CPT 302: INTRODUCTION TO CROP PROTECTION

Definition of Pest

Pests are organisms considered harmful or detrimental to humans, his possessions and other human interest. Noxious organisms considered as pests are plants or animals that carry disease, cause disease or destroy crops. They could be nematodes, insects, viruses, bacteria, molluscus, fungi, birds, rodents, herbs, shrubs, mites and annelids

ENTOMOLOGY

Entomology is the study of insects. Insects belongs to the Phylum: Arthropoda; Class: Insecta; Kingdom: Animalia. Insects could be further classified based on Family, Order, Genus and Species. The class "INSECTA" could be divided into winged and wingless insects called **Pterygota** and **Apterygota** respectively.
The class "INSECTA" possesses 29 Orders. Each order is divided into families.
The housefly could be classified as thus:
Phylum: Arthropoda
Kingdom: Animalia
Class: Insecta
Family: Muscidae
Order: Diptera
Genus: *Musca*
Specie: *domestica*

Common and Scientific names of some insects are:
Larger Grain Borer – *Prostephanus truncatus*
Lesser Grain Borer – *Rhizopertha dominica*
Been Weevil – *Callosobruchus maculatus*
Maize Stalk Borer – *Busseola fusca*
Elegant Grass Hopper – *Zonocerus variegatus*
Honey Bee – *Apis mellifera*

CHARACTERISTICS OF INSECT PEST

- Possession of one pair of antennae
- Possession of one pair of eyes
- Possession of three pairs of legs
- Possession of breathing tube or trachea
- Possession of one or two pairs of wings
- Possession of maxillae and mandible
- Body divided into head, thorax and abdomen
- Post-embryonic development is usually by metamorphosis

- Abdomen is devoid of ambulatory appendages
- Possession of chitinous exoskeleton
- Possession of segmented that bears paired limbs
- Possession of Mandible and Maxillae

CATEGORIES OF INSECT PESTS

Insects could be classified according to the degree of damage they cause, the frequency of their occurrence and their behavioral characteristics. Four categories recognized based on this are:

- **KEY PESTS (Major)**
- **OCCASIONAL PESTS:**
- **POTENTIAL PEST:**
- **MIGRANT PEST:**

INSECT PEST DEVELOPMENT

Situations that create pest problems could be broadly divided into Ecological and Economic/Cultural causes

1. **Ecological causes** – This could occur through the following:
   (a) Large Scale Agriculture – provides abundant supply o food
   (b) Planting of highly nutritious crop varieties
   (c) Planting of yield crops. These factors lead to
      - Higher fecundity of pest
      - Shorter life cycle
      - Faster development rate
      - Higher pest population

   (d) Pesticide application – This create problem such as:
      - Pollution of soil and environment
      - Pest resurgence
      - Pest resistance to pesticide
      - Development of new race
      - Deleterious effects on natural enemies

   (e) Fertilizer application -
      - Some predispose some crops to insect attack e.g. makes them more succulent
      - Roots grow bigger
      - Roots develop more vacuoles that encourage penetration by insects

   (f) Water irrigation – More relevant to water insects
   (g) Migration – Pest movement from one agro ecosystem to another
   (h) Introduction by man

2. **Economic and Cultural Changes**

These are associated with man's exploding population such

- Change in cropping system eg monocropping
- Change in value of crop can make a pest that is of insignificant important to be highly important. A higher price for a previously low priced crop makes damage to it more economical e.g. Cassava

DAMAGE ASSESSMENT AND FORECASTING

The extent of pest problems depends on:

(a) **Nature of the pest** - If highly voracious, damage will be high.

(b) **State of the host attacked -** If the host is vigorous, it may be able to resist the attack, but if already weak or susceptible it may not be able.

(c) **The resultant damage** - If a defoliator attacks a leafy vegetable, the damage will be felt more than when it attacks a fruit vegetable, because leafy vegetables are important for their leaves.

(d) Economic Value of the effects of damage

THE DAMAGING EFFECTS OF INSECTS

The damaging effects of insects on cultivated plants could be broadly divided into two categories viz-viz Direct and Indirect.

1. **Direct Effects of Insects** – This varies depending on the mouth part possessed by the insect.

(a) Biting and Chewing Insects

- Reduce the amount of leave tissues available for photosynthesis, thereby hindering the growth of plant.
- When they feed on stem, they tunnel the stem and interrupt sap low.
- They destroy apical point (growing point) of plant
- When they feed on root, they disrupt the absorption of nutrients from the soil
- When they attack flowers and fruits, they reduce seed production and seed germination

(b) Piercing and Sucking Insects

- Cause loss of plant vigour due to removal of excessive quantity of sap. In extreme cases, the plant dies (wilt off)
- They damage floral organs and reduce seed production
- Inject toxins into plant body and sometimes cause development of galls
- Their infestation provides entering point for pathogens, fungal and bacteria
- They may induce other abnormalities such as pre-mature leaf fall, leaf curl and deformations

2. **Indirect effects of insect feeding**
    - **Reduces quality of plant products**
    - **Vector of Diseases**
    - **Monetary Loss**.
    - **Cost of preventing potential damage**.
    - **Loss of Goodwill**

Pest Assessment

This could be done through two ways viz-viz direct and indirect

INSECT MORPHOLOGY

EXTERNAL ANATOMY: The three main sections of an insect body are the head; the middle section or thorax and the hind section or abdomen.

