LECTURE NOTES

For Environmental Health Students

Vector and Rodent Control

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Preface

Certain species of arthropods and fresh water snails are responsible for the transmission of some important diseases. In tropical countries the largest group of illnesses are probably insect borne. Similarly, rodents and snails are also a potential reservoirs for a number of diseases besides their contribution to economic losses.

These vector borne diseases, however, could have been prevented or controlled through the application of insect control methods, particularly through the application of environmental modification methods.

The lecture note contains six chapter: the current vector and rodent borne diseases, the general feature, life cycle, medical importance and appropriate prevention and control strategies are touched with some practical examples and review questions. In other words, it will guide the reader to the subject matter of vector and rodent control presenting general information first and then specific diseases transmitted by the vector and its control methods.

This material was prepared by collecting the necessary information relevant to the course from existing books, journals, and lecture materials. Comments of different instructors from the four training institutions in the country were also incorporated which bring the material to its present status.

Finally, it is hoped that this material will be important not only for people who are engaged in public health work but also it would be of a paramount importance to others who are interested in public health work. Generally environmental health professionals have the responsibility to plan and apply appropriate vector control
programs at community level to prevent diseases transmitted by arthropods, rodents and snails through organized community participation.

Acknowledgments

I would like to extend my deepest gratitude to The Carter Center in general and to Professor Dennis Carlson in particular for their financial and material support to prepare this lecture note.

I am also grateful to vector and rodent control course instructors in the three training institutions namely, Fantahum Wassie from Jimma University, Shiferaw Gezahegn from Gondar College of Medical Sciences and Wondimagegn Paulos from Dilla College of Teachers Education and Health Sciences for their valuable comment with out which this teaching material would have been incomplete.

My special thanks also goes to my vector control instructor Shiferaw Gezahegn from whom I have adopted the scientific name of arthropods. I am also grateful to all Carter Center-Ethiopia staffs, to my friends and others who in one way or another helped me to bring the lecture note to its final stage.

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Abbrevations

Ae:	Aedes
An:	Anopheles
BHC:	Benzene Hexa chloride
CHF:	Common Housefly
CU:	Culex
DDT:	Dichloro-Diphenyl-Trichloroethane
DNOC:	Dinitro-ortho-Cresol
Glos:	Glossina
M.L.C:	Minimum Lower Concentration
Ph:	Phelebotomus
Pla:	plasmodium
Sim:	Tetraethyl Phyrophosphate
Try:	Trypanosoma
W.W:	Water Wettable

CHAPTER ONE

INTRODUCTION

Learning Objective

At the end of this chapter, the student (the reader) will be able to: -

- List the different types of disease transmission.
- Define relevant words like vector, arbo-virus, and technical grade insecticide, etc.

1.1. Existing Problems:

The relation ships of early humans to insects were similar to those between insects and other primates and mammals. Insects parasites, fed on humans, annoyed them and transmitted diseases among them. In common with other mammals, humans have acquired host-specific parasites, for instance, the head and body louse. Insects also destroyed stored foods, shelters and articles made of wood, plant fibers and animal hides. In turn, primitive peoples, sometimes as a regular part of the diet ate insects. Honey was widely sought in both the old and new world. Honeybees are native to the old world and stingless bees produce honey in the tropics of the new world.

With development of agriculture and cities, humans came in to cooperation and conflict with insects. Despite the devastating effects of some insects as destroyers of crops and wooden structures, and as carriers of diseases, it is generally agreed that the majority of insects are directly or indirectly beneficial to human society.

Since effective vaccines or drugs were not always available for the prevention or treatments of these diseases, control of transmission of the disease often rely on control of the vector. The discovery of the insecticide Dichlorodiphenyl trichloroethane (DDT) was a major breakthrough in the control of vector borne diseases.

In the 1950s and early 1960s, programs were organized in many

countries which attempted to control or eradicate the most important vector-borne diseases by the large scale application of DDT. The objective was to eradicate the diseases or to reduce transmission to such a low level that control could be maintained through the general health care facilities with out the need for additional control measures.

Initially these programs were largely successful and in some countries it proved possible to reduce the vector control activities. However, in most countries, success was short lived; often the vectors developed the so called resistance to the pesticides in use, creating a need for new and more expensive chemicals. This situation, eventually led to a return to significant levels of disease transmission. Permanent successes were mostly obtained where environmental modification was carried out in order to prevent the disease vectors from having breeding or resting place. Due to this fact, many scholars are now advocating the importance of environmental change as an effective and first line control strategy for vector and rodent control.

1.2. Ways of Vector Borne Disease Transmission:

Generally there are three types of disease transmission. Namely, Mechanical disease transmission, Biological disease transmission, and hereditary disease transmission.

1. **Mechanical disease transmission:-** is a type of disease transmission in which the vector is no more than a carrier that transmit pathogens without any change either on the number or form of disease pathogens. E.g.Trachoma.

2. **Biological disease transmission:**

   In this type of disease transmission certain developmental pattern exists either in the vector or host or in both cases. It is sub-divided in to

2.1. Propagative:

In propagative type of disease transmission only the number of pathogens increases and the developmental stage remain constant. The disease plague and typhus are a good examples of propagative type of disease transmission.

2.2. Cyclo-developmental:

In this type of disease transmission only the developmental stage (form) of the disease pathogen changed (small to big, immature to matured stage, etc.) while the number of the pathogenic organism remain constant.

2.3. Cyclo-propagative:

This type of disease transmission is a combination of both propagative and cyclo-developmental where by the disease pathogen under take a change both in number and developmental form (stage). E.g. Malaria.

3. **Transovarian(Hereditary)disease transmission:-** is a type of disease transmission where by the causative agent is transmitted to the immature stage (usually to egg) from the adult insects and / or other arthropods who carry disease pathogens and when the infected egg complete its developmental stage, it become infective or can transmit the disease to man and other animals. Ticks are very good examples of arthropods that exhibit hereditary disease transmission.

1.3 Definition of Terms:

1. Vector(s):-are arthropods or other invertebrate which transmit disease causing microorganisms by biting or by deposition of the agent in/on the skin or on food / water etc.
2. Mechanical Vectors:-are vectors that transmit pathogenic microorganisms without undertaking any developmental change inside the insect body. Common house fly could be an example of insect that transmit disease mechanically.

3. Biological Vectors: - are vectors that transmit disease pathogens after the multiplication or development of the pathogen in the insect gut or muscle.

   Mosquitoes are good examples where by the plasmodium species under take change both in number and form inside the mosquitoes as well as man.
4. Arbo-viruses:- are viruses that are transmitted from one vertebrate to the other by the help of mosquitoes and other arthropods.
5. Insecticides: are substances or an agent that kill insects or other arthropods.
6. Technical grade insecticides: are an insecticides that exist in its purest commercial form.
7. Insecticide formulation:- is the addition of substances (solvent or diluents) which enable a given chemical insecticide to be used to greatest advantage.
8. New World:-refers to Countries or regions in the Western hemisphere.
9. Old World:- refers to the Eastern hemispher; the world of Europe, Asia and Africa.

Review Questions

1. Write the three types of disease transmission and give a short description for each.
2. Define the following terms or phrases.
   A. Vector
   B. Biological vector.
   C. Arbo-virus.
   D. Technical grade Insecticides.

CHAPTER TWO

Insects of Public Health Importance

Learning Objective

At the of this chapter the reader (student) will be able to:

- Describe the general features, medical importance and methods of control of insects of public health importance under class insecta.
- Describe the transmission cycle of onchocerciasis, filariasis, yellow fever and malaria.
- Draw applicable control strategy for the diseases caused by body louse and fleas

2.1 Introduction

Arthropod is the great phylum of invertebrate animals. They were the first animal phylum to overcome the problems of locomotion, respiration, and water conservation in a terrestrial environment. The phylum comprises at least 85 per cent of all known species of animals. All species under phylum arthropoda have the following characteristics in common

- Bilaterally symmetrical body sub-divided into segments.
- Body covered with exoskeleton, which is made up of cuticle that contain chitin. (Nitrogenous polysaccharide). Chitin is a tough and rigid substance made up of poly (N-acetyl)-D-glucosamine ($C_{15}H_{20}N_2O_{10)}$. It is water proof, parasite proof, shock proof and do not dissolve with acids.
- Jointed appendages are present on some body segments. (Wings, legs, antennae)
- Body cavity between the alimentary canal and the body wall.
- Open circulatory system that works by diffusion.
- Central ladder type of nervous system that work with ganglia.

The phylum arthropoda from public health point of view can be sub-divided in to five important classes namely Insecta, Arachnida, Diplopoda, Chilopoda and Crustacea.

Insects are the earth's most varied organisms. Almost half (50.8 per

cent) of the species of living things and 72 per cent of all animals are insects.

Of all the animal phyla, only the arthropods and the chordates have succeeded extensively in adapting to life in dry air. Insects now inhabit virtually all land surfaces of the globe except the extreme polar regions and the highest mountain peaks.

Insects that feed on green plants are termed phytophagous. All parts of green plants are attacked: roots, trunks, stems, twigs, leaves, flowers, seeds, fruits, and sap in the vascular system. Insects that kill other insects are termed entomophagous. Of these, the predators kill their prey more or less immediately, while parasitoids feed externally or internally in their host for some period before finally killing it.

A typical adult insect has a segmented body with an external skeleton, or exoskeleton, composed of chitin and protein. The exoskeleton provides not only strong support and protection for the body but also a large internal area for muscle attachments. Their body is divided in to three main regions, head, thorax, and abdomen. The head bears a pair of large compound eyes and as many as three simple eyes, or ocelli, a pair of sensory antennae, and the feeding appendages or mouth parts. The thorax is composed of three segments, each bearing a pair of legs. The last two segments may also bear a pair of wings. The abdomen is composed of no more than 10 or 11 visible segments and lacks appendages except for a pair of cerci and the reproductive external genitalia that may be present near the tip of the anal opening.

Entomologist express as the orders of class insecta could reaches to about 30. But the most common orders of insects are diptera, anoplura, coleoptera, hemiptera, hymenoptera, lepidoptera, orthoptera, siphonaptera, mallophaga, isoptera, homoptera and odonata.

Order Diptera

All species under order diptera are fliers. Adult insects belonging to the diptera have one pair of wings and undergo holometabolous life cycle. The larvae is different from adult in structure, habitat, and food source. Generally there are more than 50,000 species of both biting and non-biting diptera and the majority of which have no medical importance, but few of them are the most important disease vectors.

Non- biting Insect:

Non-biting insects are those insects that can't penetrate the skin and suck blood from humans and other animals. These insects normally lack cutting teeth, but they have either spongy or chewing type of mouth parts. Insects like the Common House Fly, blue or blow fly and flesh fly are some examples of non-biting flies.

1. Common House fly. (CHF)

Classification

Class- Insecta
Order- Diptera
Family- Muscidae- Common House fly.
Genus- Musca
Species- M. domestica.

1.1 General Feature and Identification:

House flies commonly called synanthropic or domestic flies because of their close association with man. They have hygienic importance to man due to the adult habit. Common house fly is a black coloured and small sized insect. Their body length is 1/4 of an inch from head to abdomen. The Thorax has four longitudinal strips. At the base of the abdomen there is a white yellowish colour. There are plenty of hairs all over the body.

The distance between compound eyes help to differentiate the male from the female. Males have holoptic (nearer to each other) eyes and females dichoptic eyes, means a bit far apart. The tip of the abdomen also help to

differentiate male fly from the female. It is oval shaped for male and “W” shaped for female.

1.2. Life History and Habitat:

Common House Fly (CHF) passes through complete metamorphosis. It takes 8-20 days to complete the cycle. Female fly lays white visible eggs. It is oval in shape and has a length of about 1/25th of an inch. The egg deposited on filth area such as offal, human waste, animal dropping, rubbish, etc. in batch. A single female CHF laid egg 5-6 times in her life time, which is about 400-1200 eggs/ batch or lay at once.

The larvae are an active. They feed, move, moult and defend. They sheds 3-5 times. While the pupae is brown in colour and inactive from the outside. It has no movement and out side feeding. It usually feeds on stored glycogen. It has no self defense. However, internally growth takes place and the adult comes out of it finally.

1.3 Food and Breeding Sites:

Adult Common House Fly is attracted to all type of dirty substances by way of food. Because of the structure of their mouth part food must be either in the liquid state or readily in the salivary gland secretions or in the crop. Liquid food is sucked up and solid food is wetted with saliva, to be dissolved before ingestion. Water is an essential part of fly’s diet and flies do not ordinarily live more than 48 hours with out access to it.

Common sources of food of common house fly (CHF) are milk, sugar, syrup, blood, meat broth and many other materials found in human settlements. The flies evidently need to feed at least two or three times a day. The flies active movement, the food source and their feeding habits facilitate mechanical disease transmission.

Female flies deposit their eggs on decayed, fermenting or rotting organic material of either animal or vegetable origin. Unlike blow flies and flesh flies, house flies rarely breed on meat or carrion. Dung of accumulated animal feces are among the most important breeding sites for house flies. The suitability of dung for breeding depends on its moisture (not to

wet), texture (not to solid), and freshness (normally within a week after deposition). Garbage provides the main medium for breeding. It includes waste associated with the preparation, cooking, and serving food at home and in public places, and with the handling, storage and sale of food, including fruits and vegetables, in markets. Fields that are heavily manured with organic matter such as dung, excrement, garbage and fish meal provide suitable breeding places for flies.

House flies also breed in sewage sludge and solid organic waste in open drains, cesspools. Piles of decaying grass clippings, compost heaps and other accumulations of rotting vegetable matters serve as good breeding places for flies.

1.4 Habit of Adult Flies

An understanding of the ecology of flies helps to explain their role as carriers of disease and allows the planning of control measures. Adult flies are mainly active during the day. They feed and mate at day time. At night they normally rest, although they adapt to some extent to artificial light.

During the day time, when they are not actively feeding, flies may be found resting on floors, walls, ceilings, and other interior surfaces as well as out doors on the ground, fences, walls, steps, pit latrines, garbage cans, clothes lines, grasses and weeds. At night, flies are normally inactive. Their favourite resting places at this time are ceiling and other over head structures. When temperatures remain high during the night, house flies frequently rests out of doors on fences, clothes lines, electric wires, weeds, grasses, hedges, bushes and trees. These resting places are generally favoured during day time when they are feeding and breeding. Their resting places should be sheltered from the wind. The resting places are usually above ground level, but rarely more than five meters high.

During the day, flies are mainly gathered on or around feeding and breeding places, where mating and resting also take place. When not eating, flies rest on horizontal surfaces and on hanging wires and

vertically suspended articles. At night they rest on indoor ceiling. A detailed study of the locality regarding resting places is essential for a successful control. The expected life span of a CHF is 20-60 days, depending on:-

- Environmental factors or conditions such as climate (temperature), disease prevalence and food availability along with human action on flies.

CHF is temperature dependent. They are inactive and die at a temperature below 32^0F. At 45^0F they are still inactive but do not die, and at 53^0F they start activity. At a temperature range between 70^0F-90^0F they become very active; but when the temperature goes above 112^0F they get paralyzed and die.

- *Humidity:-*

The best air humidity for fly activity is in the range 40- 55%.

