrical, C-shapped, fleshy individual, typically with short thoracic legs. Scarabaeiform larvae occur widely among wood-eating bettles. They are stout, fleshy and sub cylindrical C-Shape larva with shorter thoracic legs. They live a less active life. They are found in the coleopteran family.

Apodous Larva

The trunk appendages are complete compressed and it is derived from the olygopod type. They can be divided into 3 types depending on the degree of development of the head. These are legless grubs or maggots, both thoracic and abdominal appendages being absent. They also lack eyes and other sensory equipment. Apodous larvae occur typically among the Diptera (housefly maggots belong here), as well as during the development of several species of stored products beetles, particularly Curculidae and Bruchidae.

(i) Eucephalous (True head)

- They have well developed head
- They are found in the nematocera dipterans.

(ii) Hemicephalous Larva
There is appreciable reduction of the head capsules and the appendages, for example the branchycera.
(iii) Acephalous larva

They have no obvious head capsule or appendages e.g. cyclorrapha i.e. maggot. **Polypod larva**

This is typical of the Lepidoptera (butterflies and moths). They are characterised by the possession of abdominal legs (prologs) in addition to thoracic ones. The body is well- segmented, often hairy larvae of Lepidoptera which occur in stored products, e.g., Plodia interpunctella. Ephestia cautella, Cocyra cephalonica and Pyralis farnails, are readily distinguished from those of beetle by their possession of prologs.

3.7.5 Pupa

We have already mentioned the fact that the distinctive feature of holometabolous metamorphosis is the intervention of a pupa phase between the larva and the adult. The pupa stage is transitional stage during which the larva body and the external organs are remodeled to the extents necessary for then to adapt to the requirement of their future adult stage.

In typical cases, the pupa never moves actively nor feeds. The pupae of several Lepidoptera live in silken cocoons spun by their last instar larvae. In other cases, notably among some stored products beetles, special larval exudates are used to construct cocoons. In exception of

the actively mobile pupae of the mosquitoes, we may recognise three distinct types of pupa.

These are typical of the Coleoptera and Hymenoptera. The antennae, limbs and wingbuds are externally, and are free from any secondary attachment to the body.

The first type of pupa is the

i. Decticous pupa

They have relatively, powerful scleroteid articulated mandible used to

escape from the cocoon. . The antennae, wing buds and limbs are immovably due to the body. They are found in the order neuropteran, trichoptera, Lepidoptera etc.

ii. Adecticous Pupa

They have an articulated and reduced mandible which is not used in escaping from the cocoon. They are found in the diptera, hymenoptera, coleoptera families.

Prepupa

Among many endopterygote insect, the last instar larva goes into a quiescent form before moulting into the pupa. This stage is often structurally and behaviourably distinct from the preceding larval instars as well as from the pupa. However, since it retains the last instar larval skin, many authorities simply regard the prepupa as a larva, if only a special one. Its duration is usually very short in those cases where it has been observed.

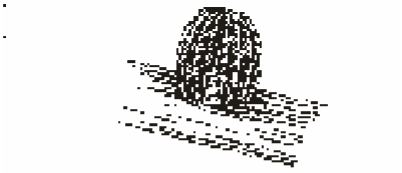
3.7.6 Insect Development

Insect eggs; shape, size and colour: Typically, they tend to be laid, darkening or changing colour to other in time. They may be laid singly or in batches. An insect may lay several hundreds of eggs in her life time. May last a few days or several months. Development of the egg takes place after fertilisation,in the formation of an embryo. However, in cases of parthenogenesis, unfertilised eggs laid by virgin females, may undergo subsequence development. The period of egg development prior to hatching is the incubation period various considerably with species of insect and prevailing enrolment conditions.

3.7.7 Development and Metamorphosis

In the general, the individual that hatches outrun the insect's egg different in form and habit from the adult. To attain the adult condition, it passes through a series of changes generally referred to as metamorphosis. All insects are divided into three categories depending on whether or not they undergo metamorphosis, if they do, whether the metamorphosis is complete or incomplete.

Lava Egg



Pupa

Adult

Complete Metamorphosis

Ametabola (apterygota)

Insects that do not undergo profound metamorphosis are said to belong to the sub-class Ametabola. This group includes such primitive insects as the Thysanura (sliver fish) and Collembola (springtails) as well as certain other wingless (apterygote) insects such as the Protura and Diplura. In this group, the insect that hatches from the egg is a kind of miniature adult, externally resembling the proper adult in every respect except for its smaller size. The individual attains the adult form merely by a process of increase in size.