THE HEAD: The head bears the antennae, the moth part and the eyes. The compound eyes are located on either side of the head and composed of hexagonal facets called corneal lenses. Compound eyes are complex and diverse

(a) **ANTENNAE**: These are paired appendage that articulate with head capsule and are located on the anterior part near the compound eye.

(b) MOUTH PARTS: This varies with feeding habits. The mouth part of a chewing insect such as the grasshopper has upper lip called the **labrum;** and a lower lip called the **labium.** These two serve to hold the food; between these are two pairs of jaws that work sideway. The upper jaws or mandibles are for crushing; and the lower pair, the maxillae manipulate (breaks it into smaller particles) the food. On the maxillae and the labium are two pairs of sensory structures called **palpi.** On the floor of the mouth is the tongue like hypopharynx which secretes digestive juices. The sucking type of mouth is a modification of the chewing type. The butterfly's coiled proboscis or sucking tube is a modification of the maxillae.

THE THORAX: The head is attached to the thorax by means of a membranous region, the neck or cervix. The insect thorax is divided into three segments namely; Prothorax, Mesothorax and Metathorax. On the each of the segment is a pair of legs in winged insects. The thorax also bears one or two pairs of wings. Spiracles which are the external openings of the respiratory system are located on each side of the pleura.

LEGS: The generalized insect legs consist of six segments as follows: (i) a basal coax (ii) Trochanter (iii) Fermur (iv) Tibia (v) Tarsus (vi) Pretarsus, which usually bears a pair of moving claws. Insect legs although typically ambulatory in function have been modified extensively in several directions. So typically developed insect legs are:

Cursorial with legs adopted for walking and running.

Fussorial with forelegs highly modified bearing heavily sclerotised digging claws e.g. the male cricket.

Raptorial with forelegs modified for grabbing and holding preys e.g. praying mantis.

Salfatorial with enlarged hind legs that accommodate muscles used in jumping e.g.grasshopper.

Natational with leg modified for swimming e.g. legs of water beetle. The legs of many insects also bear various specialized features e.g. carbiculum or pollen basket on the hind tibia of the honey bee.

WING: - The wings are borne on either or both the mesothorax and metathorax segments. The wings arise as outgrowth of the integuments between the tergal and pleural sclerites. There are considerable variation in the wings of insects with respect to size and veination.

Functions: The most obvious function of the wings is for flying; however, wings have been modified for;

(i) **Protection:** - e.g. hard forewings of the beetles.

(ii) Production of sound e.g. the Homoptera

(iii) **Stability of flight:** - Trueflies with balancers

ABDOMEN: The abdomen typically has 11 segments; though no more than 10 are visible. It contains a large part of the digestive system. The terminal segment may bear a pair of appendage called **CERCI**.

ECONOMIC IMPORTANCE OF INSECT PESTS

This refers to the merits and demerits of insect pests.

DEMERITS

- **Reduces values or quality of food**
- **Reduce yield or quantity of output**.
- **Vector of Diseases**
- **Injuries to Man and Animals**
- **Effects of Recreation.**
- **Effects on Stored Products, Household and Structural Materials**

MERITS (BENEFICIAL INSECTS)

- **Agent of Pollination**
- **Subject of Scientific or Biological Studies**
- **Source of Drugs**
- **Predators and Parasites**.
- **Aeration of Soil**
- **Food for Man and Animals**.

- **Makers of useful bi-products**

(a) Honey and wax are bi-products from the honey bee *Apis mellifera*. Wax is used in making candle, cosmetics, polish, crayon and in leathering works. Honey is the earliest sweetener and is used in healing of wounds and curing of throat ailments among other uses.

(b) Silk spun by the larva of the silkworm moth is an ultra sheer fabric used primarily for wide array of garment materials

© **Shellac** produced by the Asiatic lac insects, *Laccifer lacca* is used for making varnish.

(d) Dyes – A southwestern scale insect – *Dactylopius coccus* is a source of the crimson dye, cochineal

- **Baits** – Insects such as Dobson fly are used in sport fishing as bait
- **Crop Production**
- **Agents of Decomposition and Nutrient Recycling**
- **Destruction of weeds**

COMMON INSECT PEST OF AGRICULTURAL CROPS

1. STEM BORERS:

(i) *Busseola fusca* (ii) *Sesamia calamistis* (Pink Maize Bore (iii) *Eldana saccharina* (Sugarcane borer) (iv) *Chilo partellus*

(b) Rice

(i)Yellow paddy stem borer – *Scirpophaga incertulas*
(ii) White paddy stem borer – *Scirpophaga innotata*
(iii) Striped rice stem borer – *Chilo suppressalis*
(iv) Purple Stalk Borer – *Sesamia inferens*
(v) Dark-headed rice stem borer – *Chilo polychrysus*

© **Zorghum**

(i) Coniesta ignefusalis

2. **GRASSHOPPERS**: These belong to the order Orthoptera. The elegant grasshopper – *Zonocerus variagatus* are brightly coloured with black, yellow, green and orange markings. They are widely distributed and have a wide host range e.g. cassava, Maize, weeds etc. Both the nymphs and adults feed on plant foliage causing defoliation and death of seedlings. They are particularly abundant during the dry season in the southern part of Nigeria. The eggs are massively laid in the soil at the end of the dry season and take several months to hatch. The nymphs develop into adults by the start of the raining season. There is usually one generation in a year called univoltine

3. **ARMY WORM:** These are the caterpillars of a number of different moths which belong to the order Lepidoptera and the Family Noctuidae e.g.