- *Light:*

CHF are a photopositive insect, and therefore, they become active during the day. At night (dark) they are fully inactive.

- *Wind:*

Mild wind is useful for flies' activity. The best wind speed is about 1-1.5 kg. Normally they die at a wind level of 10-15 kg.

1.5 Public Health Importance:

1. Nuisance:

In large numbers flies can be a nuisance by disturbing people during work and at leisure. Flies soil the inside and outside of houses with their feces. They can also have a negative psychological impact because of their presence. They annoy us at meal times as intruders.

2. Diseases transmission:

Common House Fly transmit disease causing microorganisms in three ways, i.e.- by their body hairs, regurgitating a drop of liquid and by feces contaminated with pathogens. Flies can spread diseases because they feed freely on human food and filthy matter alike. The fly picks up disease- causing organisms while crawling and feeding. Those that stick

to the outside surfaces of the fly may survive for only a few hours, but those that are ingested with the food may survive in the fly's crop or gut for several days. Transmission takes place when the fly makes contact with people or their food.

The diseases that flies can transmit includes enteric infections (such as dysentery, diarrhoea, typhoid, cholera and certain helminthes infections), eye infections, (such as trachoma and epidemic conjunctivitis), poliomyelitis and certain skin infections (such as yaws).

1.6 Control Measure:

Flies should preferably be controlled by improving environmental sanitation and hygiene. Than by the application of chemicals. This approach provides longer-lasting results, more cost effective and usually has other benefits.

► **Improvement of environmental sanitation and hygiene:**

1. *Reduction or elimination of fly breeding sites: (Application of basic sanitation.)*

All waste matter from animal sheds, stables, pens and feed lots should be cleaned out and floors should be flushed daily. In poultry houses leaking water pipes should be repaired, dung should be removed and the floors should be flushed at frequent intervals. Breeding of flies in open pit latrines can be prevented by the installation of slabs with a water seal and fly screen over the vent pipe. If a water seal is not feasible a tightly fitting lid may be placed over the drop hole. Garbage and other organic refuse can be prevented from becoming breeding media by proper sweeping, storage, collection and disposal. In the absence of a system for collection and transportation, garbage can be burnt or disposed of in a dug pit. At least once a week the garbage in the pit has to be covered with a fresh layer of soil to stop breeding by flies.

To prevent the breeding of flies in tightly closed garbage container the garbage has to be collected at least twice a week. In temperate climates collection of waste once a week is sufficient. When emptying a container

it is important to remove any residue left in the bottom.

2. Protection of food, eating utensils and people from contact with flies:

Food and utensils can be placed in fly proof containers, cupboards, wrapping materials, etc. Nets and screen can be used on windows and other openings. Doors can be made self-closing. Door ways can be provided with anti-fly curtains, consisting of strings of beads or plastic strips which prevent flies from passing through.

► Killing of flies directly:

Flies can be killed directly by insecticides (chemical means) or physical means, such as traps, sticky tapes, fly swats and electrocuting grids.

1. Physical methods:

Physical control methods are easy to use and avoid the problem of insecticide resistance, but they are not very effective when fly densities are high. They are suitable for small-scale use in hospitals, offices, hotels, supermarkets and other shops selling meat, vegetables and fruits. Fly trap, sticky tapes and light trap with electrocutor are good examples of physical methods for killing flies.

2. Chemical Methods:

Control with insecticides should be undertaken only for a short period when absolutely necessary because flies develop resistance very rapidly. Insecticidal application used for quick control usually during epidemics or outbreaks of cholera, dysentery or trachoma.

- Residual Insecticide - DDT 5% (suspension, emulsion etc.)
  - DDT 10% dust.
- Non- residual insecticides- pyrethrins used as a space spray, which has a very high knock down effect.

Note that:- Basic sanitation gives the best result in fly control than insecticides.

2. Blue or Blow fly

Class - Insecta	Classification
Order- Diptera	
Family- Calliphoridae-	Blue or blow fly.
Genus 1: Calliphora.	
Species- Calliphora vicina-	Blue bottle fly.
Genus 2: Cynomyopsis	
Species - Cynomyopsis cadverina-	Blue bottle fly.
Genus 3: Lucilia	
Species- Lucilia illustries -	Green bottle fly.
Genus 4: Phaenica	
Species- Phaenica sericata -	Green bottle fly.
Phaenica cuprina	" " "
Genus 5: Phormia	
Species - Phormia regina -	Black blow fly.
Genus 6: Cochliomyia	
Species - Cochliomyia hominivorax -	Screw worm fly.

2.1. General Features of Calliphoridae:

All calliphoridae have world wide distribution. As common house fly they are also mechanical disease vectors. Their breeding place is on waste,

decaying animal matter, and some lay their egg on flesh and make human food unfit. The phormia regina species usually lay their eggs on flesh. The female cochliomia hominivorax lay their eggs on wound and result myiasis particularly on sheep, goat and cattle. Others Calliphora species also lay their egg on wound and the developing maggot damage the neighbouring tissues. (example Lucilia illustries).

2.2 Public Health Importance:

Generally calliphorids are responsible to cause myiasis.

2.3 Prevention and Control of Calliphoridae:

► **Basic sanitation:-**

By proper disposal of both human and animal wastes, it is possible to control the immature stages of these flies.

► **Application of Insecticide:**

Residual Insecticides like DDT (5% or 10%) used. From the non-residual insecticide the pyrethrins are the best to kill adult flies while flying or resting.

3. Flesh Fly:

Class Inseca
Order- Diptera
Family - Sarcophagidae
Genus-Sarcophaga.
Species - S. occidua
Common Name Flesh fly

3.1 General Feature and Identification:

Flesh flies are synanthropic (domestic) flies because of their close association with man. When compared to Common House Fly they are large in size, and have grayish colour. Their abdomen is a grayish black. There is a black strip on the thorax.

Adults are attracted towards feces and other wastes, in which they

normally breed and / or settle. Larvae, however, found on flesh, decaying organic matter, and dead body. They sometimes infest wounds or sores and cause intestinal myiasis.

3.2 Life Cycle:

Flesh flies pass through complete metamorphosis. Adults are larviparous and therefore, the immatured larvae laid on flesh, dead body and offals, etc. After the larvae changed to pupa, it dropped on the ground and with favorable condition, the adult comes out of it.

3.3 Public Health Imprtance:

1. Myiasis:
   Flesh flies can bring intestinal or wound myiasis occasionally. They are killer of sheep, goat, cattle and other animals.
2. Nuisance: The presence of flesh flies in the living environment is undesirable. Because particularly when their number in large they can make out door activities difficult.

3.4. Control Measure:

1. Application of Basic Sanitation:
   Control of the immatured stages of flesh flies is linked with sanitation. By proper disposal of refuse, the breeding place of the fly can easily be abolished.
2. Application of Insecticides:
   Both residual insecticides like DDT and non-residual insecticides such as pyrethrum are commonly used. The pyrethrins used as a space spray to knock down and kill adults when they are flying or resting in an enclosed space.

Biting flies:

1. Tse-tse fly

Class - Insecta Classification

Order - Diptera

Family- Glossindae- Tse tse fly.

Genus - Glossina

Species - 1. Glossina morsitans
2. Glossina palpalis
3. Glossina tachinoides
4. Glossina Swynnertoni
5. Glossina fuscepes
6. Glossina pallidipes.

1.1 General Feature and Identification:

Tsetse flies occur only in tropical Africa. They are yellowish or dark brown medium sized flies, 6-15 mm in length. They can be distinguished from other large biting Diptera by their forward-pointing mouth part. Wing at rest closed over one another like a closed scissors, and the tip of the wing is then extended beyond the abdomen.

Two other absolute diagnostic characteristics for glossina are the hatchet shaped cell in the wing and secondary branching of the hair of antennal arista.

1.2 Life History and Habitat:

Tsetse flies pass through complete metamorphosis. Glossina is viviparous meaning they retain a single fertilized egg at a time in a kind of uterus and hatch it there and then the matured larvae are deposited in the ground and it pupates and finally emerging as adult tsetse fly emergs. A single female hatch not more than 5 larvae during her life time.

Tse-tse flies have a piercing and sucking type of mouth parts. Their proboscis is connected with salivary duct that brings salivary secretion and the salivary secretion contains anti-coagulant that keeps blood liquid during passage to the digestive system.

The habitat of the adult fly is in areas where vegetation surrounding villages; in sacred forests, on cemeteries and coffee or cacao plantations.

All tst-tse flies, males and females, feed on blood, but the species of

animals differ in their preferences for the source of blood. Most of them feed preferentially on animals and only accidentally on humans. The most dangerous species are those that are flexible in their choice and feed on any blood source that is easily available including humans. They are attracted by large moving objects, by strikingly blue objects and by carbon dioxide. Biting occur during the day and out of door usually at down and dusk.

1.3 Public Health Importance:

1. Nuisance: Tse-tse flies cause painful bites and during the day can be a nuisance where they occur in large densities in forest land.
2. Disease Transmission:

► **Sleeping sickness:**

Adult Glossina transmit African sleeping sickness (Trypanosomiasis) to man and animals. (Wild and Domestic animals). Tse-tse is the greatest hindrance in animal production and agricultural development in tropical Africa. There are four species of protozoan trypanosome parasites. These are Trypanosome gambiense, Trypanosome rhodesiense, Trypanosome vivax and Trypanosome congolense. In west and central Africa the disease is caused by Trypanosome gambiense, which is mainly transmitted by Glossina palpalis, Glossina fuscipes and Glossina tachiniodes. It is considered to be a chronic disease.

The rhodesiense sleeping sickness is caused by Trypanosome rhodesiense which is an acute disease that occurs mainly in East Africa and mainly transmitted by Glossina morsitans, Glossina swynnertoni and Glossina pallidipes. Other trypanosome species can cause diseases in wild and domestic animals including cattle, pigs and horses.

- **Transmission of Sleeping Sickness:**

Tsetse flies acquire the trypanosome parasites by feeding on infected people and large domestic and wild animals. When an infected tsetse fly bite it injects the parasites into blood; the parasite multiply in the mid-gut and salivary gland of the fly and man infected through the bite .Infection

of sleeping sickness usually takes place where humans enter the natural habitat of the tsetse flies.

Gambiense sleeping sickness is transmitted by flies those attack people at places along rivers such as river crossing, lakeside villages, and bathing and washing places, and also near water holes, plantations and along roads bordered by vegetation.

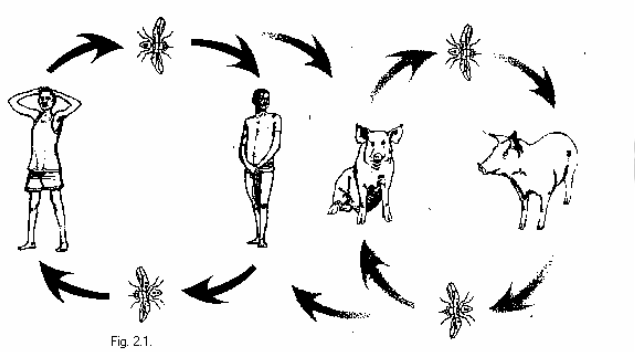


Fig. 2.1.
Transmission cycle of gambiense sleeping sickness

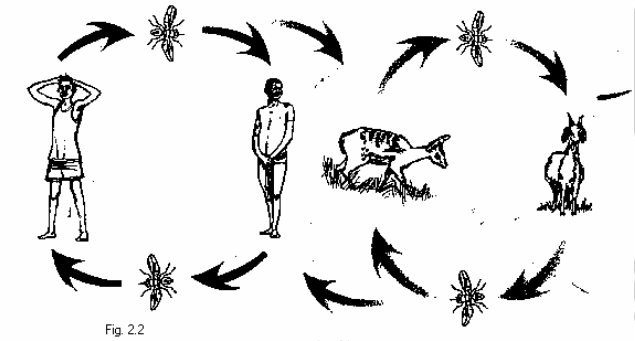


Fig. 2.2
Transmission cycle of rhodesiense sleeping sickness.

(Source: Jan A. Rozendaal: WHO 1997)

Rhodesiense sleeping sickness transmitted by flies that normally feed on wild animals that inhabit woodlands, such as the pushback or on domestic animals like cattle and goats. They also attack people who live in or enter these areas, for instance farmers, herdsmen, fishermen, hunters, travelers and collectors of honey.

- **Clinical Symptoms**:

Sign and symptoms of sleeping sickness are headache, irregular fevers, swollen tissue and joint pain. Finally the parasites invade the brain, which usually leads to mental disorders, coma and death .If untreated both types of sleeping sickness are fatal.

- **Treatment:**

In the early stages of the disease suramin sodium for rhodesiense infection and pentamidine, for gambiense infections, is usually administered intravenously and intramuscularly for rhodesiense and gambiense sleeping sickness respectively. Both drugs have side effects. Melarsoprol was the only available drug for treatment of the late stages of both gambiense and rhodesiense sleeping sickness. The drug carries a risk of serious side effects, which may be fatal and must be administered under strict medical supervision.

1.4 Prevention and Control:

1. *Cleaning of forest and bushy habitat-*

   Before suitable insecticides become available, control efforts mainly involves removal of the woody vegetation's forming the flies habitat sometimes the primary sources of foods of the flies, the wild game animals, were killed or removed. The tsetse flies then eventually disappeared because of food shortage. Now days, these methods have been abandoned.

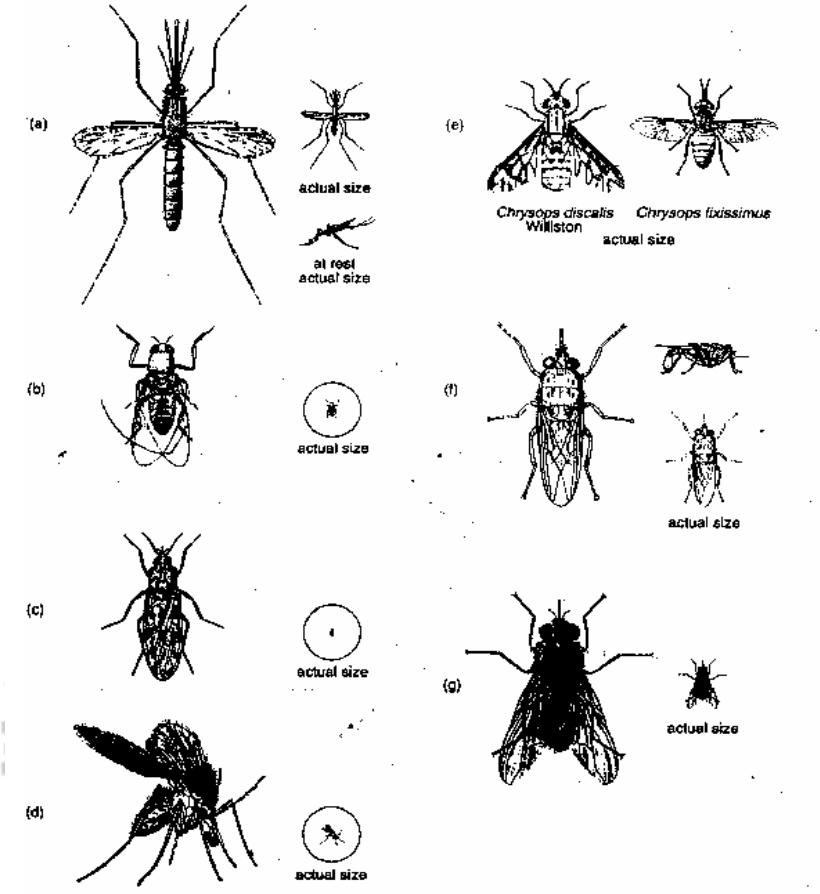


Fig. 2.3

The biting Diptera: (a) mosquitos (by courtesy of Professor M. Wéry, Institute of Tropical Medicine, Antwerp, Belgium; mosquito at rest, © L. Robertson); (b) blackflies; (c) biting midges; (d) phlebotomine sandflies; (e) deerflies (*f*) and horseflies; (f) tsetse flies; (g) stable flies (all figures by courtesy of the Natural History Museum, London, except where otherwise indicated).

