NATIONAL OPEN UNIVERSITY OF NIGERIA

BIO 407

Basic Entomology

Module 1

BIO 407 Basic Entomology Module 1

Course Developer/Writer
Prof. F. Adebanjo, National Open University of Nigeria

Dr. Mrs. M.O. Oni, Adeyemi College of Education, Ondo

Course Editor
Dr. D.D. Moro, Lagos State University, Ojo, Lagos

Programme Leader
Prof. Monioluwa Olaniyi, National Open University of Nigeria

Credits of cover-photo: Henry Ude, National Open University of Nigeria

National Open University of Nigeria - 91, Cadastral Zone, Nnamdi Azikiwe Express Way, Jabi, Abuja, Nigeria

www.nou.edu.ng centralinfo@nou.edu.ng
oer.nou.edu.ng oerunit@noun.edu.ng OER repository

Published in 2021 by the National Open University of Nigeria

How to re-use and attribute this content

Under this license, any user of this textbook or the textbook contents herein must provide proper attribution as follows: "First produced by the National Open University of Nigeria" and include the NOUN Logo and the cover of the publication. The repository has a version of the course available in ODT-format for re-use.

If you use this course material as a bibliographic reference, then you should cite it as follows: "Course code: Course Title, Module Number, National Open University of Nigeria, [year of publication] at oer.nou.edu.ng

If you redistribute this textbook in a print format, in whole or part, then you must include the information in this section and give on every physical page the following attribution: Downloaded for free as an Open Educational Resource at oer.nou.edu.ng If you electronically redistribute part of this textbook, in whole or part, then you must retain in every digital file (including but not limited to EPUB, PDF, ODT and HTML) the following attribution:

Module 1

Unit 1 Insect Evolution

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.

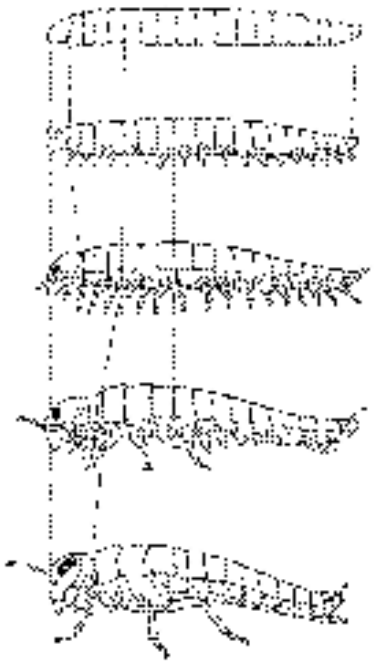


Fig. 1: How Insects Evolved

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 Self-Assessment Exercise

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.*

Unit 2 Classification and Distribution of Insects

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 walking sticks

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.