(ii) African Armyworm – *Spodoptera exempta*
(iii) Egyptian Cotton Leafworm – *Spodoptera littoralis*
(iv) Cotton Leaf Worm – *Spodoptera litura.*

They attack series of cereals, grasses and other crops. They are occasional pest and their population can be sporadic under certain climatic condition. Most of them are gregarious or swarming phases during when they engage on migratory flight as moth. They are well known for their sudden appearances. Eggs are laid in masses of about 200 -500 per egg mass on the underside of leaves and hatch in 3 - 4 days. Pupation takes place in the soil after about 20days and the moth emerge after another 6 – 7 days. In the tropics, as many as 8 generations a year are possible.

4. **LOCUST.** Locust exists in two distinct forms or phases. They are gregarious and solitary phase. Gregarious locusts are attracted to each other and form population of higher density. These populations are active juveniles and flying when adult. Solitary locusts are not attracted to each other and are relatively occur at lower density. Locusts are sporadic pest: and favourable climatic condition or intervention in the agro-eco system can cause occasional upsurge of the pest e.g. are

(i) African Migratory Locust - *Locusta migratoria migratoroides*
(ii) Red Locust – *Nomadacris septemberfasciata*
(iii) Desert Locust – *Schistocecer gregaria*

1. **SUCKING INSECTS.** They belong to the order Hemiptera. The insects have sucking and piercing mouth parts; and cause damage to crops by sucking saps from them. Their attacks on crops lead to wilting in severe cases; and this can be confused with symptoms of drought. Sucking insects encouraged secondary infection by introducing diseases organism into the host. e.g bacteria, Fungi; and in some cases, the secondary damage can be more than the primary damage resulting from feeding activities of the insects. Hemiptera has two sub –orders viz- viz

(i) Homoptera – smaller bugs belong to this sub-order e.g. Leafhoppers, Aphids, Mealybugs, Cicadas, Psyllids, Scales, Treehoppers

(ii) Heteroptera – These are bigger bugs eg *Clavigralla tomentosicollis*), major pest of cowpea); and *Lygus limeolaris*, the tarnished plant bugs

2. **INSECT VECTORS** – insects are the most important agents in the transmission of viruses; most insect vectors have sucking mouth parts. These are aphis, leafhoppers, whiteflies and mealybugs. Nonetheless, some insects

with biting mouth parts such as flea beetles and grasshopper also transmit viruses e.g. Grasshopper are known to transmit Tobacco Mosaic Virus mechanically. Other insect vectors of diseases are (i) White fly *Bemisia tabaci* – vector of African Cassava Mosaic Virus.

7. STORAGE INSECTS

Stored product insects belong to the order Coleoptera. They have complete metarmophosis ie eggs → larva → Pupa → adults. There are two major groups of storage insects

(i) Primary Insects: These are the ones that are able to attack whole and undamaged seeds or grains and usually initiate their attack on the field e.g. Rice weevil - *Sitophillus oryzae*, Bean weevil – *Callosobruchus maculatus*

(ii) Secondary insects – These are insects that feed on broken or damage grains and flour eg flour beetle – *Tribolium casteneum*

SOME IMPORTANT STORAGE INSECT PESTS

(a) ***Sitophillus oryzae* – Rice weevil**
(b) ***Sitophillus zeamais* (Motsch.) – Maize weevil**
(c) ***Lasioderma serricone* (F.) - Cigarette Tobacco Beetle**
(d) ***Tribolium casteneum* (Hbst.) - Red Flour Beetle**
(e) *Trogoderma granarium* (Everts). – Khapra Beetle.
(f) *Oryzaephilus surinamensis* (L) – Saw-toothed grain beetle.
(g) ***Ephestia cautella* (Walk) -Ware House Moth**
(h) ***Sitotroga cereallela* (Oliv.) - Angoumois Grain Moth**.
(i) ***Dermestes lardarius* (**L)
(j) ***Rhizopertha dominica* (F) - Lesser Grain Borer**
(k) ***Prostephanus truncatus* (Horn) - Larger Grain Borer (LGB)**
(l) ***Cryptolestes ferrugineus* (Steph) - Rust-red Flour Beetles.**
(m) ***Callosobruchus maculatus* (F.) - Bean weevil**.

OTHER PESTS OF ECONOMIC IMPORTANCE

A. Birds: Birds and mammals are warm blooded thus; their activities are not limited by low or high weather to the same extent as insects and other invertebrates. Hence, they are highly destructive all the time of the year. They are among the most mobile creature that existed; their powerful flight is must superior to insect flight and more purposeful.

ECONOMIC EFFECT OF BIRDS

(i) Digging and consumption of planted seed
(ii) Pulling and uprooting of seed.
(iii) Pecking of flower causing fall off.
(iv) Sucking of milk from developing fruits.

(v) Consumption and shattering of seed. e.t.c

EAGLE BIRD

Eagle bird is one the living creature that has long life span. This is due to some behaviour of the bird that aids its survival. They do not pose problem to agricultural production because they don't feed on plant. They however prey on insects when hibernating to renew their youth.

SURVIVAL ATTRIBUTES OF EAGLE BIRD.