(Source: Jan A. Rozendaal: WHO 1997)

2. *Traps and Insecticide-Impregnated screens:*

   Traps and screens are an effective means of tsetse control. They are cheap, easy to transport, and completely safe for the users and the environment. Once the trap developed, it does not require expertise. Unlike traps, screens are effective in killing tse tse flies only when impregnated with an insecticide.

3. *Genetic control (Insect chemosterilant)*

   By insect chomosterilant it is possible to reduce the population of the

tse tse flies by arresting reproduction. Ideally it is believed to be the best method in reducing fly population than the other control strategies. The procedure is: -

- Breed the tsetse in the laboratory.
- Sterilize the female by radiation or other technique.
- Release them in the forest.
- Then finally mating becomes a futile exercise. No fertilization and no larval hatching take place, and eventually result in the reduction of tsetse population. Even though insect chemosterilant is a very neat process, it is very expensive. It requires technical person, equipment, etc. There is also possible danger of radiation hazard.

4. *Application of Insecticide:*

   During acute epidemic it may be preferable to control tsetse flies by aerial or ground spraying of insecticides. Spraying is not generally required for routine uses because of high costs, the need for specialized equipment and trained personnel, and because of pollution of the environment.

   The aim of spraying is to apply residual insecticide to the day time resting places of the flies, such as tree trunks, roots. The insecticide must remain active for at least two months, the duration of the pupal stage, to kill all the emerging flies.

   For ground spraying knapsack sprayers, portable motorized sprayers and motorized spray pumps may be used. For aerial spraying Helicopters and fixed wing aircraft have been used.

5. Repellents:

   Repellents in the form of oil, lotion or cream are used and give temporary protection. It should be applied to all exposed skin- such as arms, neck and faces. Clothing can be lightly sprayed with suitable repellents.

2. Black fly

Common name

Class- Insecta

Order- Diptera

Family- Simulidae - Black fly.

Genus- Simulium

Species - Simulium damnosum

Simulium neavei

Simulium ochraceum

Simulium metailicum

Simulium callidum

2.1 General Features and Identification:

Black flies occur around the world and there are about 1300 species. They are small stout and fat bodied, about 1.5mm - 6mm long, and usually black in colour, although some are yellow or orange. Black flies have relatively large eyes that occupy most of the head. The legs are short and stout compared to others, and the wings are short, broad and colourless. They have also a short and stout antennae. Their existence or distribution is governed by the existence of running water. Thorax is humped at the back.

Black flies bite by day and out of doors. The female mouth part is adapted for blood sucking. Normally these flies do not enter house to take blood meal. Male flies do not suck blood, rather it feeds on nectar because the maxillae and mandibles lack cutting teeth. Biting usually takes place along river banks. Certain species show a strong preference for biting specific parts of the body. For example, simulium damnosum in West Africa mainly attacks the legs. Most species feed predominantly on birds or mammals; several feeds on humans. In the tropics black flies digest blood meals over a period of 2-3 days in outdoor resting places on trees and other natural sites.

2.2 Life Cycle:

Black flies normally lay their eggs in fast flowing, oxygen rich water in streams, rivers and spill ways of dams. In the tropics, the eggs hatch after 1-4 days. The larvae do not swim, remaining attached to submerged vegetation, stones and other substrates. They feed on small suspended particles. Depending on the climate, the larval stage lasts from one week to several months. The pupae are also attached to submerged objects and the adults emerge after 2-6 days.

2.3. Public Health Importance:

1. *Nuisance:*

   Black flies are a serious nuisance in many parts of the world because of their painful bites and some times enormous numbers involved in attacks. Their bite may cause localized swelling and inflammation and intense irritation of the skin lasting days or weeks.

2. *Human Onchocerciasis (River blindness).*

   Onchocerciasis is caused by a parasitic filarial worm, onchocerca volvulus. It is transmitted from person to person by simulium black flies. In Africa the most important vector species are simulium neavei and members of the simulium damnosum. The infection (disease) due to the reaction of the body induced by dead microfilaria cause intense itching of the skin and finally giving wrinkled appearance of old age. The infection also cause itching of eye lesions and its repeated infection leads to blindness. The disease has a focal distribution and occurs through out West and Central Africa and parts of East Africa. The most heavily infected areas are savanna regions in West Africa.

   Transmission of Onchocerciasis:

   Black flies are the only vectors for transmitting the disease. Embryos of onchocerca (microfilariae) are ingested during feeding. The microfilariae develop in to infective larvae in the body of the fly after 6-10 days and then transmitted to humans during feeding and develop into adult worms.

The female worms can live in the human body for up to 12 years and produce millions of microfilariae, which migrate to the skin where they can be ingested by biting black flies. Transmission is most common near the fast flowing rivers or streams where the black flies breed and where they may attack humans in large numbers. Transmission does not take place below 18^{o}C and the disease occurs only in the tropics.

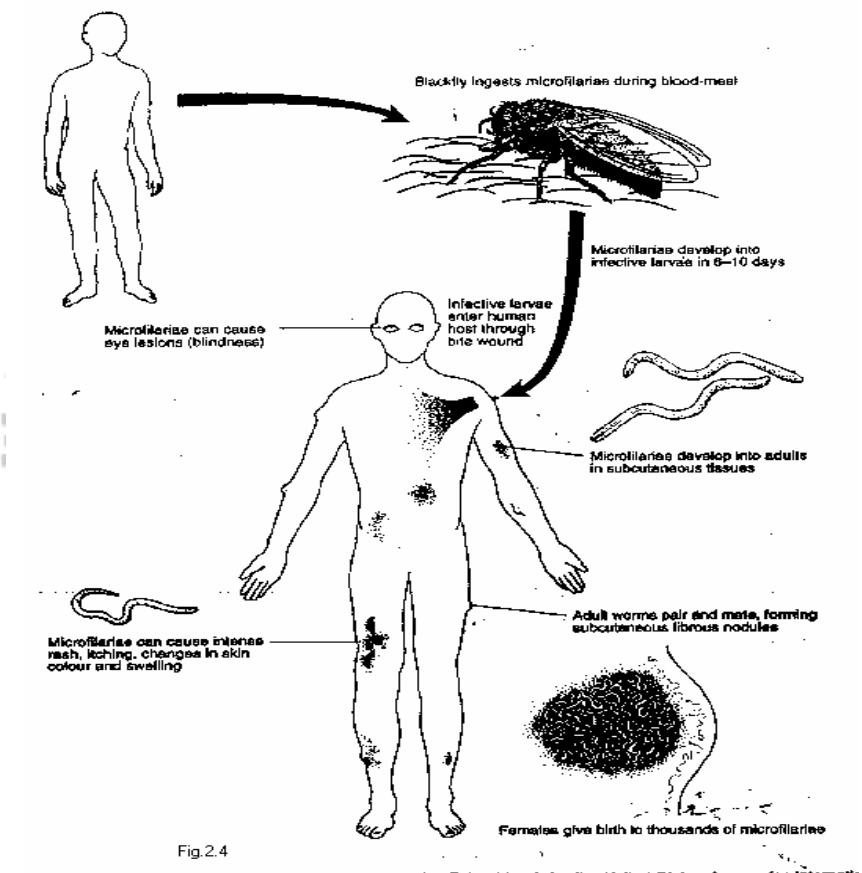


Fig.2.4

Life cycle of *Onchocerca volvulus* (by Taina Litwak for the United States Agency for International Development's VBC Project).

(Source: Jan A. Rozendaal: WHO 1997)

2.4. Prevention and Control:

1. Treatment of cases:

   The prevention of infection is possible through black fly control. Ivermectin kills the microfilariae but not the adult worms. However, annual re-treatment with one tablet is sufficient to prevent blindness. It is now being used on a large scale to treat infected people and to stop further development of the disease.
2. Biological control: - by the use of predatory fish and snail. In addition a bacteria known as Bacillus thuringiensis H-14 is used as a biological control against black fly.
3. Damming of stream: -

   By damming of a stream or a river- it is possible to reduce the speed of the water flow and then reduce the amount of dissolved oxygen and eventually the immature stage (larvae) die due to lack of oxygen.
4. Use of used up motor oil: - spraying of used up motor oil used to kill the immatured stages due to lack of oxygen (suffocation).
5. Application of insecticide:

   The application of insecticides to streams and rivers in order to destroy the larva is the only practical method of controlling the black fly vectors. The application of an insecticide to a selected breeding site also results in the killing of larvae in breeding sites located up to 10 km down stream. Among the commonly used larvicides are temephos, and phoxim. Temephos is the main larvicides used effectively in Africa at 0.05 mg/L dose. One of the reasons for the large-scale applications to extensive networks of water courses is the ability of the black flies to fly with the wind over distances of up to several hundreds of kilometers. Localized control of breeding sites would not be sufficient because of the likelihood of reinvasion from outside areas.
6. Personal protection measures during the day:
   - Proper clothing
   - Repellent
7. Avoiding washing of the body in fast flowing streams could help to

prevent from being bitten by the infective flies.

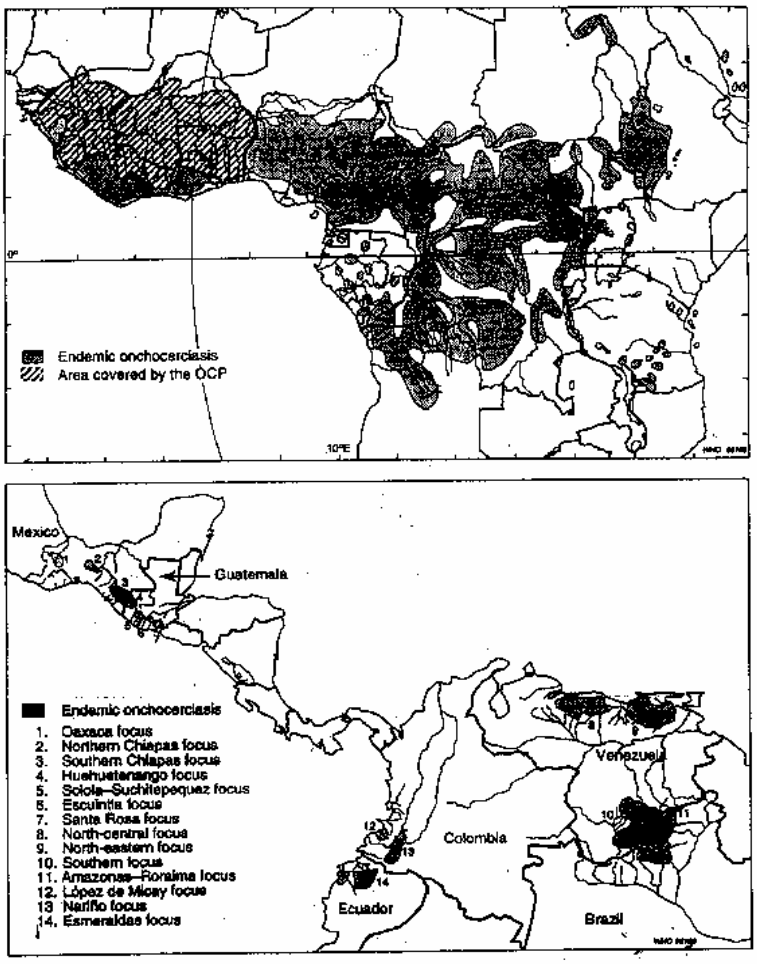


Fig. 2.5
Geographical distribution of onchocerciasis, 1995 (© WHO).

(Source: Jan A Rozendaal:WHO)

Sand Fly

Class –Insecta Common Name.

Order- Diptera

Family- Psychodidae

Genus -1. Phlebotomus ___ Sand fly.

Species: Phlebotomus longipes
Phlebotomus longerone
Phlebotomus pedifer
Phlebotomus orientalis
Phlebotomus argentipes
Phlebotomus papatasi
Phlebotomus chinengis.

Genus 2: Psychoda_____ filter fly. (Responsible for bronchial Asthma).

Species: Psychoda alternate.
Psychoda phalendoides

3.1 General Feature and Identification

Sand flies are small blood sucking flies that are important as vectors of Leishmaniasis and that can cause a serious but localized biting nuisance. Species that occur in the Mediterranean region can transmit sand fly fever, a viral disease also know as pappataci fever or three-day fever. They have a characteristic hopping flight with many short flights and landings. Sand flies are about 1.5mm to 2.5mm long. They have a hairy appearance conspicuous long and round black eyes with no eye bridge and stilt like legs, brownish colour. They have narrow wings-about 1.3 to 2.8mm longs. In contrast to all other biting diptera, the wing is held erect over the body when at rest. Sand flies usually bite after dark, but may bite in daytime during cloudy weather in forests. Only the females that bite and mostly feeding takes place outdoors but a few feeds indoors. Because of their short mouth parts they can not bite through clothing.

3.2 Life Cycle:

Sand flies are found in various habitats ranging from semi-desert to rain forest.

They deposit their eggs in humid places on damp soil rich in humus. The larvae feed on decaying organic matter. The life cycle may last from 1 to 4 months, depending on species and temperature, although it usually lasts less than 45 days.

Breeding is in the soil independent of surface water. Examples of suitable breeding sites are small cracks and holes in the ground, termite hills, animal burrows, cracks in mud walls and masonry, among tree roots, on decaying vegetable matter, sewage manure & rotten wood. Large populations of sand flies can build up in family compounds where cattle are kept at night. The cattle provide an abundant source of blood, while the stables and houses provide suitable resting places.

3.3 Resting Place, Food and Feeding:

Sand flies usually rest in the day time in sheltered, dark and humid sites, such as those used for breeding, but also in tree holes, caves, houses and stables; other resting places near houses are crevices in walls, stacks of fire wood, bricks and rubbish.

Sand flies feed on plants juices but most of the females need a blood meal in order to develop eggs. Autogeny occurs in a few species.

3.4 Medical Importance:

1. Nuisance:-

   Sand flies can cause a serious biting nuisance. Particularly ph. papatasi can be a pest causing irritation from its bites.

2. Leishmaniasis:-

   It is a zoonosis-caused by protozoan parasites of the genus leishmania, and occurs in both human and animals. Human leishmaniasis is of two types.