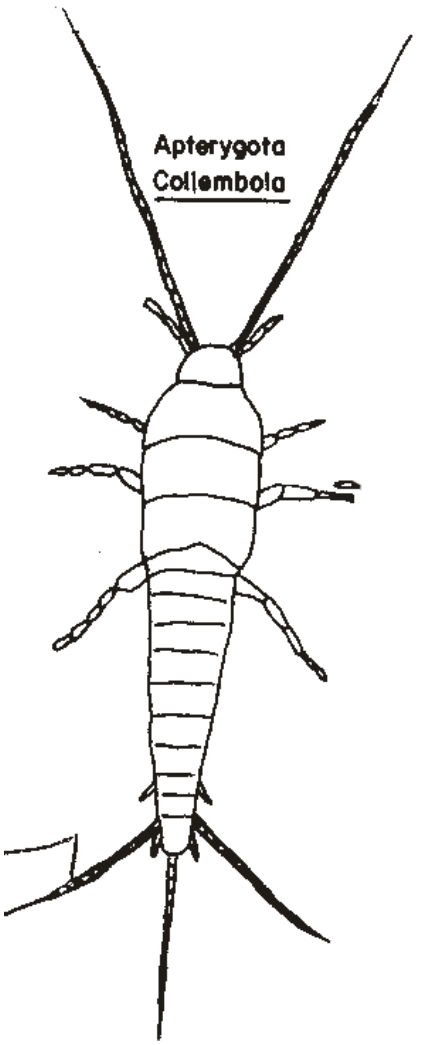


Fig. 2: Collembola

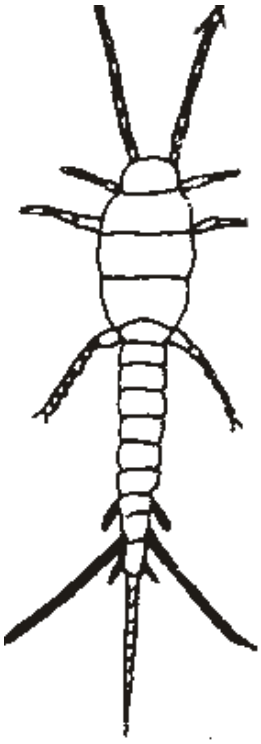
3.3.3 Order Diplura - Diplurans

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.