1. AN EAGLE CAN RENEW ITS YOUTH.
2. AN EAGLE HAS A VERY LONG LIFE SPAN
3. AN EAGLE HAS AN UNSUAL STRENGHT
4. WHEN PURSUED, AN EAGLE HEAD FOR THE SUN
5. WHEN AN EAGLE IS HUNGRY, IT DOES NOT CRY
6. THE EAGLE CAN ASCEND UP TO A HEIGHT OF THIRTY THOUSAND FEET (30,000FT) ABOVE SEA LEVEL.
7. THE EAGLE LEAVES A FLYING LEGACY TO HER YOUNG ONES
8. THE EAGLE SELECTS THE HIGHEST MOUNTAIN TO LIVE ON AND LOOKS FOR THE TALLEST TREE AND THE TALLEST BRANCH TO BUILD HER NEST.
9. THE EAGLE ALWAYS FLIES ABOVE THE CLOUD, THE RAIN AND THE STORM
10. AN EAGLE CAN TRAVEL (FLY) AT SPEEDS OF UP TO 136 MILES (220KM/HR)
11. GREAT EAGLES FLY WITH OTHER EAGLES OR ALONE
12. THE EAGLE'S FEED MAINLY ON FRESH AND BLOODY ANIMALS
13. THE EAGLES STICK TO ONLY ONE PARTNER TILL DEATH.
14 AN EAGLE HAS THREE LEVEL OF LOCOMOTION.

B. RODENTS: These include bush rat or grass cutters, rabbit's, mice etc. They can be very serious pest of stored produce.

C. MOLLUSCUS. These are large group of animal characterized by soft and non-segmented bodies. They may be aquatic o terrestrial and may or may not possess shells. They include snails, octopus, slugs, squids, scallops.

D. **WEEDS**: Weeds also constitute pest that reduces crop yield. They could be free-living or parasitic.

E. **MITES:** These are arthropods belonging to the order ACARINA of the class ARACHNIDA. They have 3 pairs of legs when fully grown. The flour mite, *Acarus siro* is commonly involved in infestation of cereal products

F. **NEMATODES:** Nematodes are tubular, non-segmented transparent colourless micro-organism that belongs to the phylum NEMATODA. They are often called Round worm or Ealworm

CROP PROTECTION METHODS

1. **Cultural Method** – This is concerned with manipulation of the environment in such a manner that it would be unfavourable for the pest thereby adversely preventing the damage or at least limiting its severity. Cultural control practices includes: Selection of good site, use of clean planting materials, tillage, deep sowing, manipulation of planting and harvesting time, crop sanitation, crop rotation, intercropping, close season , planting of trap crop, mulching, irrigation, manipulation of crop spacing
2. **Host Plant Resistance** – This is the relative amount of heritable quality possessed by the plant which influences the ultimate damage done by the pest. Host resistance to pest could be exhibited as Antixenosis (Anti-guest), Antibiosis and Tolerance.
3. **Biological Control** – This is the use of living organisms as pest control agents. Biological control have the following advantages
   - **(i)** Save and no danger is involved during application
   - **(ii)** It provides lasting control once the natural enemies have been established
   - **(iii)** It is economical in the long run
   - **(iv)** The pest is not likely to develop resistance
4. **Chemical control –** This involves the use of natural or synthetic chemicals that cause the death, repulsion or attraction of pest. Such chemicals are called pesticides. Pesticides are classified according to the type of pest they control. Insecticides are used to control insects, herbicides to control weeds, fungicide to control fungi, nematicides to control nematodes, rodenticides to control rodents, ascaricides for mites and avicides for birds.
5. **Regulatory or Legal Control**

This concerns Government regulations to prevent the spread of pest from one country or region to another. Legal control could be

- **(i)** Absolute prohibit (ii) Quarantine (iii) Post-entry quarantine services (iv) Restricted materials (v) Closed season

6. **Integrated Pest Management (IPM)**

   This is a method of controlling pest in an economically efficient and ecologically sound manner. It utilizes all suitable techniques either to reduce pest population and maintain them at level below those causing economic injury or to manipulate the population so that they are prevented from

causing injury. IPM strives to prevent the needless destruction of the environment and human health

Introduction to Plant Pathology

Plant Pathology is a science that studies plant diseases and attempts to improve the chances for survival of plants when they are faced with unfavourable environmental conditions and parasitic microorganisms that cause disease. Disease involves a change from normal or healthy state to physiological disturbance of normal functions of plants caused by pathogens. Plant pathogenic organism can be broadly classified into nematodes, bacteria, fungi and viruses.

Importance of Plant Diseases

(a). Plant Diseases reduce the quantity and quality of plant disease
(b). It may limit the kinds of plants and industries in an area
(c). Plant diseases may make plants poisonous to humans and animals
(d). It can also cause financial losses

Fungi as Plant Pathogens

Fungi are small, generally microscopic, eukaryotic, usually filamentous, branched, spore-bearing organisms that lack chlorophyll. They have cell walls that contain chitin and glucans (but no cellulose) as the skeletal components.