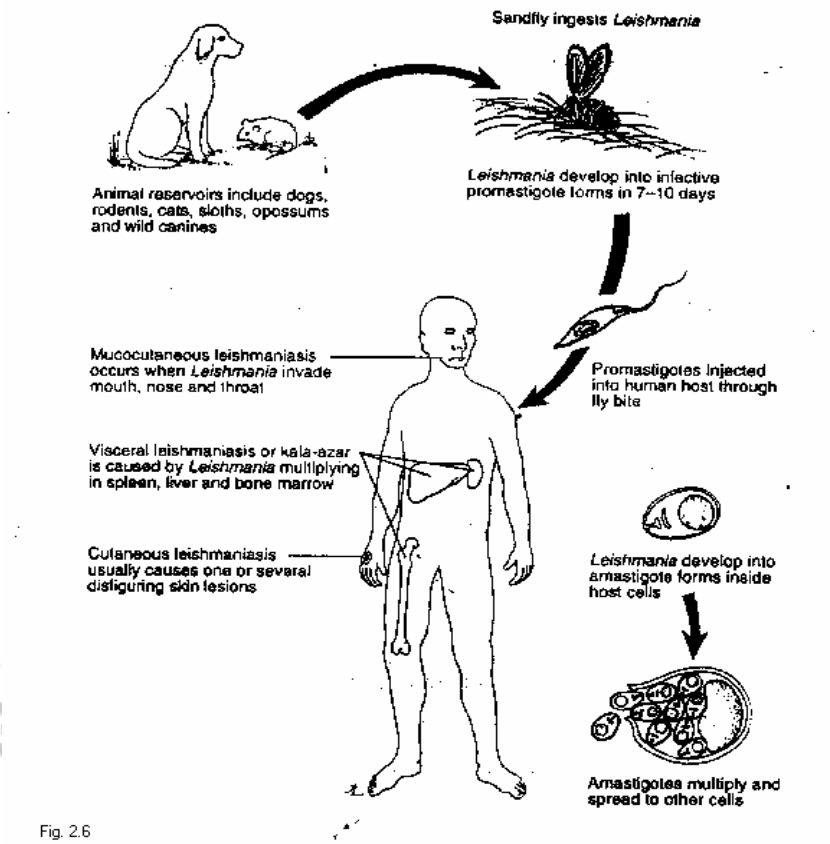


Fig. 2.6

Life cycle of *Leishmania* (by Taina Litwak for the United States Agency for International Development's VBC Project).

(Source: Jan A. Rozendaal: WHO 1997)

- Visceral leishmaniasis, also known as in Indian subcontinent by its Hindi name, kala-azar, is caused by Leishmania donovani, Leishmania infantum, or Leishmania chagasi, it is endemic in East Africa, the Indian subcontinent and south America. For all of this type of leishmaniasis canidae is the wild host.
- Cutaneous Leishmaniasis:-is known under a variety of common names such as oriental sore. It is caused by Leishmania tropica and Leishmania aethiopia and species of the brazilienses and mexicana complexes, and results in ulcers of the skin. It is the most common form of leishmaniasis and occurs in Afric a, South America, the Indian subcontinent, and south-West Asia. For this

disease rodents are the wild host.

- Mucocutaneous leishmaniasis:-also known in south America as espundia, is caused by Leishmania brazilienses. It is a disease of the skin and mucosal tissues in the nose and mouth, and can lead to gross deformities. Oronasal Leishmaniasis due to other Leishmania species has been recorded in Ethiopia and Sudan.

Transmission:

Most forms of leishmaniasis are primarily infections of small mammals. Humans are often infected by sand flies which previously fed on infected animals. For dermal and vesceral leishmaniasis, for instance, dog is a liaison carrier to man. The importance of animals as reservoirs of parasites varies from place to place and transmission from human to human also occurs. The sand fly species involved in transmission also vary from one place to another and often differ in their ecology and behavior.

Clinical Symptoms:

When visceral leishmaniasis (kal-azar) is endemic, Children are most affected. The disease starts slowly with fever, malaise, loss of weight and, in many cases, cough and diarrhea. A major clinical sign is enlargement of the spleen, liver and lymphadenopathy may be present. Kala-azar may cause darkening of the skin of the face, hands, feet and abdomen in India. Other signs are similar to those of malnutrition, such as edema and changes in skin and hair.

In cutaneous leishmaniasis typical ulcer starts as a nodule at the site of the sand fly bite; a crust develops in the middle which exposes the ulcer. The ulcer heals generally and leaves a permanent depressed scar different in color from the surrounding skin. Some ulcer do not heal with out treatment and may develop into mucocutaneous leishmaniasis. Some times the disease spreads via the lymphatic system and causes ulcers all over the body.

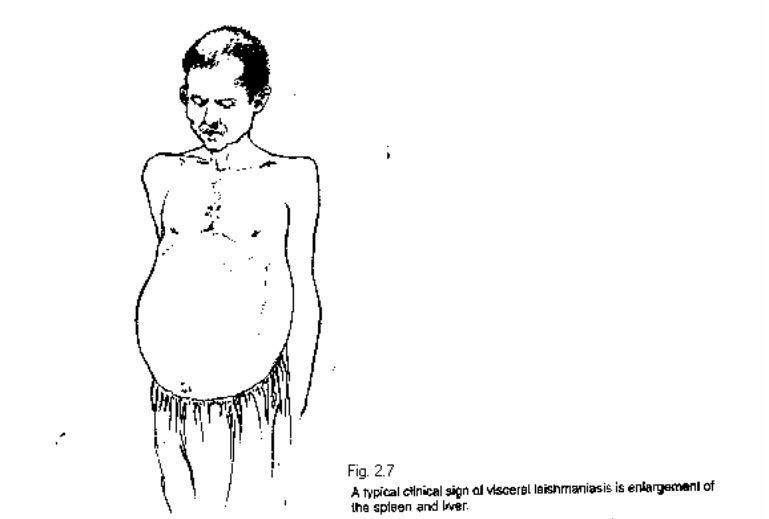


Fig. 2.7
A typical clinical sign of visceral leishmaniasis is enlargement of the spleen and liver.

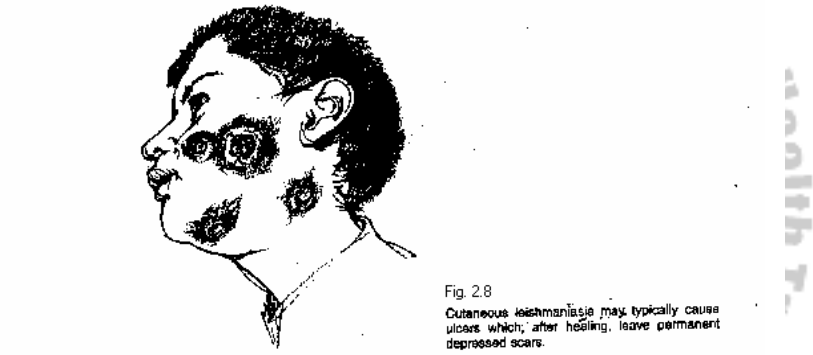


Fig. 2.8
Cutaneous leishmaniasis may typically cause ulcers which, after healing, leave permanent depressed scars.

(Source: Jan A. Rozendaal: WHO 1997)

In mucocutaneous leishmaniasis the soft tissue and cartilage in these areas are then progressively destroyed by ulcers and erosion. Swelling of the lips and nose may produce a so called “tapir nose”. Mutilations are severe and occasionally result in death due to malnutrition and bronchopneumonia.

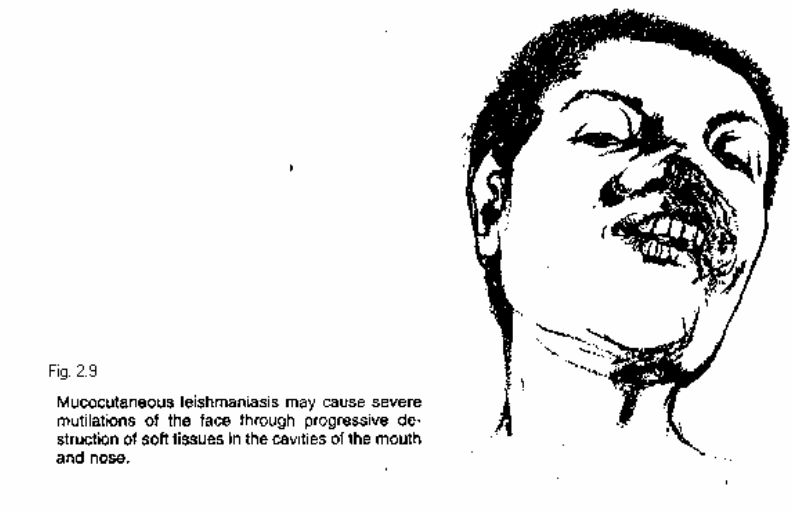


Fig. 2.9

Mucocutaneous leishmaniasis may cause severe mutilations of the face through progressive destruction of soft tissues in the cavities of the mouth and nose.

(Source: Jan A. Rozendaal: WHO 1997)

3.4 Prevention and Control:

1. Treatment:

Simple cutaneous leishmaniasis usually heals with out treatment and renders the person immune to other infections with the same parasite species. For this reason, infants have sometimes deliberately been infected on their back or buttocks to protect them from other infections which might have caused ugly scares on the face.

The other forms of leishmaniasis are difficult to treat and usually require a long course of pentavalent antimony-meglumine antimoniate or sodium stibogluconate.

2. Personal protection measure:

Individuals can prevent infection by avoiding being bitten by sand flies. It is recommended that personal protection measures be taken, that fine mesh or insecticide treated bed nets be used and that house improvements be carried out.

3. Application of Insecticide:

Indoor resting sand flies can be effectively controlled by spraying the inside surfaces of walls and the interiors and exteriors of doorways, windows and other openings with residual insecticide. Practically, insecticides have not been sprayed against leishmaniasis vector alone.

- DDT-suspension at the rate of 1g/m
- Solution-0.5g/m^2 can be used.

4. Control of animal reservoir:

In Ethiopia, control measures were carried out against the rock hyrax, a wild animal reservoir of leishmaniasis-where by reduction of the prevalence of leishmaniasis occurred. Similarly control measure against dog also used to reduce leishmaniasis.

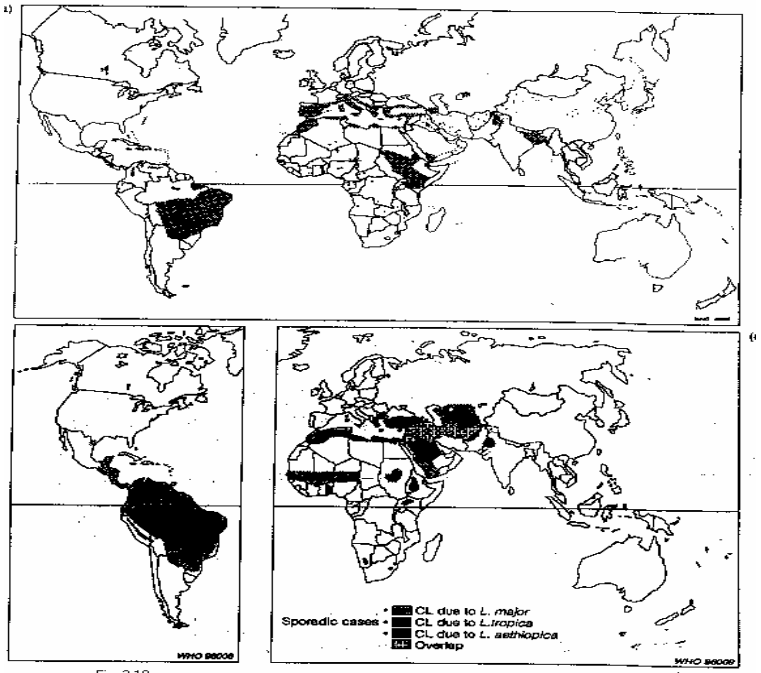


Fig. 2.10
Distribution of leishmaniasis: (a) visceral leishmaniasis in the Old and New World, 1989; (b) cutaneous and mucocutaneous leishmaniasis in the New World, 1996; (c) cutaneous leishmaniasis in the Old World, 1996 (© WHO).

(Souce: Jan a. Rozendaal: WHO 1997)

5. Application of basic sanitation:

It is possible to control the larva of leishmaniasis species by abolishing the breeding place around human habitation, such as proper disposal of refuse, filling of cracks in soil and walls and urbanization are some of the control methods.

4. Horse or Dear fly.

Class Insecta
Order Diptera
Family Tabanidae
Genus 1. Tabanus - horse fly.
2. Chrysops- Dear fly.

4.1. General Feature and Identification:

The tabanids are medium size to large and occur around the world. Their bite is very painful, particularly during summer they make out door activities difficult. They are most common in forests and swampy areas with woody vegetation. They do not usually enter houses to feed. They need a large quantity of blood and are frequently disturbed while feeding; for this reason they take several small blood meals from the same or different sources. The tabanids are especially active in day time, in bright sunshine.

The female tabanids feed on large domestic and wild animals, such as horses, cattle and deer, and also on small mammals, reptiles and birds. In addition they feed on humans. Most species feed in the day time especially during the sunniest hours. They hunt by sight and can fly over long distances. Their bites are deep and painful and wounds often continue to bleed after the flies have left.

The tabanids are 6 - 25mm long and powerful fliers. Some species are the largest biting diptera, having a wing span of 6.5cm. They vary in colour from very dark to light. They have a large head with large conspicuous eyes. The mouth part do not point forward (as in tsetse flies) but down ward. The wings are completely clean or have a brownish

colour. At rest the wings are folded flat along the body.

4.2. Life Cycle:

The eggs are deposited on the underside of objects such as leaves, plant stems and small branches hanging above water. After emerging the larvae drop down on to the underlying mud or water. The larvae of most species live in mud, rotting vegetation, humus, damp soil and shallow muddy water at the edges of pools, swamps and streams. They generally feed on decaying material of animal or vegetable origin. Depending on the species the larvae are between 1- 6 cm long. Development from egg to Adult may take 1-3 years.

4.3 Medical Importance:

1. Nuisance:-

Both male and female tabanids can cause sever annoyance because they inflict a painful bite and causing a very irritating pain.

2. Loiasis:-

This disease is caused by the filarial parasite loa loa. It is transmitted by deer flies of the genus chrysops and occurs only in woods and forests in West and Central Africa from Benin to Uganda and southern Sudan.
Its life cycle resembles that of Onchocercea volvulus. This adult worm lives in tissues under the skin. Migration of the worms under the skin may cause a pricking, and itching sensation. Infection sometimes causes swelling of various parts of the body. The larvae occur in the blood stream and are picked up by biting tabanids. Treatment is possible with diethyl carbamazine and ivermectin.

3. Tularaemia (Rabbit fever)

This is a bacterial disease transmitted by the bites of deer flies (chrysops) and hard ticks. The agent is Francisella tularensis. The symptoms which vary according to how the agent enters the body, include headache, chills, fever and the swelling of lymph nodes.

Transmission of the disease takes place through the bite of deer flies

and ticks or as a result of handling of infected animals such as rabbits and other game. Hunters and forest workers are at the highest risk of infection.