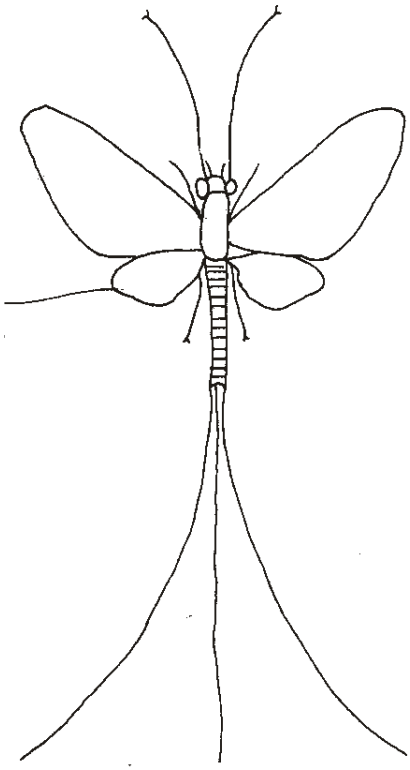


Fig. 4: A Mayfly

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

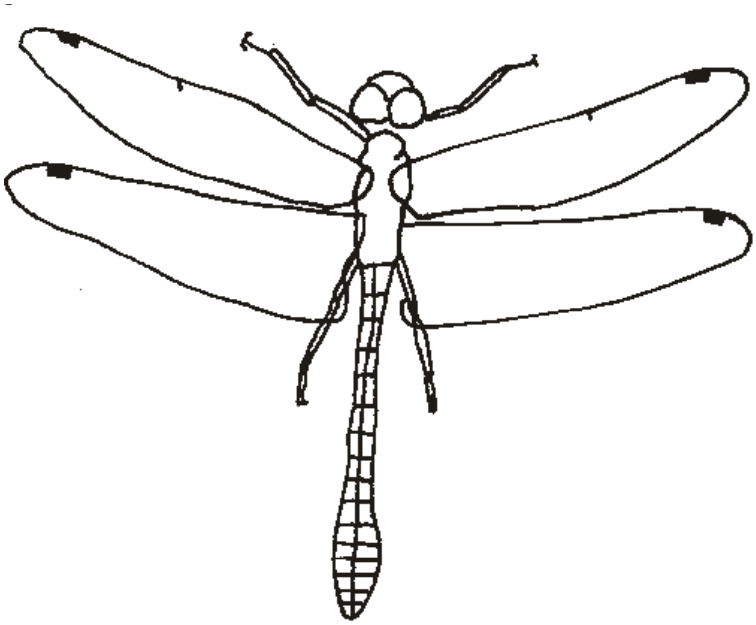


Fig. 5: Dragon fly

3.4.3 Order III – Dictyoptera

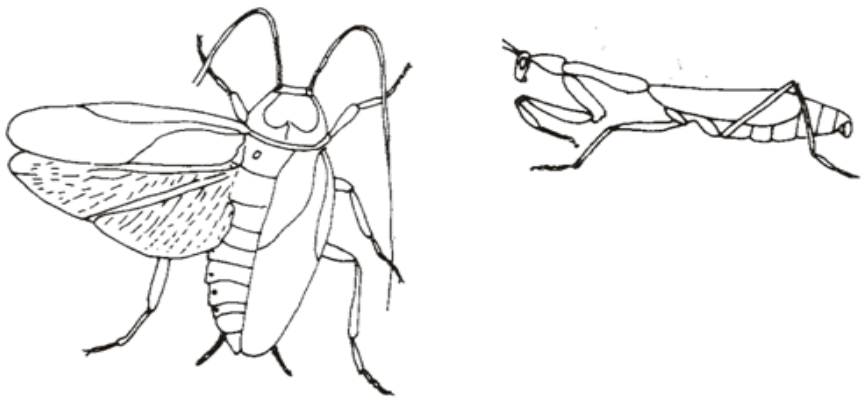
This order includes the cockroaches and praying mantis. They have general biting mouth part. The forewings are narrower and stouter membranous and fan-folding. The cerci are short and jointed. Styles are present in males and eggs are laid in Ootheca.

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**

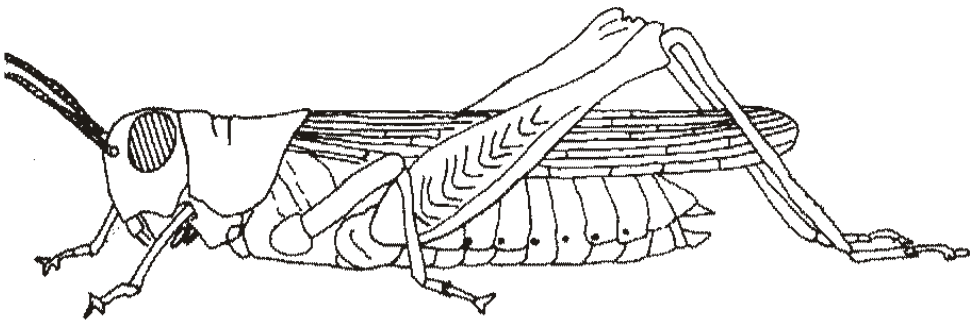
3.4.4 Order IV Orthoptera

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.