Classification of Plant Pathogenic Fungi

Phylum Oomycota
Class Zygomycetes
Order Mucorales (Rhizopus, Mucor etc)
Phylum Ascomycota
Class Saccharomycetes (Yeast)
Order Erysiphales (Blumeria, Erysiphe etc.)
Order Hypocreales
Genus Gibberella, Claviceps, Trichoderma
Phylum Deuteromycota
Penicillium
Aspergillus
Cercospora
Phylum Basidiomycota
Order Ustilaginales (the smut fungi)
Order Uredinales (the rust fungi)
Order Agaricales (the mushroom)
Genus Armillaria

Some Symptoms of Plant Diseases

Bacteria as Plant Pathogens

Bacteria are prokaryotic organisms, which means that they do not contain membrane-bound organelles such as nuclei or mitochondria. Most bacteria have cell walls. The cell wall determines the shape of the bacterium, which can be round (cocal), spiral-shaped, or rod-shaped (bacilliform). Some bacteria also produce long, branched filaments. Many bacteria secrete extracellular polysaccharides (EPS) high molecular weight carbohydrates that become attached to the exterior surface of the cells as a slime layer (capsule) and serve to promote the disease process. Bacteria also often have flagella, external structures that rotate to propel the cells short distances through liquids. The location of flagella, either at the ends of the bacterial sells (polar) or all over the cell surface (peritrichous), is a useful taxonomic characteristics. Bacteria reproduce by a process called fission, in which a single cell divides into two identical cells following the replication of the chromosomal DNA.

Classification

Bacteria can be divided into major genera based on the structure of the bacterial cell wall, using the gram stain. One group of bacteria, with thick cell walls, traps a dye and becomes purple (called Gram-positive). The other group has thin cell walls that do not retain the purple dye (called Gram-negative). A different stain must be used to make the Gram-negative bacteria visible, commonly basic fuchsin or safranin, which stains them pink.

Common Plant Pathogenic Bacterial

Gram-negative

Agrobacterium

- Aerobes, peritrichous flagella, abundant EPS
- Example: *Agrobacterium tumefaciens*

Erwinia and closely related newer genera:

Brenneria, Pantoea, Pectobacterium

- Facultative anaerobes, peritrichous flagella; pectolytic enzymes (some species)
- Examples: *Erwinia amylovora* (no pectolytic enzymes), *Pectobacterium carotovorum* (pectolytic enzymes).

Pseudomonas

- Aerobes, one polar flagella; some fluoresce under ultraviolet light and chelate (remove) iron from their environment

- Example: *Pseudomonas syringae* (many pathovars)

Xanthomonas

- Aerobes, one polar flagellum, yellow colonies; source of "xanthan gums"

- Examples: *Xanthomonas axonopodis* pv. *citri, X. axonopodis* pv. *vesicatoria*

Gram-positive

Clavibacter

- Aerobes, irregularly shaped rods, nonmotile

- Examples:*Clavibacter michiganesis* subsp. *michiganesis, C. michiganesis* subsp. *sepedonicus*

Streptomyces

- Aerobes, branched filaments, sporeforming (actinomycete)

- Example: *Streptomyces scabies*

Books
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NEMATODE PESTS OF AGRICULTURAL PLANTS

WHAT ARE NEMATODES?

Nematodes are unsegmented roundworms. The word nematode means "threadlike" derived from Nemat = thread and ode = like.

CHARACTERISTICS OF NEMATODE

They are microscopic aquatic, triploblastic, unsegmented, bilaterally, symmetrical, roundworms, transparent, colourless, usually bisexual, worm-shaped (vermiform) with some (particularly adult female) becoming swollen (pyroform), lack external appendages. They look like white thread. Nematodes are members of the Kingdom Animalia and phylum Nematoda. They are the most abundant animal life form. They inhabit ecological riches that are most varied than those of other groups of animals. They are found in the air, on top of mountains and the bottoms of seas and oceans. They inhabit all plants and animal tissues including the muscles, body fluid and various organs of the body.

NEMATODE GROUPS

1. TROPHIC GROUP: These include marine nematodes, fresh water and soil types that are not parasitic on plants. Some members of this group are free-living which usually feed on decaying organic matters. They are therefore not harmful but beneficial to agriculture.
2. HELMINTH GROUP: These are animal parasites. This group are either parasitic on vertebrate or invertebrate animals. About 50 species attack humans. The vertebrate animal parasites include*: Dracunculus medinensis* (guinea worm), *Ascaris Lumbricoides* (intestinal roundworm), *Onchocerea Volvulus* (eye worm), *Wuchereria malayi* (Elephanthiasis), Heart worm (*Diro filaria spp*) etc. These are responsible for various health problems particularly in the developing countries. Invertebrate animal parasitic nematodes are those that are predators on insects (entomopathogenic). They are useful as biocontrol agents of insects. Some are parasitic on other pathogens including parasitic nematodes.
3. VECTOR GROUP: Some nematodes are involved in transmission of bacteria and viruses form plant to plant and place to place thereby assisting such pathogenic organism to cause diseases. They viruses and bacteria are usually acquired by the vector nematode during feeding.
4. PLANT-PARASITIC GROUP: Although nematodes are the most numerous multicellular animals, only an estimated 3% of all nematode species have been studied. Up to 4300 species of plant-parasite nematodes (Phytonematodes) in 197 genera have been described. Phytonematodes constitute the smallest in terms of size. They are microscopic ranging in size from 0.50mm – 4.0mm long and 0.025mm – 0.05mm wide. Because they inhabit the soil and cannot be seen with the naked eyes, they are often called the hidden enemies.