4.4. Prevention and Control

It is difficult to control both adult and larval stages of tabanids species because of their long flight range and due to a variety of suitable habitat for breeding. It is almost impossible to identify and control them by both physical means and by application of chemicals. But to get temporary relief particularly during their peak flight periods it is possible to spray residual Insecticides like DDT and non-residual insecticides like pyrethroids.

5. Mosquitoes:

Class Insecta

Order Diptera

Family Culicidae

Genus	1. Anopheles	2. Culex	3. Aedes
Species	Anopheles gambiae	Culex. pipens	Aedes. africanus
	Anopheles fenstus	Culex. fatigan	Aedes. aegypti
	Anopheles Christy	Culex. Quinquefascitus	Aedes.sipsoni
	Anoph.Caustani		Aedes albopectus
	Anoph. kingi		
	Anoph.marshalli		
	Anoph. nili		
	Anoph. dancalicum		
	Anoph. arabinesis		
	Anoph. balbacensis		

-
- **General Feature and Identification:**

The majority of mosquitoes are limited to aquatic habitats such as, tree

holes, pools, small ponds, and other stagnant water bodies. Mosquitoes are one of the most important groups of biting diptera, which have a long slender body and long, needle-shaped, piercing mouth parts. These are different from the diptera by their body shape, leg and mouth parts.

There are about 3000 species of mosquito, of which about 100 are vectors of human diseases. In countries with a temperate climate they are more important as nuisance pests than as vectors. Control measures are generally directed against only one or a few of the most important species and can be aimed at the adults or the larvae. Many species are not strong fliers and avoid strong wind.

Mosquitoes have one pair of narrow wings and halters; three pair of long thin legs.

The wings sometimes have patterns of scales. They have two large compound eyes. Paired palps are available on either side of the proboscis. Outside the palps and just below the eyes, there is a pair of antennae, which are heavily covered in long hairs for male mosquito and sparsely haired in female mosquito. This helps us to differentiate the blood sucking female from the non-biting male. Thorax holds three pair of legs and one pair of wings with a characteristics venation common to all mosquitoes. The wings are covered in flattened hairs or scales which may occur in dark patches. The adult mosquito is small and fragile insects ranging in body size from 2mm to 12.5 mm in length (from the tip of proboscis to the tip of the abdomen)

- **Life cycle:**

Mosquitoes have four distinct stages in their life cycle: egg, larva, pupa and adult. The females usually mate only once but produce eggs at intervals through out their life. In order to be able to do so most female mosquitoes require a blood meal.

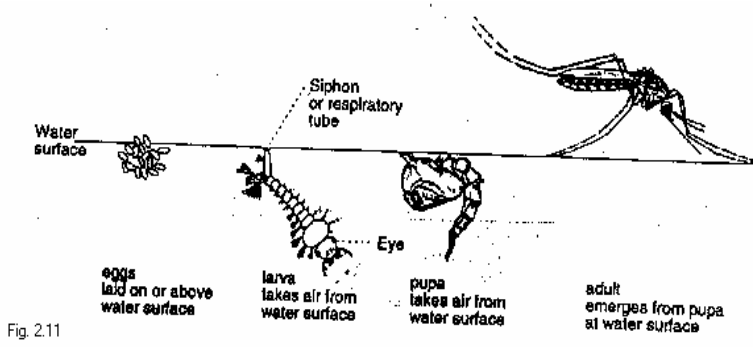


Fig. 2.11

The life cycle of the mosquito (© WHO).

Fig. 2.12

Freshly blood-fed mosquitos have a dilated abdomen.

(Source: Jan A.Rozendaal: WHO 1997)

Males do not suck blood but feed on plant juices. The digestion of a blood meal and the simultaneous development of eggs takes 2-3 days in the tropics but longer in temperate zones. The gravid females search for suitable places to deposit their eggs, after which another blood meal is taken and another batch of eggs is laid.

Depending on the species, a female lays between 30 and 300 eggs at a time. Many species lay their eggs directly on the surface of water, either singly (Anopheles) or stuck together in floating rafts (culex). In the tropics the eggs usually hatch with in 2-3 days. Some species like Aedes lay their eggs just above the water line or on wet mud; these eggs hatch only when flooded with water. If left dry they can remain viable for many weeks.

Once hatched the larvae do not grow continuously but in four different

stages (instars).The first instar measures about 1.5mm in length the fourth about 8-10mm. Although they have no legs, they have a well developed head and body covered with hairs, and swim with sweeping movements of the body. They feed on yeast, bacteria and small aquatic organisms. Most Mosquito larvae have a siphon located at the tip of the abdomen through which air is taken in and come to the water surface to breathe; they dive to the bottom for short periods in order to feed or escape danger. Anopheles larvae, which feed and breathe horizontally at the surface, have a rudimentary siphon. Larvae of mansonia do not need to come to the surface to breathes since they can obtain air by inserting the siphon in to a water plant to which they remain attached for most of the time.

In warm climates, the larval period lasts about 4-7days, or longer if there is a shortage of food. The fully grown larva then changes in to a comma shaped pupa; which does not feed but spends most of its time at the water surface. Unlike most insect pupae it is able to move around rapidly in water due to the presence of paired paddles at the end of the abdomen. If disturbed it dives swiftly to the bottom. In pupae the cephalothorax usually have a pair of respiratory trumpets which help to take in air, that attached to thoracic spiracles. The breathing trumpets of pupae of mansonia are different in that it is long and modified to pierce aquatic vegetation.

- **Feeding Habits:**

Female mosquito feed on animals and humans. Most species show a preference for certain animals or for humans. Mosquitoes are attracted by the body odours, carbondioxide and heat emitted from the animal or person.

Male mosquito normally feed on nectar and plant juice. Generally mosquitoes can be divided into two by their feeding habits. Those species of mosquitoes that bite man to obtain blood meal is called as antropophilic and those that prefer feeding on non-human animal and never bite humans called zoophilic. The anthropophilic mosquitoes can

be subdivided into endophagic and exophagic by their feeding habite. Endophagic mosquitoes feed on humans by entering houses where as the exophagic mosquitoes bite man outside the house or in the forest.

The behaviour of mosquitoes determines whether they are important as nuisance insects or vectors of disease, and governs the selection of control methods. Species that prefer to feed on animals are usually not very effective in transmitting diseases from person to person. Those that bite in the early evening may be more difficult to avoid than species that feed at night. Mosquitoes that rest indoors are the easiest to control.

5.1. Anopheles Mosquito

About 380 species of Anopheles occur around the world. Some 60 species are sufficiently attracted to humans to act as vector of malaria.

5.1.1. Anopheles Egg and Larva

After mating and blood feeding the gravid anopheles lay singly some 50-200 egg on water surface. It has a float and is boat shaped. The egg is white in colour when first deposited and after one or two hour it is changed to dark brown colour.

The larvae floats horizontally beneath the surface of the water. They have two pair of anterior hair, which help them to swim. It feed on small organic particles. (filter feeders) and when feeding the head normally rotate 180^0. Until disturbed the larvae remain at the water surface.

Larvae occur in different temporary and permanent habitat, but most anopheles larvae prefer clean and unpolluted water. They are absent from a water that contain rotting plants and faces. The most preferred breeding sites are pools, quiet places in slow running streams, rice fields, leaf axils of certain epiphytic plants and puddles of rain water. Anopheles larvae are absent in artificial containers except in the case of anopheles stephensi in south west Asia. Generally in the tropics the duration of development from egg to adult is 11-13 days.

5.1.2 Adult Habit

Anopheles mosquitoes are active between sunset and sunrise. Usually they become very active at twi- light. Each species has specific peak biting hours, and there are also variations in their preference for biting indoors or outdoors. The anophelines that enter houses to feed often rest indoors for a few hours after feeding. They may then leave for outdoor sheltered resting sites, among them vegetation, rodent burrows, cracks and crevices in trees or in the ground, caves and the undersides of bridges. Alternatively, they may stay indoors for the whole period needed to digest the blood meal and produce eggs. Indoor resting sites are scarce.

The resting position of adult anopheles is angled or perpendicular to the resting surface. Many adult species like their larvae can't survive in water polluted with organic debris, where as others can breed in contaminated water.

5.1.3. Public Health Importance:

1. Nuisance: some species of anopheles attack and may cause considerable annoyance. In some areas, particularly in the northern areas of temperate regions, out door activities can be made impossible by swarms of biting mosquitoes.

2. Malaria

Brief Introduction of malaria Epidemiology in Ethiopia

In Ethiopia, malaria is the most important causes of morbidity and mortality, and it is one of the five leading causes of hospital death (Ministry of Health, 1995). It is estimated that about ¾ of the country's population are at risk of malaria infection. Annually, over two million clinical cases of malaria are reported from the different health institutions.

Available data indicate that clinical malaria accounts for 10-40% of all out patient consultations. Malaria also accounts for up to 30% of all in-patient admissions with proportional waves of epidemics. In most part of the country, malaria transmission is seasonal and consequently communal

immunity is underdeveloped; and population at risk are exposed to frequent waves of epidemics.

Although all four plasmodium species have been reported from Ethiopia, plasmodium falciparum and P. vivax are dominant and roughly account for 60% and 40% of all malaria cases, respectively. The relative frequency of these species vary from season to season and from place to place. P. falciparum is predominant during the peak transmission season while P.vivax dominates during the dry season. P. malariae, restricted in distribution, accounts only to less than 1% of cases. P. ovalae is rarely reported in Ethiopia. P. falciparum is responsible for most, if not all, epidemics of malaria in Ethiopia.

The effort to control malaria in Ethiopia has been in operation since early 1960s, initially with an objective of eradication which later changed to prevention of mortality and reduction of morbidity and socio-economic losses due to the disease. Currently, malaria control activities focus on the provision of early diagnosis, prompt and effective treatment, application of selective and sustainable vector control measures and early detection, prevention and control of epidemics.

World wide distribution of malaria parasite

Only mosquitoes of the genus anopheles is responsible in transmitting the disease malaria. It is caused by a single celled protozoan parasite of the genus plasmodium. There are four species of plasmodium parasite that infect man.

- ► Plasmodium falciparum:- occurs through out tropical Africa, Asia, the Western pacific, South and Central America, Haiti and Dominican Republic.

- ► Plasmodium Vivax:- is one of the malaria parasite in Africa, and is the predominant malaria parasite in Asia and Western and Central America.
- ► Plasmodium malariae:- is found world wide but has a very patchy

distribution.

► Plasmodium ovale occurs mainly in tropical West Africa and rarely in the pacific.

Malaria is widely distributed in the tropics and also occurs in subtropical and temperate regions. It is among the most important causes of death and illnessin Africa, especially among children and pregnant women.

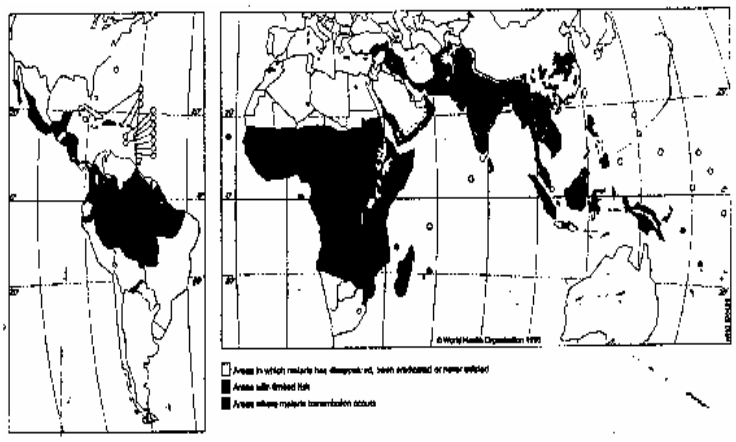


Fig. 2.13
Approximate distribution of malarious regions, 1996 (© WHO).

(Source: Jan A. Rozendaal: WHO 1997)

5.1.4. Transmission:

Malaria parasites enter the human body via the bite of a plasmodium carrying mosquito of the genus Anopheles. The parasite invades the liver via the blood stream and multiplies. The incubation period of the disease is about 9 to 12 days.

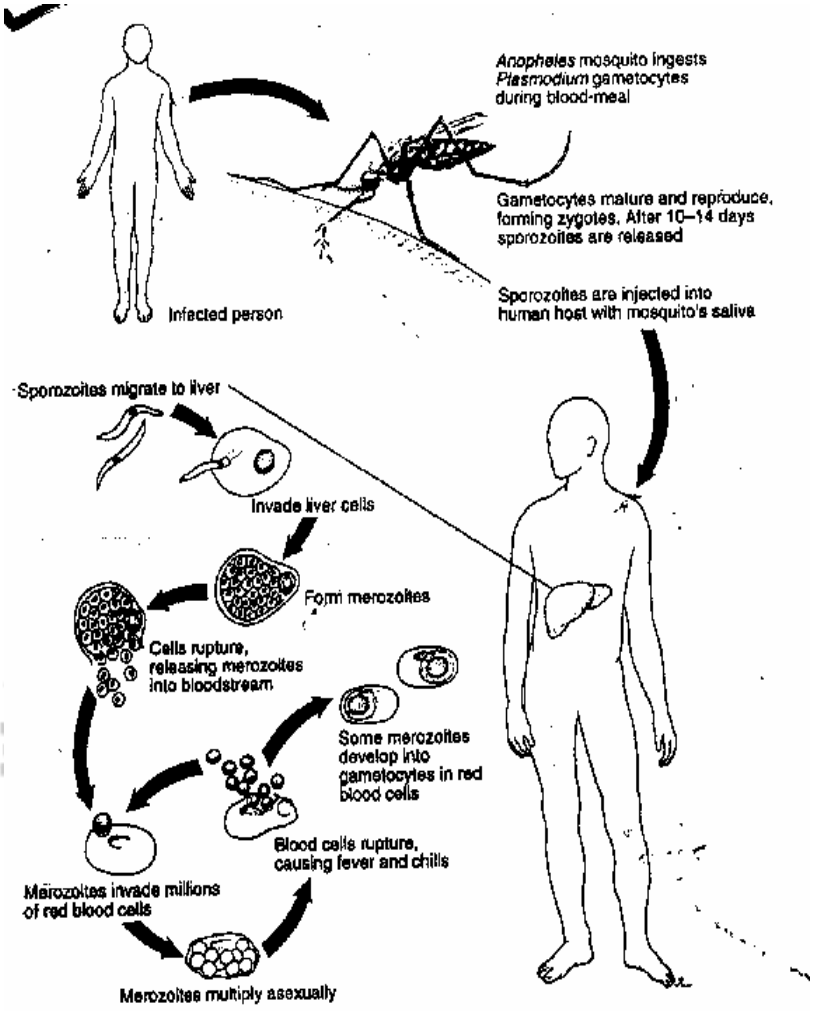


Fig. 2.14

Life cycle of the malaria parasite (by Taina Litwak for the United States Agency for International Development's VBC Project).

(Source: Jan A. Rozendaal: WHO 1997)

5.1.5. Clinical symptoms

Malaria begins with attacks of fever. Cycles of fever, shaking chills, drenching sweats, and headaches may develop. Malaria caused by Plasmodium falciparum does not always show this cyclic pattern. It is the most sever type of malaria and, if untreated, may progress to shock, kidney and liver failure, coma or death.