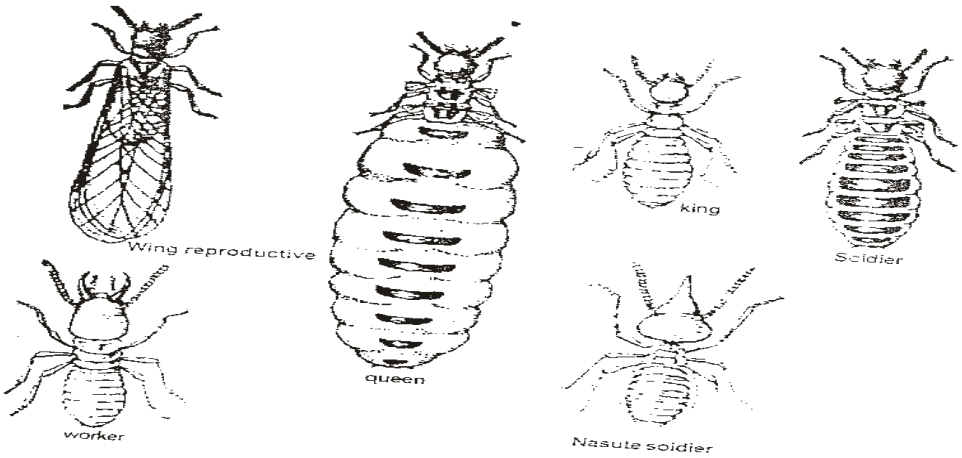
1 Reproductive forms

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

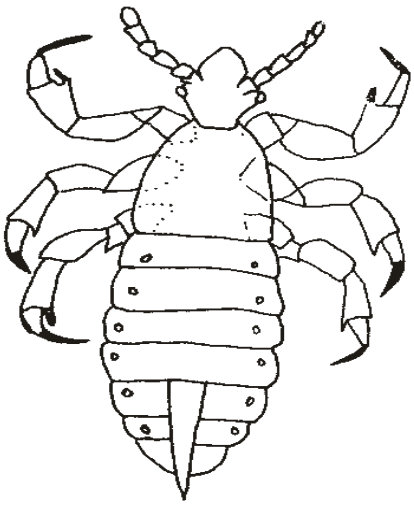
their mouth parts. The soldiers have highly sclerotised head with well developed mandibles. Some lower termites feed on wood, digested through the help of symbiotic protozoa e.g. Trichonympha in the gut while the higher termites feed on fungi, humus and soil organisms and maintain a garden of fungi to feed the young ones and the queen.



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.

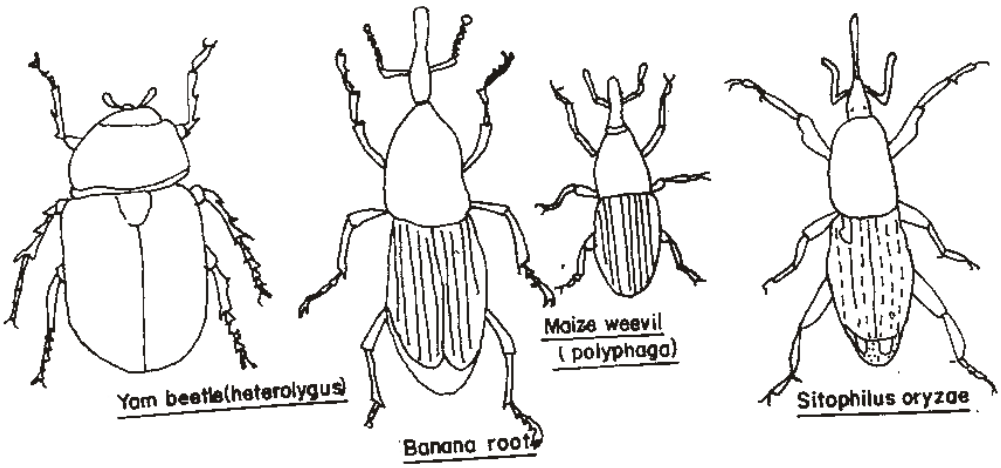


Sucking lice

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.



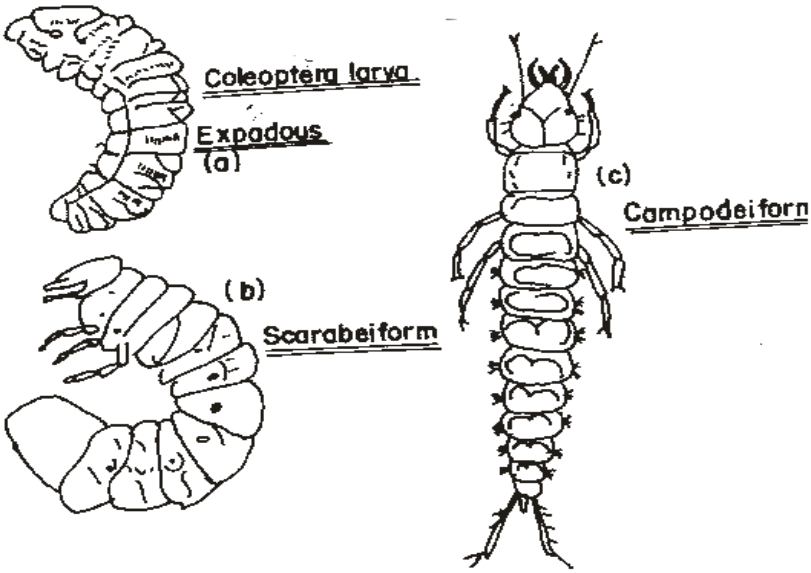
The Beetles

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.