PLANT-PARASITIC NEMATODES – Structure and biology

A. **MORPHOLOGY:** Plant –parasitic nematodes are usually cylindrical in shape, tapering towards the head and tail. Although phytonematodes are microscopic, they have intricate systems of feeding excreting and reproduction that are similar to that of higher animals. The internal structures/anatomical details features of the nematodes can easily be seen directly under the microscope without dissecting the nematode generally, phytonematodes possess the following unique morphological features:

i) **STYLET**: All plant-parasitic nematode possess stylet. Stylet is a hard, sharp, spear-shaped structure on the cephalic region of the nematode. Through back and forth thrusting movement the stylet allows nematodes to

puncture intact plant cells. The stylet is used to empty cell content and to inject enzymes. Stylet may or may not possess basal swelling known as stylet-knob. Stylets with knobs are referred to STOMATOSTYLETS and members of plant-parasitic nematodes in this group are known as TYLENCHIDS in the order TYLENCHIDA. On the other hand, Stylets devoid of knobs is known as ODONTO stylet. Members of this group are DORYLAIMIDS in the order DORYLAIMIDA. In the Triplonchida, it is called ONCHIOSTYLE because of the arch shape.

ii) **BODY WALL**: The body wall is composed of three layers, an outmost cuticle, a middle hypodermis and a layer of unstraited muscles. The cuticle is a flexible coating around the nematode. It protects the organism from physical and chemical danger. As the nematodes grow they shed their cuticles four times (molting). The cuticles are usually in three layers (Tribloblastic).

iii) **TAIL**: The tail is the region between the anus and the back tip of the nematode.

iv) **REPRODUCTIVE SYSTEM**: Sexes are separate and sex organs are usually threadlike or tubular with duets. Female organ is made up of the ovary, the uterus and vagina (vulva). Ovary is where germ cells give rise to eggs. Fertilization taken place in the uterus. In male nematode sperms are produced in the testes. During mating sperms are deposited in the vagina via the spicule. Mode of reproduction in nematodes include:

a) **AMPHIMIXIS**: Cross fertilization invoving males and females.

b) **PARTHENOGENESIS**: Nonsexual implying that males are not required for reproduction.

c) HERMAPHRODISM: Male and female organs are present in one individual. Reproduction potential of plant-parasitic nematode is quite high. Egg production per female per life cycle ranges between 250 to 25,000. Nematode diseases' are usually polycyclic hence several generations occur in the span of the lost plant.

V) **OESOPHAGUS**: Is the tube where food moves from the head to the intestine. It is referred to as the **pharynx**. it comprise a narrow cylinder or **procorpus** which expands to form a **median bulb**, a muscular swelling containing refringent valve plates, before narrowing to the **isthmus** and the expanding into a **glandular portion**. Note- they lack circulatory or respiratory organs. Exchange of gas is directly through the cuticle. The oesophagus is divided into three parts in the Tylenchids and into tow parts in the dorylamids and triplonchids

Characteristics of the Tylenchids: They are basically bilaterally symmetrical, typically vermiform, animals that usually range from 0.2 – 1 mm in length. In some genera, the female loses the vermiform habit, becoming obese, even globose in form. The body is enclosed in a cuticle which is usually transversely annulated and may be ornamented with variety of processes in the criconematid forms. The female reproductive organ are generally monodelphic.

Charateristics of Longidorids: they are much longer nematodes and range from 0.9 – to over 12 mm in size. The cuticle is smooth and lateral fields are absent. The female reproductive organ is either didelphic or monodelphic.

Charateristics of Trichodorids: they are plump, cigar – shaped nematodes, about 0.5 – 1.1 mm long and with a bluntly rounded labial region and tail. The cuticle is smooth and may swell enormously under the influence of acidic fixation. The female genital system is usually didelphic, very exceptionally monodelphic.

LIFE CYCLE: Plant-parasitic nematodes have a simple life cycle of six stages. The embryo develops inside the egg to become the first stage juvenile. The first stage juvenile moults inside the eggshell to become a second-stage juvenile, which hatches from the egg. In most species second-stage juvenile must feed to continue its development. It therefore has to move to locate food source (plant lost). After locating roots of plant it penetrates the root and continues it's feeding. This then moult the second time to produce the third stage juvenile. The fourth stage juvenile moults to produce adult. Adult female would lay eggs to complete a full cycle, marking the commencement of another cycle.

Life cycle vary considerably in phytonematodes depending on nematode species, host plant, and the temperature of the habitat. It is as short as 28-30 days when temperature is high but much longer when temperature is low.

NEMATODE FEEDING AND HOST-PARASITE INTERACTION

All phytonematodes feed on living plant tissues. They all have stylet with which they puncture plant cell wall. Many nematodes inject enzymes into the host cell before feeding. The enzymes partially digest the cell contents before they are sucked into the gut. The damage or injury caused to plant depends on their feeding process. Nematodes may feed on plant tissues from outside or inside the host tissue. Nematodes may be free-living, predaceous or parasitic, and many of the parasitic species cause important diseases of plants, animals, and humans, the only insect parasitic nematode possessing an optical balance of biological control attributes are entomo pathogenic (also referred to as "beneficial" or "insecticidal") nematodes in the general Steinernema and Heterorhabditis.

KINDS OF PARASITISM IN PLANT NEMATODE.