3. Filariasis

Lymphatic filariasis is caused by three species of parasitic worm which occur in the lymph vessels and may cause huge swellings of the limbs and other parts of the body. The disease is rarely life threatening. Some Anopheles species are responsible to transmit the Bancroftian filariasis in tropical Africa and other parts of the world.

5.1.6. Prevention and control

1. Personal protection measure:

Measures that are taken to avoid being bitten by anopheles mosquitoes includes the wearing of protective clothing, the use of repellents on exposed skin, sleeping under mosquito nets, and improving dwellings (Screening of doors and windows). Impregnated bed net gives good protection.

2. Measure against the Vector:

2.1. Biological control:

The biological control of mosquitoes involves introducing their natural enemies in to the environment, such as parasites, disease organisms and predatory animals. The use of larvivorous fish and the use of bacterial larvicides have become widely employed.

Larvivorous fish feed on mosquito larvae. They have been widely used around the world in attempts to control malaria, other mosquito-borne diseases and mosquito nuisance. Some of the most successful species to have been introduced in to different countries are mosquito fish-Gambusia affinis and Poecilia reticulata. Gambusia is most efficient in clean water, while poecilia can be used successfully in organically polluted water. It has to be noted that the impact of these predatory fish has never been sufficient to interrupt disease transmission.

2.2. Alteration of natural breeding place and media:

The filling of mosquito breeding sites with soil, stones, ash or rubbish is the most permanent control measure available. It is most suitable for reducing breeding in small depressions, water holes, burrow-pits, ditches

or pools, which do not require much filling material.

The drainage of water can be accomplished by constructing open ditches and dykes with tidal gates, subsoil drainage and pumping. This method is not also practical and effective for all anopheles species, for instance, Anopheles gambiae, the most important malaria vector in tropical Africa, occur in small temporary pools and puddles and Anopheles balbacensis also occur in forest swamps, therefore, drainage can not indeed affect them.

2.3. Application of Insecticides:

By the application of insecticide control mainly focus on adult. Powder of residual insecticide to the interior surface of wall, ceilings and roofs can be sprayed. In the absence of resistance DDT is the best dose at the rate of 2g/ m^2. In endemic areas houses need to be sprayed at six-monthly intervals. If malaria transmission is seasonal single spraying for a year is sufficient. For DDT resistant mosquito organophosphate insecticides such as malathion can be used. Since malathion is less persistent, spraying is need to be repeated at three to four monthly interval

2.4. Application of Larvicides

Application of larvicides such as temephos and burnt oil on larval infested water bodies used to control the larval population.

2.5 Culicinae Mosquitoes

The sub-family culicinae contains 30 genera, of which the medically important are the genera culex, Aedes, Mansonia, Sebethes and Haemagogus.

5.2.1. Culex Mosquitoes

About 550 species of culex have been described, most of them from tropical and subtropical regions. Some species are important as vectors of diseases and in some areas they are a considerable nuisance.

5.2.2. Life Cycle

Culex eggs have never floats like anopheles mosquitoes. Some 100 or more eggs are laid in the form of egg rafts. The rafts remain afloat until hatching occurs 2-3 days later. The position of culex larvae in the water is vertical which is opposite to anopheles mosquito. The larvae has siphon (air tube) which may be long and slender when compared to Aedes siphon. They hang upside down and at an angle from water surface when getting an air. The head of the larvae do not rotate while feeding.

Culex species breed in a large variety of still waters, ranging from artificial containers and catchment basins of drainage systems to large bodies of permanent water. The most common culex species, Culex quinquefasciatus breed in a water polluted with organic debris, such as rotting vegetation, household drains and ditches, in septic tank etc. In many developing countries culex quinquefasciatus is generally associated with urbanization and town with poor and inadequate sanitation.

Culex quinquefasciatus is markedly domestic species. The adult females bite human and animals at night, meaning nocturnal, meaning become active during the night. Biting takes place both in door and outdoors. During the day they are inactive and are often found resting in dark corners of rooms, shelters and culverts. They also rest outdoors on vegetation and in holes, in trees in forested areas.

5.2.3. Public Health Importance:

1. Nuisance:

In many area some species of culex are a major nuisance rather than transmitting diseases.

2. Lymphatic filariasis:

Culex quinquefasciatus is the most important vector of filariasis in tropical Africa, Asia and south America. There are two types of filariasis. The Bancroftian filariasis- caused by Wuchereria bancrofti, is mainly transmitted by culex quinquefasciatus and by some anopheles and

Aedes species. The Brugian filariasis, caused by Brugia timori and malayi. It is mainly transmitted by the vector mansonia species.

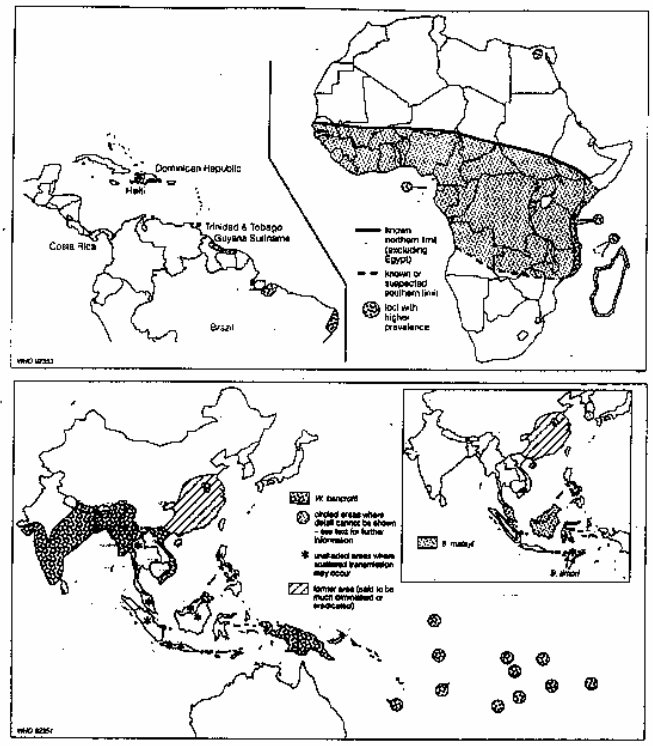


Fig. 2.15

Geographical distribution of lymphatic filariasis, 1992 (© WHO).

(Source: Jan A. Rozendaal: WHO 1997)

► **Transmission:**

The adult worms live in the lymphatic vessels in the human body and produce embryos called microfilariae, which circulate in the blood stream and are picked up by biting mosquitoes. After developing for several days in the mosquito, infective larvae enter the skin when the mosquito feeds, migrate to the lymph nodes and develop in to adult worms in the lymph vessels. The chance of an infection being established from a single bite by an infected mosquito is very low. The adult worms can live for many years, giving rise to large numbers of micro-filariae in the blood.

Severe inflammation of the lymphatic system and acute recurrent fever are some of the major clinical symptoms. Secondary bacterial infections are a major factor in the progression towards lymphoedema and elephantiasis- the characteristic swelling of the limbs, genitalia and breasts.

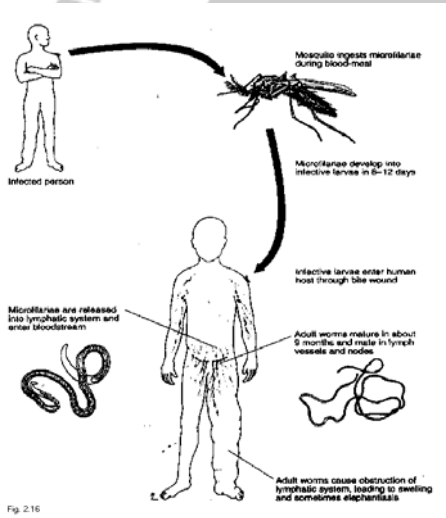


Fig. 2.16

Life cycle of filarial parasites (by Taina Litwak for the United States Agency for International Development's VBC Project).

(Source: Jan A. Rozendaal: WHO 1997)

Preventive and Control Measures:

1. Treatment of cases:

People who are infected can be treated with diethylcarbamazine (DEC). DEC is much more lethal to the microfilariae than to the adult worms, which may only be killed after prolonged treatment.

2. Application of Basic sanitation:

The control or elimination of breeding sites in polluted water is possible by improving sanitation systems and hygiene in general. By improving surface water drainage, covering septic tank, filling sewage lagoons, and by preventing water from collecting on unoccupied building plots helps to reduce or eliminate breeding sites. Where such improvements are impossible, larvicides or polystyrene beads can be applied to breeding sites. Polystyrene beads prevents the breathing tube of the larvae/ pupae from having access to the air and also inhibits egg laying by preventing the female mosquito from having access to the water.

3. Application Insecticides:

Indoor residual spraying is generally not very effective against culex quinquefasciatus, partly because of the habit resting on unsprayed objects, such as clothes, curtains etc. rather than on walls and ceilings. Treated bed net can give good protection. Out side resting place can be sprayed with residual insecticide to control adult population.

5.3 Aedes Mosquito

Aedes mosquitoes occur in the world and there are over 950 species. Most Aedes adults have conspicuous patterns on the thorax formed by black, white or silvery scales. Aedes aegypti is readily recognized by “lyre” shaped markings.

5.3.1. Life Cycle:

The eggs are laid singly on damp surfaces just above or near the water line in temporary pools and other habitats where the water level rises and falls. They can withstand desiccation for many months and hatch only

when flooded with water.

Aedes aegypti mainly breeds in the domestic environment. Its preferred habitats are water storage tanks and jars inside and outside houses, and roof gutters, leaf axils, bamboo stumps and temporary containers such as jars, drums, used car tyres, tin cans etc. All these habitats contain relatively clean water.

Aedes albopictus breeds in temporary containers but prefers natural ones in forests, such as tree holes, leaf axils, ground pools and coconut shells and breeds more often outdoors in gardens and less frequently indoors in artificial containers.

5.3.2. Biting Habit

Aedes mosquitoes bites mainly during the day or early evening. Most biting occurs out of door. But in tropical areas Aedes aegypti breeds, feeds and rests in and around houses.

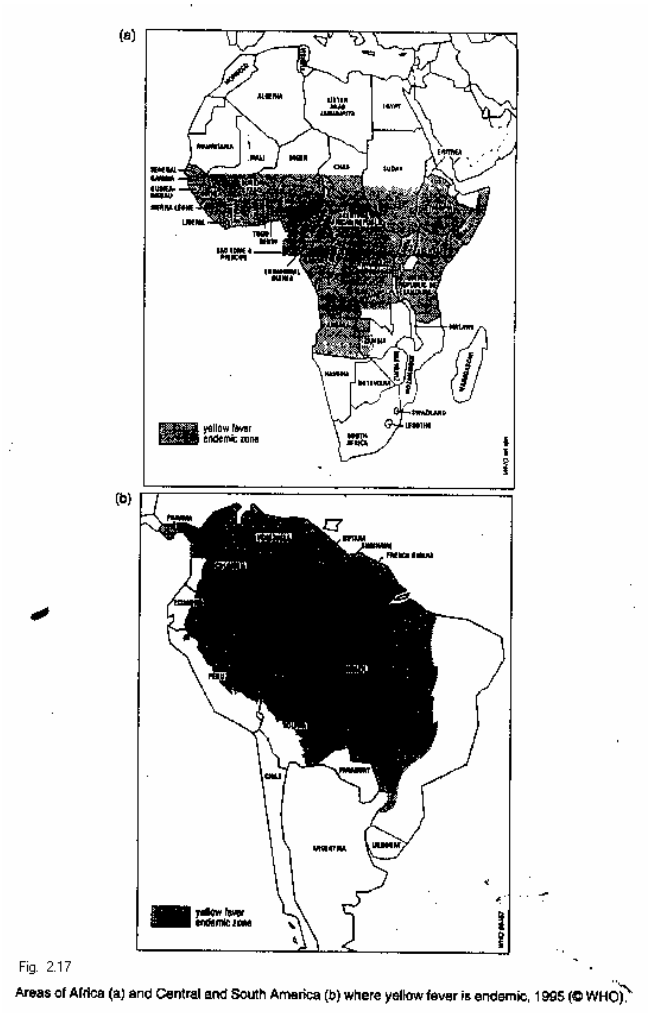


Fig. 2.17
Areas of Africa (a) and Central and South America (b) where yellow fever is endemic, 1995 (© WHO).

(Source: Jan A. Rozendaal: WHO 1997)

5.3.3. Public Health Importance:

1. Nuisance:- mosquitoes are a troublesome bitters, in addition to vectors of diseases.

2. Yellow Fever:

Yellow fever is a zoonosis, essentially a disease of forest monkeys, which occasionally transmitted to man. It is an acute disease of short duration which often causes death.

The disease starts with a high fever, headache, body aches, vomiting and sometimes jaundice(which gives the patient a yellow colour). This is followed by internal haemorrhages (bleeding) and vomiting. Death may occur with in three days after the onset of the disease.

The yellow fever virus mainly occurs in populations of monkeys in dense forests and gallery forests in Africa and South and Central America. The disease is transmitted from monkey to monkey by forest dwelling mosquitoes called Aedes Africanus in Africa, Haemagogus and Sabethes in south and Central America.

In Africa monkeys sometimes leave the forest in search of bananas in plantations and may then infect the local mosquito species,(Aedes simpsoni) which intern infect humans living or working on the plantation. People infected in or near forests can carry the virus to rural or urban areas where Aedes agypti or related mosquito can pick it up and transmit it among the human population.

3. Dengue and dengue haemorrhagic fever:

Dengue is caused by several closely related arboviruses, called dengue types 1,2,3 and 4. The disease is transmitted from person to person mainly by Aedes aegypti, but Aedes albopictus can also act as a vector. Dengue fever is the common disease in tropical and subtropical countries.

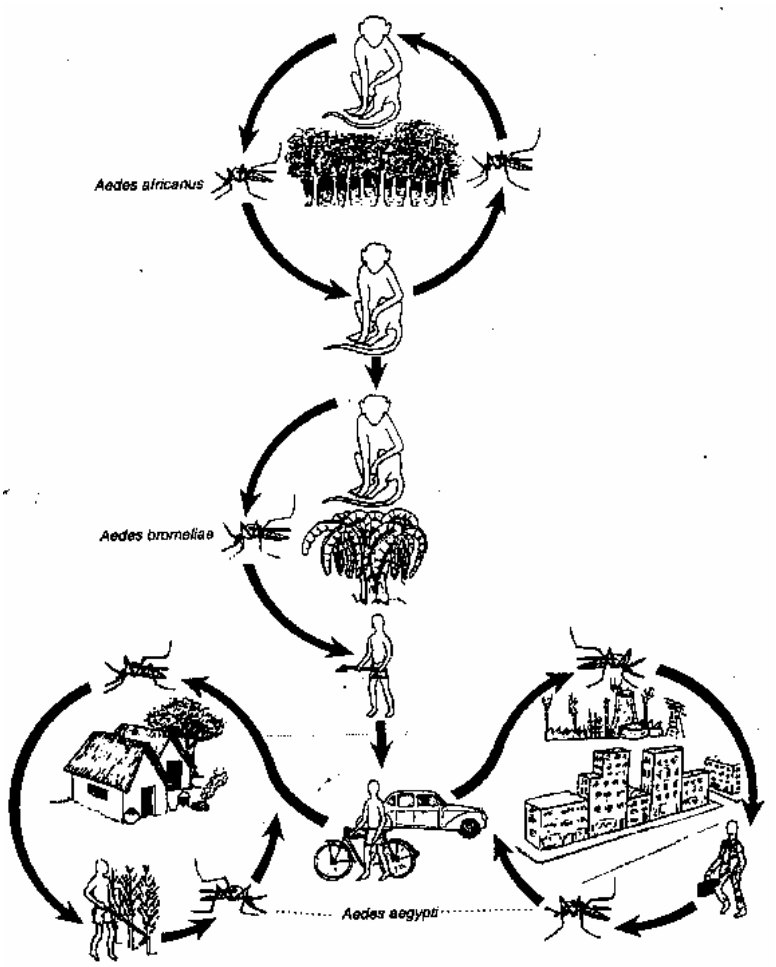


Fig. 2.18
Sylvatic, rural and urban transmission cycles of yellow fever in Africa (2). Copyright Blackwell Science Ltd.