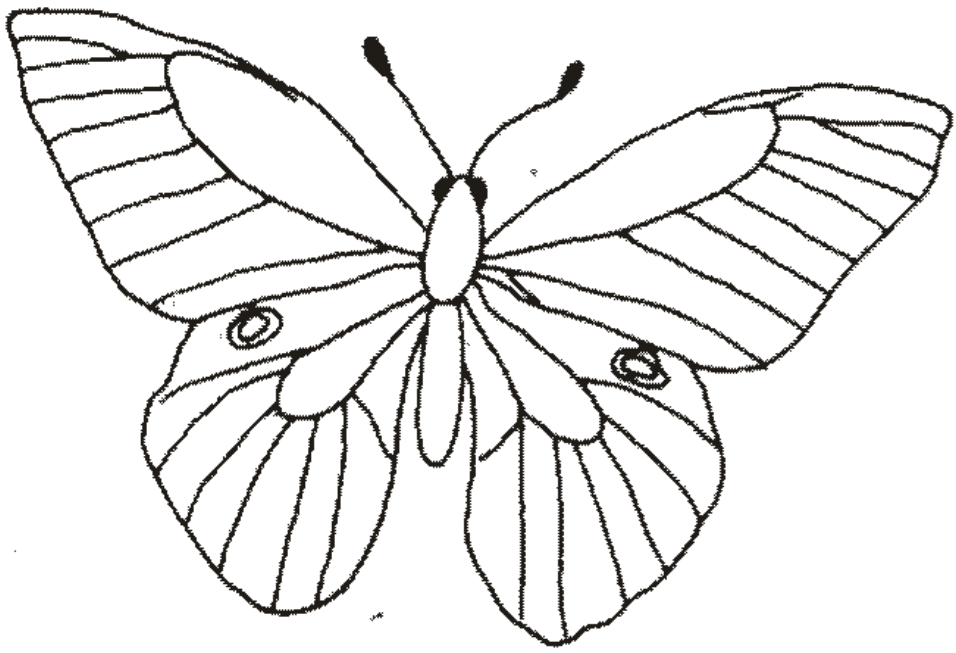
2 **Eruciform (Scarabeiform**): These are "C Shaped with large sclerotised head. Thoracic legs are well developed and abdomen is inflated, soft and whitish in colour.

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.

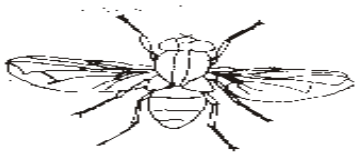
Three basic types of mouths exist in this order:

1 Housefly type – proboscis are modified for sucking only

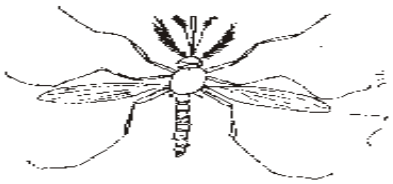
2 Female mosquito type-proboscis modified for sucking and piercing

3 Glossina type - mandible and maxillary stylets are lacking. The labium forms the main piercing organ.

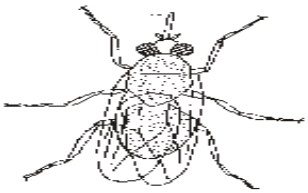
Members in this order undergo complete metamorphosis.