Hemimetabola (exopterygota)

These undergo incomplete metamorphosis. Here the individual that hatches from the egg is usually called a nymph, although the modern tendency is to call it a larva. It is smaller than the adult, possesses compound eyes and has evident wing buds. Its mouth parts and feeding habits closely resemble those of the adult, but its genitalia during which wings developed it attains the adult form by gradual growth during which wings develop fully and external genitalia appear. A pupal stage does not occur in the Hemimetabola. Many familiar insects such as cockroaches, grasshoppers, biting and sucking lice, termites and bugs fall into this group. The wings of the adult members of this group develop externally, and so they are also called Exopterygota.

Holometabola (Endopterygota)

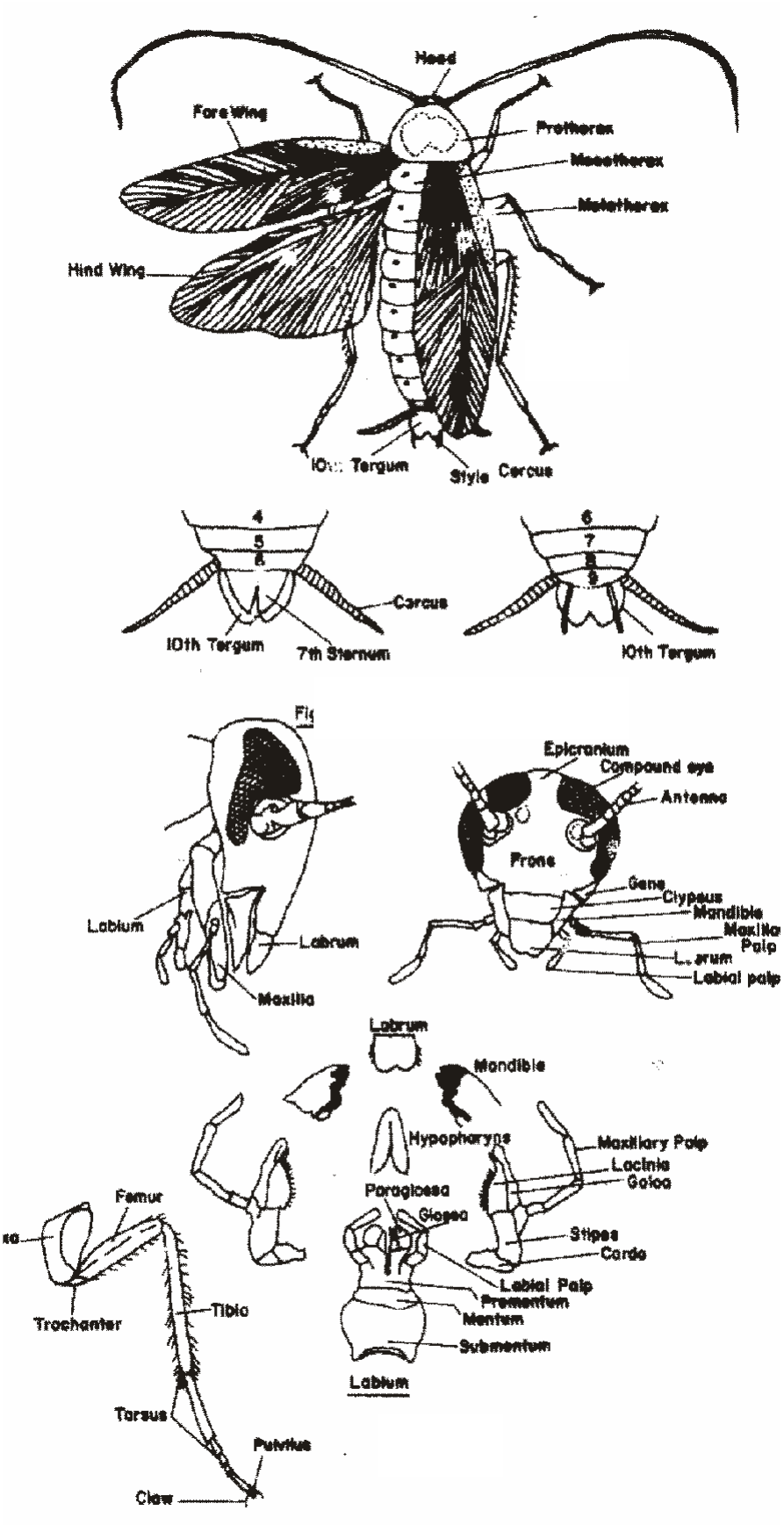
All other insects fall into the category called Holometabola (or Endopterygota, since their wings originate internally). Among the holometabolous insects, the individual that emerges from the egg is entirely different from the adult in form and habit and is called a larva. Typically, the larva bears a pair of short antennae, simple eyes and chewing mouth. In most cases, the larva develop to the adult stage by passing through a pupa stage, during which the insect remains quiescent and the body undergoes considerable internal structural and physiological reorganisation.