(Source: Jan A. Rozendaal: WHO 1997)

2.120
Internal bleeding in dengue haemorrhagic fever may cause darkening of the skin of the face and hands. Children are most commonly affected.

(Source: Jan A. Rozendaal: WHO 1997)

5.3.4. Prevention and Control techniques:

1. Application of basic sanitation:

It is possible to abolish man made as well as natural containers to reduce or control mosquitoes breeding sites. The disadvantage of this method is that it is very difficult to persuade people to cover and change water at regular interval.

2. Personal protection measure:

It is also recommended the use of personal protection measure against day time biting mosquitoes, including the use of protective clothing, repellents and house screening.

3. Application of Insecticides:

Environmental management can not act sufficiently to arrest epidemics. Therefore, ground based ultra-low volume applications of insecticides such as malathion are used against adult. Insecticidal sprays are usually applied to the parts of towns where abundant breeding sites are available supporting large populations of Aedes. Residual wall spraying against Ae. aegypti is generally ineffective as this species normally rests indoors on surfaces that are not suitable for spraying such as curtains and other fabrics.

4. Larvicides:

Temephos can safely be used in potable water as larvicides.

Determination of Sex of a Mosquito:

The sex of a mosquito can be determined by the following characters.

S.No	Character.	Female	Male
1.	Proboscis	Sharp	Blunt
2.	Bite	yes	NO
3.	Antennae	Slender, thin and sparsely haired.	Thick, bushy and heavily haired.

Differentiation of Anopheles larvae from Culled Larvae

Sen.	Character	Anoph., larva	Culex larva.
1.	Siphon	Short	Longer
2.	Body at rest.	Parallel	Vertical or an angle to the water surface.
3.	Head	Rotates 180^0 when feeding.	Do not rotate
4.	Float hairs	Bushy	Simple.

Differentiation of Adult Culex from Adult Anopheles.

S.No.	Character.	Adult Culex.	Adult Anopheles.
1.	Palp	Shorter than proboscis and not clubbed at the tip	As long as proboscis and clubbed at the tip.
2.	Resting position	Parallel	Angled or perpendicular.
3.	Wing	Not spotted (clear)	Highly spotted (marked)
4.	Scutellum	Tri-lobed	One lobe.

6 . Lice Control

Class Insecta

Order - Anoplura

Family - Pediculidae

Genus 1. Pediculus

Species 1.1. Pediculus humanus corporis - Body louse.

1.2. Pediculus humanus capitis - Hair louse.

Genus 2. Phthirus

Species 2.1. Phthirus pubis - Crab or Pubic louse.

6.1. General Feature and Identification

Lice are small wingless blood sucking insects with leathery integument's, and live on the skin of mammals and birds. Three species of lice have adapted themselves to humans; the head louse, the body louse and the crab louse. Three of them occur world wide. They feed several times a day. Lice can only develop in a warm environment close to human skin, and die within a few days if they lose contact with the human body. In other words all species and forms of lice spend their whole life cycle on the host, and away from which they can't thrive for more than a short time. They are normally spread by direct contact, usually by some articles of clothing or bedding used by an infested (lousy) person. Transmission usually takes place at time of high fever or sweating, example, in overcrowded sleeping quarters and other crowded living conditions.

Adult body and head lice are 2-4 mm in length. The crab louse is about 2mm long. The louse normally is grayish in color and that of crab louse after fed is darken. All louse species have distinct head which is narrower than the thorax, one pair of short antennae; a pair of simple eyes. Thorax has 3 pair of short and stout well developed legs which have spine and claw that help to grip hairs of the host or his clothing's. The segmented abdomen is bilobed in the female lice and in the male the pointed aedeagus protrudes from the end of the abdomen. The head

lice are usually smaller than body lice, but otherwise there are only minor anatomical differences.

6.2. Life Cycle

All lice undergo an incomplete metamorphosis. The gravid human lice lay about six pinkish eggs a day which glued individually to hair for hair louse and glued to seams and threads of clothing for body louse. Female lice live for about one month and during this time, lay about 200 - 300 eggs.

The nymph of both louses resembles the adults in general appearance, and it also sucks blood. Nymph with in 10 days changed to adults. Generally for egg to hatch, for nymphs to pass through three stages, and for adults to reach to sexual maturity takes two to four weeks depending on temperature.

6.3. Habits and Habitat

The body louse live only on the body being attached to clothing in contact with the body, it commonly exist on under wear, armpits, waist line, collar and shoulder. They attach themselves to body hair only when feeding. The eggs are attached to thin threads of clothing. Body lice are most common in colder area where people do not frequently wash or change clothes.

The head louse is the most common louse species in humans. It is generally confined to the hair of the head, and sometimes found on hairs on other parts of the body. It mainly occurs on the scalp and the back of the head and behind the ears in children. The eggs (nits) are firmly glued to the base of hairs of the head.

Head lice are spread by close contact between people, such as children at play or sleeping in the same bed. Head lice are also spread by the use of other people’s combs that carry hairs with eggs or lice attached.

The crab lice, also called pubic lice, are grayish-white and crab-like in appearance. They lives on the hairs in the pubic area and rarely found

else where on the body. Eggs are laid at the base of the pubic hair. Crab lice are usually spread through sexual contact or other close personal contact, and are most common in young, sexually active adults.

6.4. Public Health Importance

1. Nuisance:

The presence of body and head louse on a person is sometimes referred to us pediculosis. For pubic louse it is called pediculosus pubis or phthiriasis. Lice feed several times a day and heavy infestations can cause intense irritation and severe itching. Toxic reaction to the saliva injected in to the skin may lead to weariness and a general feeling of illness. The scratching of the bite may give rise to secondary infection.

3. Louse borne epidemic typhus:

This disease is caused by a microorganism, Rickettsia prowazekii, and it is an acute, highly infectious disease with headache, chills, fever and general pains. The disease has occurred on all continents except Australia. It is prevalent in cool areas where heavy clothing is worn and where the vector is most common.

Transmission

Richettsia prowazeki ingested with the blood meal taken by both male, female, and by their nymphs from infected person, and then the agent passed out with faeces. The dry powdered louse faeces can infect small wounds, such as those caused by scratching, or the mucous membranes of the nose and mouth. It is dangerous to handle the clothing or bedding of patients with typhus because it is believed that the Rickettsia prowazeki can remain alive for about a month in dried louse feces.

3. Louse borne Relapsing fever:

The disease is caused by a microorganism called Borrelia recurrentis. The agent is entirely transmitted by body louse like in typhus. The infected person suffers of fever, lasting 2-9 days which alternate with periods of 2 - 4 days without fever. During epidemics the mortality rate

among untreated may go as high as 50 %. the disease occurs in limited areas of Africa, Asia and South America.

Transmission of Relapsing fever

The causative agent ingested with blood meal from infected person. The agent under take growth in the tissues of louse outside the gut, and therefore, for the disease to be transmitted the infected louse must be crushed between the finger nails or the teeth. The organisms are then released and can enter the body through abrasions, wounds or the mucous membranes of the mouth. Neither the bite nor the fecula is infectious.

4. Trench Fever:

The disease caused by a bacteria called Rochalima eaquintana, which involves intermittent fever, aches and pains all over the body, and many relapses. It rarely result death. The disease can occur every where the human body louse exist. Cases have been detected in Ethiopia and other parts of the body. Transmission is through infected louse feces like that of typhus fever.

6.5. Prevention and Control methods

1. Personal hygiene:

The most obvious way to eradicate body lice from a person is by changing and washing of clothing, preferably followed by ironing and regular body bathing. Regular washing of head with soap and combing may reduce the number of nymphs and adults on the hair. All hair can be shaved from the head to eradicate both the adults and nymphs.

2. Better housing condition and sanitary facilities:

Good house keeping and the presence of washing facilities encourage body and cloth washing and therefore, promote personal hygiene and avoid re-infestation.

4. Application of Insecticide:

Insecticide applications to the hair and body give the most effective control against the nymph and adult louse. They can be in the form of shampoos, lotions, emulsions or powder.

To avoid re-infestation after cleanliness, application of insecticide is very important. Ten percent DDT dust can be blown between the body and under cloths. Insecticidal formulated for this purpose can also be used. The active ingredient is usually malathion or carbaryl which will kill all stages including eggs. During epidemic all members of the house/ community should be treated at the same time.

4. Health education:

Specially during epidemic mass health education is very important to give up disease transmission.

7. Flea Control:

Class- Insecta

Order - Siphonaptera

Family	Genus	species	Common name.
1. Pulicidae	Pulex	P. irritans.	Human flea
2. Tungidae	Tunga	T. penetrans	Jigger flea
3. Ctenocephalidae	Ctenocephala	1. Ct. canis	Dog flea
		2. Ct. felis	Cat flea
4. Xenopsyllidae	Xenopsylla	1. X. cheopis	Oriental rat flea
5. Ceratophyllidae	Ceratophylla	Ce. gallinae	Hen flea.

7.1. General Feature and Identification:

There are about 3000 species of fleas worldwide. They are a small, wingless blood sucking insects and temporary ecto-parasites of warm blooded animals, mainly mammals. But a few species feeds on birds, and small proportions attack humans.

Fleas are comparatively host specific, but often feed readily on other animals if their preferred host is not available. They are laterally flattened from side to side as opposed to dorsoventrally in most insects. It is a useful adaptation to enable them to move easily through the hairs or feathers of their hosts.

Fleas are small, wingless insects with oval shape and dark brown color. Adult length is about 1- 4 mm. They have small head, which bears proboscis that projects down wards; small antennae and pair of single eyes with some exceptional fleas that are blind (mouse flea). Thorax bears three pair of powerful and well developed legs which are specialized for jumping. The three distinct segments on the thorax called pro, meso, and meta thorax. Each thoracic segment has conspicuous dorsal plat named as pronotum, mesonotum and metanotum respectively. Posterior margin of the pronotum may form a teeth like coarse spines (bristle) called pronotum comb (thoracic comb).

Some species of flea may have well developed coarse spines along the bottom margin of the head capsule known as the genal comb. Some genera of fleas lack both the pronotal and genal comb and are called combless fleas.(Eg. Pulex irritans and Xenopsylla species).

7.2. Life Cycle

The life cycle of fleas is a holometabolous cycle, and has four stages. The developmental stage typically takes place in the resting place of the host, and in the nest, burrows and other habitation. After taking a blood meal female flea lay about 20 - 30 egg per day. The eggs are comparatively large about 0. 5 mm in length; oval or round in shape; white in color; usually eggs are laid in the hosts resting place or sometimes on the host itself from where they fall to the ground.

Egg hatch after a week (2 - 12 days) to larvae. The larvae have chewing mouth part and small antennae. It is 4 - 10 mm long and white in color. Larvae has no legs but very mobile. Some of the blood taken by adult flea defecated in to the habitat where it dries and provides nutriment for the larval stage (unusual form of parental care). The larvae feed on organic matter such as the feces of the host, small dead insects and undigested blood expelled by adult fleas. Larvae moult 2 - 4 times, then the matured larvae spine a cocoon around itself, inside which it pupates.

The adult will break out of the pupal case with in a week or two, but it can remain inside the cocoon up to a year depending on the availability of the host. Thus, a heavy flea infestation may appear in a building or room which has been unoccupied for some time.

7.3. Feeding habit

The male and female flea requires blood for nutrition, and feed on nothing else. The female requires blood from her preferred host in order to lay viable eggs. Fleas avoid light and are mostly found among the hairs or feathers of animals or in beds and in people's clothing. If possible, a flea will feed several times during the day or night.

Most flea species feed on one or two host species, but in the absence of their normal host they feed on humans or other animals.

7.4. Public Health Importance:

1. Flea Nuisance:

Although a certain species of fleas are vectors of diseases, the most widespread complaint about them is the annoyance caused by the bite. Particularly ctenocephalida felis and canis are able to bite and cause a very irritating pain. Heavy flea infestation may cause allergic reactions and dermatitis.

2. Tungosis (Chigoes):

The sand flea, chigoe or jigger flea (Tunga penetrans) is a nuisance because the females burrow in to the skin. The adult flea after

copulation, the fertilized females attach themselves under the skin of humans, pigs, dogs, poultry and other animals, penetrating soft areas of skin. The soft skin between the toes or under toe nails is found to be the bestsite. Other parts of the body might be attacked during heavy infestation. (hand, arm etc.).

The flea burrows entirely in to the skin with the exception of the tip of the abdomen. It feeds on body fluids and swells up to the size and shape of a small pea in 8 - 12 days. The body of the female flea is completely filled with thousands of eggs which are expelled in the next seven days. Most of the eggs fall to the ground where they hatch after a few days.

3. Parasitic worms (Cestods):

Several parasitic worms are associated with flea. For instance, the Diphylidium caninum is a common worms of dogs and cats, and also uncommon human parasite. Cat flea, dog flea and rarely human flea are important intermediate host of this tape worm. Animals (dog and cat) become infected by swallowing such an infected fleas when, for example, licking its coat. Similarly such fleas do occasionally contaminate food or water of human consumption then which eventually cause helminthosis in humans.

4. Plague:

Plague is a disease caused by the bacterium Yersinia pestis. It occurs primarily in wild rodent population. Plague bacteria are transmitted by fleas, and humans may be infected by fleas that have fed on infected animals. Rural plague is acquired by people entering rural area and handling wild animals. Most at risk are hunters who may be bitten by infected fleas while handling recently killed animals.

Urban plague may occur when rats living in and around human dwellings are infected. Rat fleas that normally feed on rats may occasionally feed on humans and thus spread the disease. Other fleas, such as human flea, may subsequently transmit the disease from person to person. Generally there are three clinical types of plague:

- Bubonic plague:- is one type of plague in which the suppressed bacteria localized in the lymph nodes, especially in the armpits and

groin. This form is the commonest form of plague and transmitted to humans by infected fleas. If left untreated, it causes death in about 50 % of cases.