Housefly



Mosquito



Tsetse fly

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

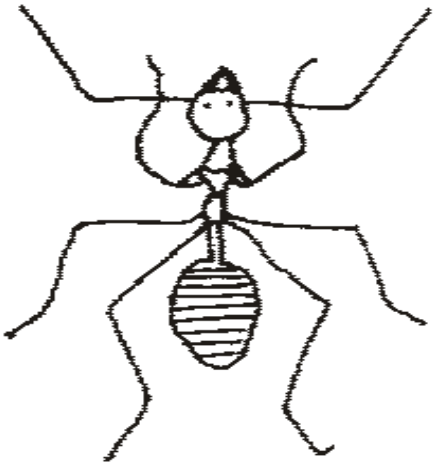
6 Drosophilidae

3.4.10 Order X – Hymenoptera

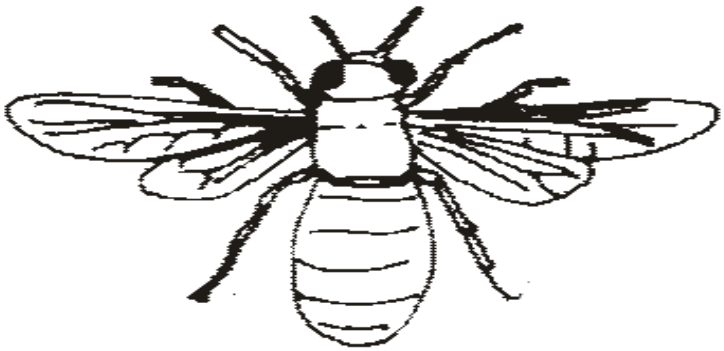
This order constitutes sawflies, bees, ants, wasps. Members are large and about 100,000 species. They exhibit interesting social habit, instinctive behaviour, polymorphism, parasitism and communication. Wings are membranous and have biting mouth type modified for licking and sucking. The larva may be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

Species of hymenoptera are economically important:

- Honey bees yield honey and wax
- Bees are important pollinators of flower
- Parasitic hymenoptera are helpful in the biological control of injurious insects
- Family Vespoidea – wasps are carnivorous, they paralyse caterpillars with their sting and store them in the nests for young ones to feed on.
- 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