3.8 Biology of the Cockroach (Periplaneta): A Representative Insect

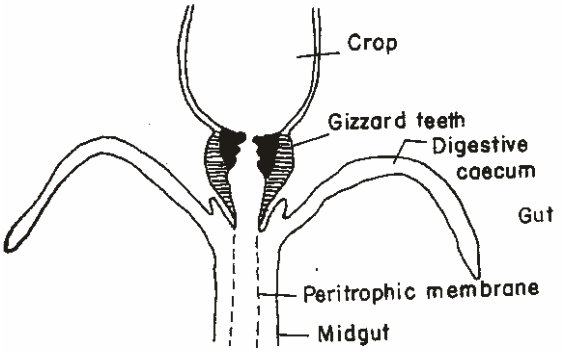
External Features

The small triangular head is at right angles to the rest of the body (Hypognathous. The six segments that form the head are not distinct in the adult. The antenna is filiform (whip-like); the mouth parts are of the primitive biting type and consist of the labrum, mandibles, maxilla and the labium which represents the fused second maxillae.

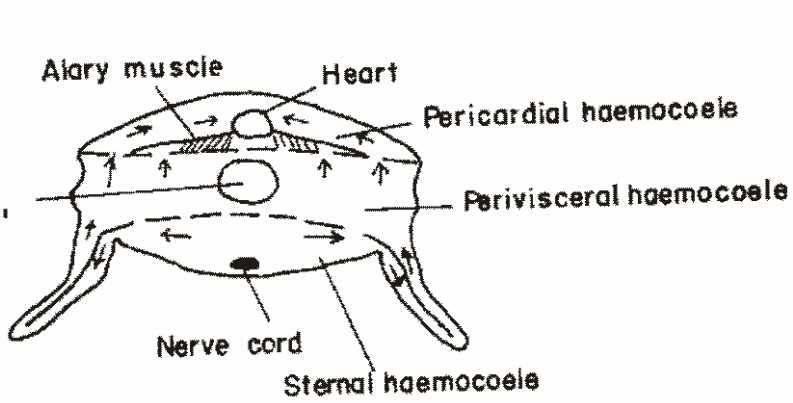
The large shield shaped prothorax bears no wings. The mesothorax bears the elytra while the metathorax bears membranous wings used for flight. Nine of the eleven abdominal segments are visible externally. The ninth abdominal segment bears the cerci in the two sexes; they bear a pair of style in addition. See diagram below:


Head
Fore Wing
Prothorax
Mesothorax
Metathorax
Hind Wing
10th Tergum
Style
Cercus
4
5
6
Cercus
10th Tergum
7th Sternum
6
7
8
9
10th Tergum
Epicranium
Compound eye
Antenna
Frons
Gena
Clypeus
Mandible
Maxilla
Palp
Labrum
Labial palp
Labium
Maxilla
Labrum
Mandible
Hypopharynx
Maxillary Palp
Lacinia
Galea
Paraglossa
Glossa
Stipes
Cardo
Labial Palp
Prementum
Mentum
Submentum
Labium
Femur
Trochanter
Tibia
Tarsus
Pulvillus
Claw

The Alimentary Canal: Two salivary glands empty into the buccal cavity. The oesophagus, crop and gizzard form the fore-gut which is lined by ectodermal cuticle. The conical and muscular gizzard bears rows of teeth internally, the midgut bears eight mesenteric caeca which serve for enzyme secretion and food absorption. The midgut which is lined by endoderm produces a permeable peritrophic membrane, which encloses the food in the midgut and prevents abrasion of the gut by hard food particles .The hindgut consist of the colon and rectum and is lined by cuticle. The main function of the hindgut is water absorption.