Plant-parasitic nematode punctures plant tissue when in contact with the plant. The puncturing process through intact surfaces is made possible by repeated thrusts (pressing) of tissue by the stylet. Several hundred species of nematodes are known to affect plants. Every crop has its full compliment of nematodes which attack them. Below and above ground parts roots, bush, stem, floor are usually parasitized by the nematodes. Most of the plant of the plants parasitic nematode feed on plant roots. Depending on the part of the plants attacked plant-parasitic nematodes may be classified as follows:

a) **ROOT PARASITES**: This can further be classified as:

i) **ENDOPARASITES**: These are plant parasite nematodes which enters plant roots completely with their entire body. They therefore stays, develops, mature and lay eggs within the root. Endoparasites may be

1) Sessile (sedentary endoparasites) which are those that become stationery as soon as they penetrate the root and pick up their feeding sites. E.g. *Meloidogyne spp, Globodera, Heterodera spp, Nacobbus spp*. etc. They are most virulent of all plant parasitic nematode. They are responsible for galling of roots. Only 2nd stages are infective.

2) Migratory Endoparasites which normally advances (move) from one cell to the other. E.g. *Pratylenchus Penetrans*. All stages except egg are infective (motile).

ii**)** **SEMI ENDOPARASITES**: These include nematodes that partially penetrate the root. E.g. *Rotylenchus, Helicotylenchus* (both are spiral nematode), *Criconemella* (ring nematodes) and *Paratylenchus* (pin nematodes).

iii) **ECTOPARASITES**: These are nematodes which feed on root with the aid of their long stylets but without themselves entering the root. E.g. *Xiphinema*, *Longidorus*, *Trichodorus*. They parasitize the epidermal layer of the roots.

b) **STEM, LEAF & SEED NEMATODE**: Aerial (above ground) parasites. This include rice nematodes (*Aphelenchoides besseyi, A. oryzea* etc which are folial nematodes. *Anguina, tritici* (wheat gall nematodes) are seed borne nematode & 1st to be studied. Stem nematode include *Ditylenchus dipsaci*.

ECONOMIC IMPORTANCE OF PLANT PARASITIC NEMATODES

A crop losses due to plant parasitic nematode constitute one of the most wide spread pests being very costly. Periodically their interaction with plants and/or other organisms result in crop devastation and economic woes. In Nigeria 20% - 75% crop loss, including outright crop failures are common with plant nematode interaction. While feeding, plant parasitic nematode injects secretion from oesophageal gland. This secretion perhaps digest partly the juice of sap of the plant which is then drawn through the stylet into the oesophagus and then into the intestine. This feeding activity deprives the plant of nutrient synthesis. Roots are

equivalent mouth of the plants where nutrients and water are taken up. Since most damage is done to the root, distortion (damage) in the root will result in malfunctioning of the root and because they are hidden muted damage to the plants and become only apparent when above ground symptoms become manifested. Most symptoms are similar to those of water/nutrient deficiencies. Nematode damage and its associated crop losses in the fields, store or markets are most severe in the tropic where the climatic conditions favor continuous (all year round) reproduction of plant parasitic nematode. useful crop loss assessment is that which consider crop to crop basis for specific nematode. In Nigeria, it is possible to give the major nematode pest of the top ten Nigeria crops :

NIGERIAN TOP TEN CROPS AND SOME OF THEIR MAJOR PESTS

S/NO	CROP	MAJOR NEMATODE PESTS
1	CASSAVA (*Manihot* spp)	*Meloidogyne spp, Pratylenchus brachyurus, Rotilenchulus renifornis*
2	MAIZE (*Zea mays*)	*Pratylenchus spp, Meloidogyne spp, Helicotylenchus spp*
3	YAM (*Dioscorea* spp)	*Scutellonema bradys, Meloidogyne spp, Pratylenchus spp*
4	COWPEA (*Vigna unguiculata*)	*Meloidogyne spp, Rotylenchulus, renifornis, Hoplolaimus seinhorsti*
5	RICE (*Oriza sativa*)	*Aphelenchoides besseyi, A. oryzae, Hirschmaniella spp, Meloidogyne*
6	BANANA/PLANTAIN (*Musa* spp)	*Radopholus similis, Meloidogyne spp*
7	SORGHUM (*Sorghum bicolor*)	*Meloidogyne spp, Pratylenchus spp, Tylenchorynchus spp*
8	MILLET (*Pennisetum typhoides*)	*Meloidogyne incognita, Heterodera spp, Longidorus elongatus*
9	SOYABEAN (*Glyane max*)	*Meloidogyne incognita, Belonolaimus spp, Hoplolaimus*
10	COCOA (*Theobroma cacao*)	*Meloidogyne spp, Helicotylenchus cavenessi, Tylenchorynchus coffee*

COMMON WEEDS OF AGRICULTURAL PLANTS

a) FREE-LIVING WEEDS AQUATIC TERRESTRIAL

b) PARASITIC WEEDS

FREE-LIVING

CHARACTERISTICS OF WEEDS

- INDIVIDUAL (i.e. degree of harmfulness)

i) Persistence/Resistance to Control: Some weeds are very difficult to control because they possess some forms of propagates like seed, rhizome and/or tuber e.g. *Talinum, , Imperata, cylindrica*.

ii) High Reproduction Capability: Very successful weeds have the ability to produce very many seeds in one generation *Amaranthus spinosus*, have recorded 235 thousand seed/plant, *Tridax* about 40 thousand.

iii) SEED DORMANCY: Dormancy is a survival strategy in weeds it ensures that all viable seeds do not germinate at the same time even when environmental condition is favorable for all the seed. In this manner weeds always have a recession of seeds in the soil and this is responsible for repeated weeding.