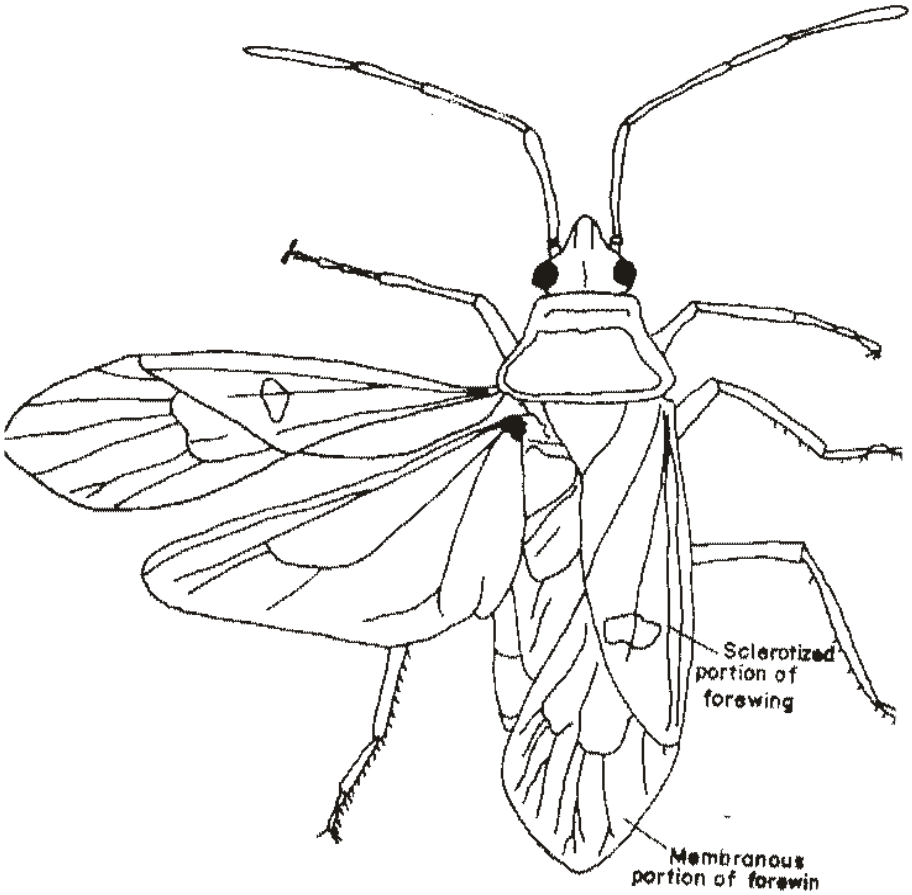
Bees

Wasps

3.4.11 Order XI Hemiptera

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

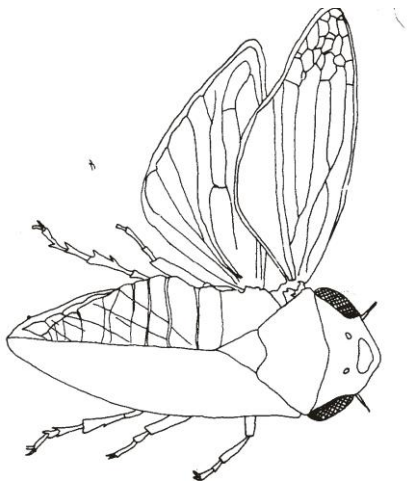
1 Heteroptera – (true bugs) see diagram below



2. Homoptera – Cicadas, Aphids, scale insects.

Cicadas

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



Economic importance of hemipterans

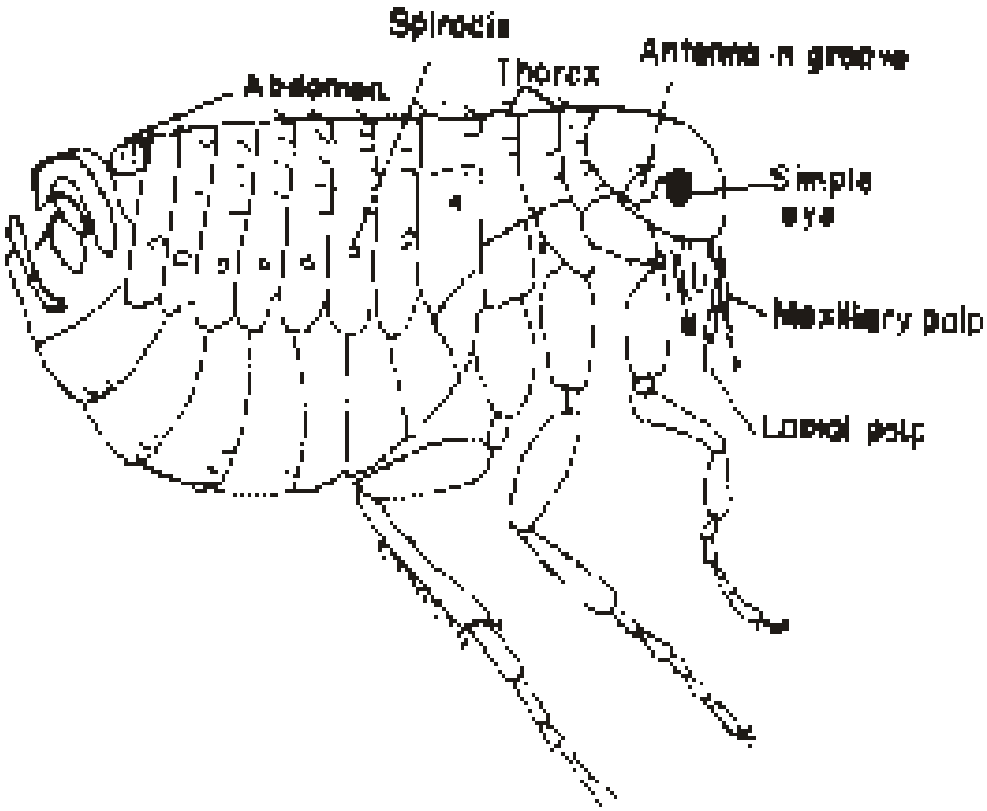
1. Cause direct and indirect injury to cultivated plants e.g. bugs transmits diseases to economic crops such as potato, tobacco, citrus, fruits, sugarcane, maize and cocoa.

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.

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 Self-Assessment Exercise

i. What is binomial nomenclature?

i. Outline the characteristics of order coleopteran

ii. Discuss the economic importance of flea.

7.0 Reference/Further Reading

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