Alimentary Canal The Blood System



The Diagram Showing Blood Flow

The dorsal tubular heart consists of about thirteen chambers. It lies in a pericardial haemocoel .The heart is closed at the posterior end but there is a single artery anteriorily. Twelve pairs of alary muscles attach the heart to the floor of the pericardial cavity. The alary muscles bring about expansion of the heart chambers, resulting in the sucking in of blood into heart from pericardial cavity through the ostia. Valves in the ostia prevent backflow. The blood is colourless and has no respiratory pigment. It contains leucocytes.

Respiration

The tracheae are a system of ectodermic tubes. They open via two parts of thoracic and eight pairs of abdominal spiracles. The spiracles have valves which reduce water loss through them. The tracheae have spiral cuticular lining.

The tracheae end in tracheoles which carry oxygen into the cells. The tracheoles are intracellular and lack cuticular lining. When the insect is passive, the tracheoles are fluid filled but when they are active, the fluid is withdrawn so that the oxygen passes directly to the cells.

When an insect is at rest, there is no active respiratory movement; oxygen goes in by simple diffusion. Active insects carry out respiratory movement which involves dorsoventral movement of the abdomen. Insects have very high rate of metabolism and this can be attributed to their efficient respiratory mechanism. The fact that oxygen intake is by diffusion limits the size of insects.

Excretion: The main excretory organs are the numerous fillform, yellowish, malphighian tubules located at the end of the midgut.

The Nervous System

The subesphageal ganglia area formed by the fusion of three pairs of ganglia which innervate the mandibles, maxillae and labium. The double, ventral nerve cord has three ganglia in the thorax and six in the abdomen.

The compound eyes are complex structures made up of numerous ommatidia. Each ommatidium consists of a lens below which are two crystalline cones contained in virtrellae. The rhabdom which lies below the vitrellae is surrounded by retinular cells. Both the vitrellae and retinullae are covered by pigment cells.

Reproductive System

The gonads lie embedded in fat at the hind end of the abdomen. In males, a vas deferens conveys sperms from each of the two testes to the mushroom gland. The ejaculatory duct from the mushroom gland of seminal vesicle opens on the ninth sternite, ventral to the anus. In the females, each of the two ovaries consists of eight tapering ovaries. The two oviducts join to form the vagina which opens on the seventh sternite. Other parts of the female system include the spemotheca and collecterial glands which secrete the ootheca.

The eggs are laid in ootheca containing sixteen eggs. Cockroaches have incomplete metamorphosis. The nymph undergoes moulting, develops

wings and becomes the adult

4.0 CONCLUSION

You have leant about the systems of life processes in insects and their roles in the successful living of insects on land.

5.0 SUMMARY

This unit discussed the details of these systems separately, with particular reference to the biology of cockroach, and their systems. You should not lose the perspective that they operate interactively and concurrently.

6.0 TUTOR-MARKED ASSIGNMENT

i. List three types of feeding in insect.
ii. Discuss what happens at each phase of alimentary canal in insects.
iii. Explain the functioning of the excretory system in insects.
iv. Describe the functioning of tracheal system in gaseous exchange of insects.
v. Outline the blood composition in insects.

7.0 REFERENCE/FURTHER READING

Larry, P. P. (2004). *Entomology and Pest Management*

UNIT 3 SOCIAL INSECTS

CONTENTS

1.0 INTRODUCTION

Social insects include termites and white ants because of their colour and social habit. They differs in size, wings and in their habitats. Social insects live in groups in communal nests and they are organised that, there is division of labour among them. The termite society is based on castes within embers of each caste differing from those of other casts include primary reproductive (Kings and queen), supplementary reproductive, workers and soldiers.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain what social insects are
- distinguish between termites and ants
- name and draw the various castes in termite community
- describe the behavioural adaptations of termites
- explain the behavioural adaptation of honey bees.

3.0 MAIN CONTENT

3.1 The Termites

Termites are the most dreaded insects' pests of human dwellings and other structures because of their ability to destroy wood and wood products.

Termites are often called “white ants”, because of their colour and social habit. Their bodies differ from those of ants by having an abdomen broadly joined to the thorax and a narrow waist.