COLLECTIVE CHARATERISTICS

1) LARGE POPULATION: Grow very densely around crops of *Ageratum, conyzoides, Bidens pillosa*.
2) Aggressiveness: Ability to grow very rapidly and over-shadow crop plant.
3) Precocity: Having several generations within a growing period. i.e. complete their life cycle within short time.

SOME COMMON WEEDS

FAMILY	BOTANICAL NAME	COMMOM NAME
AIZOACEAE	*Trianthema portulacastrum*	Horse, purslane
AMARANTHACEAE	*Amaranthus, spinosus*	Horny, Pig weed
ASTERACEAE(ACANTHACEAE)	*Aspilia, africana, Ageratum, conyzoides, Chromolaena, odorata, Tridax prolumbens*	Haemorrhagy, Plant, goat weed, Siam weed, Coat bottom,
CAESALPINACEAE	*Cassia hirsute , Daniella oleveiri*	Stinking cassia, Ilorin balsam,
POACEAE	*Andropogon gayanum, A.. tectorum, Cynodon, dactylon, Imperata cylindrica, Penisetum purpureum*	Gambia grass, Blue stem giant grass, Bahama grass, Spear grass, Elephant grass.

WEED DEFINITION:

Weeds are plants that interfere with human activities or in some way intrude upon human comfort and welfare. They are plants which people have not yet discover their virtue.

CLASSIFICATION OF WEEDS

Weeds can be classified in several ways that include life cycle, habitat, nutritional habit and morphological characteristics.

1) **LIFE HISTORY**: Based on length of time it takes tom die.
   a) Annual Weeds: Are weeds that grow from seed germination to seed production in one or two growing seasons within one calendar year. In other words they are weeds that complete their life cycle within one calendar year. Such weeds die during the dry season. E.g. Tridax, Procumbers, Aspilia, Africana, Ageratum, Conyzoides.
   b) Perennial Weeds: Are those that will stay alive for more than one calendar year even after producing seeds during the growing season proceeding the dry season. They survive dry season with the aid of perennating

structures/organs such as corns, rhizomes, bulbs, stools and long tap root. E.g. Chromolaen, Odorata, Tahrium, Triangulae etc.

1) **HABITAT**: Based on the location of the weed.
   a) Terrestrial (Upland) Weeds: Any of the annual weeds can be classified as terrestrial.
   b) Aquatic Weeds: Weeds found on water bodies. E.g. Nymphaea, Lotus, Pistia, Stratiotes (water Lettuce), Ipomea, Aquatica, Eichhornia, natans (water hyacinth).
   c) Weeds of arable crops
   d) Weeds of plantation crops
2) **MORPHOLOGY**:
   a) Narrows leaf weeds - Grasses are usually characterized by narrow leaves parallel veins and are generally monocotyledons.
   b) Broad leaf weeds: Are generally characterized by net veination, tap root system and are dicotyledons.
3) **SCIENTIFIC CLASSIFICATION**: Based on binomial scientific classification based on family general and species.
4) **NUTRITIONAL HABITS**:
5) PARASITIC PLANTS: On the basis of growth habit, weeds may be classified into 2: free-living (autotrophic) and parasitic weeds. Weeds that live as independent organism and manufacture their own food through photosynthesis are known as autotrophic while those weeds that grow on living tissues of other plants deriving part or all of their food, water, mineral needs therefore are known as parasitic weeds.

Parasitic weeds can be classified into

a) Root Parasites: Those which are obligate parasites because they need chemical stimulant from host plant to initiate seed germination. Root parasitic weeds include Striga spp and Orobancle spp.

   Striga spp (witch weed) are important parasitic weeds causing serious economic losses to cultivate host crops. Three species are important namely: *Striga hermonthica* (millet, Sorghum, rice and sugar cane, *S.aspera* (Maize and Cowpea) and *S. gesneroides* .

   Usually chemical exudates from the host plant would stimulate geminination of the seed and as soon as it germinates the seedlings will attack itself to the root of plant host deriving assimilates, water and mineral from the host. After some days when green tissues are established, they begin to synthesis their assimilate but would still depend on the host root for water and minerals, thereby causing severe havoc/loss to the crop.

b) Stem Parasites: Attach themselves to the stem of the host plant through historian. They synthesize their own food but will depend on the host for water and minerals. Example include: *Cuscuta* spp (*Cuscuta campestris, C. chinensis, C. reflexa*) and Loranthacae (*Viscum capitellation*, *Loranthus* spp) – Mistletoe

PRESSING, DRYING AND PRESERVATION OF WEED SPECIMEN

1) Collect weed specimen around the University.
2) Press them using plant press made up of tub wooden frames each measuring 45cm X 30cm between which specimens are kept in absorbent paper folder or old newspapers, for partial drying and flattering up.
3) Specimens should be pressed as soon as possible after collection.
4) Mount dry specimen on A4 plain sheets of paper with the aid of stripes of gummed papers. Cello-tape is not encouraged because it does not last.
5) Label - Date of collection
   - Location
   - Common name
   - Botanical name
   - Family