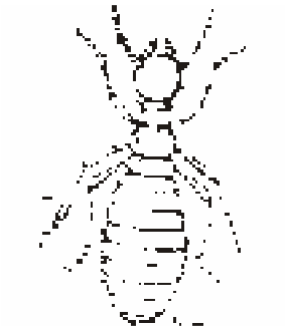
3.2 Castes in Social Insects

The termite society is based on castes with members of each caste differing from those of other castes in body structure and behaviours. In most common species, these castes include primary reproductive’s (Kings and queens), supplementary reproductive’s, workers and soldiers. New termites are formed in the spring or fall by winged primary reproductive that swarm from the parent colony. After a short flight, the wings break off and males and females form pairs. Each pair excavates a cell soil or wood and they mate. The original king and queen remain mated for life.

3.2.1 King and Queen

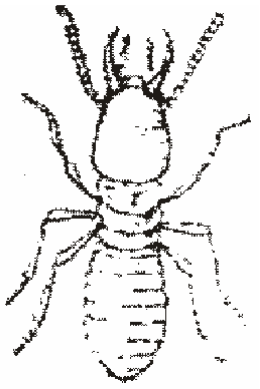
They are the only members with functional reproductive organ and are referred to as reproductive (are initially winged)

King ***Queen***



3.2.2 Workers

Workers are immature, undifferentiated individual that are wingless and lack compound eyes, with pale and soft exoskeleton. They do the work of the colony: gathering foods, feeding reproductive, soldiers and the young, constructing nests, associated tunnels and galleries and completing other tasks like tend fungal gardens, collected laid eggs and equally look after the nymphs.



3.2.3 Soldiers

Worker

Soldiers have enlarged heads and/or mandibles; they may not have compound eyes, have thick exoskeleton, huge mandibles. When present in a colony, soldiers attack intruders or protect the structural integrity of the nest. In some species soldiers are called nasuti. They defend the territorial integrity against intruders into the colony.

Soldier Feeding

Most termites are saprophagous, feeding on dead wood and other non-living plant materials. The cellulose of wood is a major termite food component. Cellulose is digested with aid of symbiotic microorganisms that supply the needed enzymes for this purpose. Because they can break down woody tissues, termites have extraordinary ecological importance in the humification of soil.

3.2.4 Behavioural Adaptations of Termites

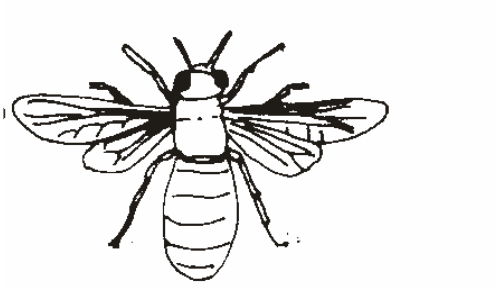
1 They ward off enemies easily as they move in mass
2 They feed on dead or living organic matters
3 They make burrows that are air-conditioned even in the harsh tropical savannah soil
4 New colonies are formed when the winged reproductive go on nuptial flight
5 As only few survive getting into a new colony, many eggs are laid

to avoid their going into extinction

6 The secondary reproductive always stand by in case the queen and king are killed

3.3 The Bees

The queen bee is concerned with laying of eggs. They fertilise the queen, the queen is known to be lazy. They sterile females are the workers that do the building of the hives. See diagram below.



3.3.1 Behavioural Adaptations of Bees

1 Workers feed on nectars from flowers
2 The senses of smell and sight are used in search of food
3 The worker bee dances around a food site, signaling other workers to come around.
4 Numerous eggs are always laid during summer when flowers bloom and there is enough nectar for the bees.
5 The activity in a beehive tends to stop during cold weather due to the fact that the queen and workers must have gone liberating.

IN TEXT QUESTION

Give a brief explanation on workers in the caste system of social insects

Answer

Workers are immature, undifferentiated individual that are wingless and lack compound eyes, with pale and soft exoskeleton. They do the work of the colony: gathering foods, feeding reproductive, soldiers and the young,

4.0 CONCLUSION

In this unit you learnt:

The features and caste composition of termites The functional roles of each caste member Feeding habits of termites
Composition of bees
Behavioural adaption of termites and bees

5.0 SUMMARY

Termites are the most dreaded insect pests of human dwellings and other structures due to their wood and wood products destruction. Termites resemble other individuals by living in a communal nests and undergoing a division of labour.

6.0 TUTOR-MARKED ASSIGNMENT

i. What are social insects?
ii. Differentiate between termites and ants.
iii. List each caste functional role in termite community.
iv. Mention 4 behavioural adaptations of termites and bees.

7.0 REFERENCES/FURTHER READING

Fabian, O. (1985). *Outline of Stored Product Entomology.*

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