- Pneumonic plague:- it is a secondary form in which the lungs become affected. It is highly contagious, the plague bacillus easily spreading from person to person in sputum or droplets coughed up or sneezed by sick people. Therefore, in this form of plague an infected person can transmit the disease to other person with out involving the fleas. If left untreated it very often result death.
- Septicaemic plague:- by this form , the blood stream is invaded by the bacillus, resulting in death before one of the above two form can develop. In this form there is a possibility that a flea can acquire the bacteria from sick person.

5. Tularemia (Rabbit fever):

It is a plague like disease of mammals such as squirrels, water rat and rabbit. It is caused by the infectious agent francisella tularensis. Transmission of the disease takes place as a result of handling of infected animals such as rabbits and other animals. Hunters and forest workers are at the highest risk of infection.

6. Murine typhus (flea borne typhus):

It is caused by Rickettsia typhi and occurs sporadically in population of rat and mice. In man the disease is clinically a mild disease than epidemic typhus.

The disease is transmitted mainly by rat fleas and cat fleas, and humans become infected as a result of contamination from the dried feces and crushed bodies of the fleas. The disease occurs worldwide and is found in areas where people and rats live in the same building.

7.5. Prevention and Control Measure:

1. Promote house cleanliness: (Simple hygienic measure)

Fleas and their eggs, larvae and cocoons can be effectively removed by keeping houses well swept and floors washed. Earthen floors attracts fleas. Therefore, regular wet sweeping of floors reduce fleas infestation and/or multiplication.

2. Self Protection:

An effective repellent such as DEET, applied to skin and clothing, prevents fleas from attacking. In addition to specifically attack, jigger fleas wearing of shoes prevents attacks.

3. Application of insecticides:

Heavy infestations can be controlled by spraying or dusting insecticides in to cracks and crevices, corners of rooms and areas where flea and their larvae are likely to occur. Insecticides can also be applied to clothing and the fur of animals. Insecticides that have a very fast knockdown effect are used such as the pyrethroids, propoxur and bendiocarb. However, the insecticidal effect is brief and re-infestations may appear quickly.

8. Control of Dedbugs:

Class – Insecta	Common Name.
Order Hemiptera ---	Bugs.
Family 1. Cimicidae -	Bed bugs.
2. Reduvidae	
Genus - Cimex	
Species 1. C. lecturalit__	Temperate bedbugs.
2. C. hemipterus__	Tropical bedbugs.

8.1. General Feature and Identification:

Bedbugs belong to the order hemiptera known as “bugs.” The majority of bugs are plant feeders, having mouth parts adapted for piercing vegetation and sucking fluids from the stems and leaves. Many bugs such as aphids are important agricultural pest and will carry a number of viral diseases from infected to uninfected crops. Two families of bugs - Cimicidae and Reduvidae contains members whose mouth parts adapted to feed on blood. The cone-nose bugs with in family Reduvidae occur only in new world and can transmit chagas disease.

Bedbugs under family cimicidae are temporary ectoparasites of humans. They are a severe nuisance when they occur in large densities, being

commonest in places with poor housing conditions. Bedbugs have a flat, oval-shaped body with no wings, and are 4-7 mm long. Their color is shiny reddish- brown but after a blood meal they become swollen and dark brown in color. They have short and broad head, which bears pair of antennae, pair of small dark compound eye and long slender proboscis.

Bedbugs are without functional wings, but fore wings remain represented in adult by two small brown pad on the top of the thorax. They have three pairs of well developed legs, which enable them to crawl rapidly. The abdomen is large and segmented. The tip of the abdomen is rounded in female and pointed in the male with a curved penis at the end. Both sex suck blood including the nymphs. They have a disagreable smell.

Bedbugs are active during the night (meaning nocturnal in their activity). Blood feeding carried out at night while the host is sleeping. If they get starved- can feed on man during the day. Feeding takes 10 - 15 minutes for adults, less for nymphs, and is repeated about every three days. The presence of bedbugs is detected by their fecal spot, eggs and cast skin. They attracted to a potential blood meal by the exhaled carbondioxide. Analogues to roaches they are able to live for a long period of time without food (a year).
During the day they hide in cracks, crevices, behind wall paper, in furniture including beds, chair etc.

8.2. Life Cycle

Bedbugs pass through incomplete metamorphosis. After mating female lay 2 - 3 eggs every day for the rest of her life. The eggs are white and about 1mm long. Egg hatch in 8-11 days at room temperature (20^{o}C). Sometimes hatching takes place in less than a week, if temperature is about 25-27 ^{0}C. Egg will not hatch at all below 14^{0}C.

There are five nymphal stages and each will take one or more blood meals. The nymph look like adults but are smaller. Complete development from egg to adult takes from six weeks to several months, depending on temperature and the availability of food. In the absence on humans bedbugs feed on mice, rats, chickens and other animals.

8.3. Public Health Importance:

1. Biting nuisance:

Bedbugs are an important biting nuisance. People never bitten before may suffer from local inflammation, intense itching and sleepless night. The bite produces a hard whitish swelling that often continues to bleed. Scratching may cause secondary infections.

There is no evidence that bedbugs are vectors of any disease under natural condition. But it has been suggested that they play a role as vectors of the hepatitis B virus. Cases of Iron deficiency have been reported in India on infants, due to their extreme feeding.

8.4. Prevention and Control Measures:

Generally bedbugs are more difficult to control, because they tend to hide deeper in to their harbourages. In any case, the following methods can be applied.

1. Application of basic sanitation:

Through proper house maintenance, detaching of houses and furniture cleanliness, it is possible to attack bedbugs. In other words by eradicating cracks and crevices in walls and ceiling, preventing their entrance from near by dwellings and abolishing their harbourage used to reduce their population.

Light infestations can be treated by thoroughly cleaning infested articles, pouring boiling water over infested goods and housing structures by exposing articles to sunlight.

2. Application of Insecticide:

Aerosol spray cans can be used to spray household insecticides on to mattresses, in crevices in walls, and in other possible hiding places. Among the effective insecticides are the pyrethroids, propoxur, bendiocarb and dichlorvos.

Houses with heavy infestations need to be treated with long-lasting residual insecticide. One treatment is normally sufficient to eliminate bedbugs but, if an infestation persists, re-treatments should be carried out at intervals of not less than two weeks. In many place, bedbug is found to be resistant to DDT, lindane and dieldrin. Therefore, during

spraying appropriate chemical has to be selected.

Methods of application:

Surfaces over which bedbugs will crawl to reach the host and hiding places should be sprayed with residual insecticides.

- **Cockroaches control**

Class Insecta
Order- Dictyoptera
Family - Blattidae

Genus.	Species.	Common name:
1. Blatta	B. Orientals	Oriental cockroaches
2. Blattella	B. germanica	German cockroaches
3. Periplaneta	P. americana	American " "
	P. australasiae	Australian " "
4. Supella	S. longipalpa	Brown Banded cockroaches.

► **General feature and Identification:**

Cockroaches are very ancient insects and have changed little in appearance since ancient time. There are some 2500 species, but only those that have adapted to living in buildings are of importance to people. They are pests because of their filthy habits and bad smell.

Adult cockroaches are dorsoventrally flattened insects (from top to bottom) and have smooth, shiny and tough integuments. They vary from 2 - 3mm to over 80 cm in length. And have two pair of wings but rarely fly. Body clearly divided in to head, thorax and abdomen. The head bears one pair of long filamentous antennae, one pair of eyes and chewing mouth part that adapted for omnivorous feeding.

Thorax holds three pairs of strong legs, often covered in stout hairs or bristles. They like warmth, and nocturnal in their activities. During the day they hide away behind radiators, hot water pipes, behind refrigerator, cup boards and tea and coffee machine. Pest cockroaches live in close association with people. They usually live in groups.

Cockroaches are voracious feeders and any of man's food is eaten. They prefer starchy and sugary materials. They also feed on cardboard,

decayed food, fabrics, book bindings, inner lining of shoe soles, their own cast-off skins, dead and crippled cockroaches, etc. They regurgitate fluids from their mouth while feeding.

► **Life Cycle:**

Cockroaches pass through incomplete metamorphosis. The dictyoptera differ from all other insects in that the female lay her eggs in leathery, bean shaped egg case or capsule called an ootheca. The female foaming the ootheca and put in either on her back or deposited in cracks and crevices.

Oothecae are very distinctive and can frequently be used to determine the species present. The average number of ootheca deposition per life span is 7 - 30 depending on the type of species, and the average number of egg per ootheca is 13 - 35.

Depending on the species, temperature and humidity , the eggs hatch after 1-3 months. The young cockroaches or nymphs are wingless, and usually only a few millimeters long; they are white on hatching but darken within a few hours. There are about 5 - 13 nymphal instars depending on the species. Nymphs become adult after several months to more than a year. The adult may or may not possess wings. (fig. 5.3., pp.290)

► **Public Health Importance**

1. Nuisance:

The presence on cockroaches in homes and hotel is undesirable because of their feeding habit on both human food and excreta. They discharge a nauseous secretion both from their mouths and from glands opening on the body which give a long-lasting, offensive cockroaches smell.

2. Diseases Transmission:

The habit of feeding on both human food and excreta, regarded them as a potential mechanical disease transmitter. Cockroaches like houseflies may play in the spread of a disease like diarrhoea, dysentery, cholera, leprosy, plague, typhoid fever and viral diseases such as poliomyelitis.

► **Prevention and Control Methods**

1. Promote house cleanliness:

Cockroaches require adequate food, water and shelter to survive, cleanliness is, thus, the key to control them. Ensuring that neither food nor dirty kitchen utensils are left will reduce their number. In isolated homes, control is easier to achieve than in apartments where cockroaches may have easy access from adjacent quarters.

Food should be stored in tightly covered containers in screened cabinets or refrigerators. All areas have to be kept clean so that no fragments of food or organic matter remain. Rubbish bins should be securely covered and emptied frequently, preferably daily.

2. Application of Insecticides:

If cockroaches present in near by houses good house keeping alone will not prevent them from entering houses. Therefore, application of insecticide is necessary. The spraying or dusting should be in/ on selected sites such as cup boards, under neath sinks and refrigerator, etc.

Application of insecticide should be supported by adequate sanitation. Otherwise, spraying alone doesn't give the intended result. Cockroaches are usually resistant to organochlorine, organophospherous, carbamate and pyrethroid insecticides.

3. Baits and traps:

Baits have been used for many years in cockroach control and still employed in certain situations, such as offices and laboratories, particularly if there is resistance to some of the insecticides in use.

Review Questions

1. Write the common characteristics of species under phylum arthropoda.
2. Write the common characteristics of insects that belongs to the order diptera.
3. List the common sources of food, breeding places and resting places of common house fly.
4. Write all possible factors that affect the distribution of common house fly in a given environment.
5. List all possible diseases that can be transmitted by common house fly.
6. List the applicable control techniques against common house fly.
7. Write at least four distinguishing features of tsetse fly from other large biting diptera.
8. List the possible prevention and control methods against tsetse fly.
9. For which of the following insects the presence of fast flowing running water is necessary for their existence or distribution.
   A. Sand fly. B. tse-tse fly. C. Black fly. D. All
10. Write the transmission cycle of human onchocerciasis.
11. List the three types of leishmaniasis and try to write the difference and similarity between them.
12. What are the possible control techniques for sand flies.
13. Write the medical importance and control methods for Anopheles, Culex and Aedes mosquitoes.
14. Write the transmission route of bancroftian filariasis.
15. Write the transmission cycle of yellow fever from wild monkey population to human being.
16. Write the principal diseases transmitted by body louse and discuss about the diseases. Draw control techniques for each disease.
17. Write the medical importance and control methods of fleas.

CHAPTER THREE

Other Classes of Public Health Importance Arthropods

Learning Objectives:

At the end of this chapter the student (reader) will be able to:

- Describe the control methods for ticks, mites and crustaceans.
- Draw the transmission cycle of guinea worm and schistosomiasis.
- List the different diseases transmitted by crustaceans and schistosoma.

3.1. Class Arachnida

General feature and Identification

The Arachnids with the exception of certain mites, which adapted to live in water, are terrestrial or land dwellers. All species under this class lucks antennae, wings and compound eyes. Their body is divided into two- that is cephalothorax and abdomen. In place of antennae they have the pedipalps- which do what antennae do. Respiration is by trachea or “lung books”. All arachnids have four pair of legs. Species like ticks, mites, scorpion and spider belongs to this class.

3.1.1. Ticks Control

Class Arachnida

Order- Acarina Common Name.

Family - 1. Ixodidae_____ Hard tick

2. Argasidae_____ Soft tick.

Genus of Ixodidae:	Species:	Common Name.
1. Dermacenter	D. andersoni __	Wood tick
2. Bophilus	B. annulatus __	Cattle tick
3. Amblyomma	A. americanum __	Lonestar tick
4. Rhipicephalus	R. sanguineus __	Brown dog tick.

Genus of Argasidae:	Species:	Common Name:
1. Ornithodorus	O. moubata	Human tick
	O. turica	Human tick
	O. tholozon	Human tick.

3.1.1.1. General Feature and Identification:

Ticks are the largest acarines and cosmopolitan in distribution. The majority of them are external parasites of terrestrial vertebrates. They suck blood from animals and humans, and are important as a vector for a large number of diseases. All post embroyonic stages, with few exceptions, feed on the blood and tissue fluids of the host. There are about a total of 800 species of ticks in the world.

The adult soft ticks are flat and oval in outline and have tough, leathery, wrinkled bodies. The mouthparts are situated underneath the body and are not visible from above. Most species can survive for more than a year between blood meals, and some for more than 10 years.

The soft ticks live apart from their hosts and are most common in the nests and resting places of the animals on which they feed. Species that commonly feed on humans are found around villages and inside houses. Their habits are comparable to those of bedbugs.

The adult hard ticks are flat and oval in shape and between 3 and 23 mm long, depending on the species. The mouthparts are visible at the front of the body, differentiating them from the soft ticks. In contrast to the soft ticks they have a shield like plate or scutlum behind the head on the back of the body, and there is only one nymphal stage.

Most species of hard tick feed on three different hosts: one each for the larva, nymph and adult. For instance, some species feed on only one or two hosts. (One or two host ticks). The Argasids are a multi-host ticks and therefore, nymphs as well as adults may take several short blood

meals from different hosts.

3.1.1.2. Life Cycle:

Ticks pass through gradual metamorphosis. They have one nymphal instar and six legged larva. Ixodidae have one eight-legged nymphal instar, however, the argasidae may have up to eight nymphal stage. The immature stages resemble the adults and each of them need a blood meal before it can proceed to the next stage. Adult ticks live for several months with out food and resist starvation. Both sexes feed on blood, the males less frequently than the females, and both can be vectors of diseases.

3.1.1.3. Public Health Importance:

In the tick species, the female ticks can pass on certain disease agents to their offspring's, in addition to transmitting diseases from one host to another during blood feeding.

1. Nuisance

Ticks can cause discomfort and irritation by their bite. They may cause local traumatic and inflammatory damage when they puncture the skin and suck blood.

In public health ticks are important largely because of their activity as vector of pathogenic organisms. Transovarian transmission has been observed to a greater or lesser extent in the case of all the major categories of ticks. The majority of ticks are essentially ectoparasites of wild animals, and humans must be regarded as an incidental host, for both the ticks and the organisms which they transmit. Tick borne human diseases are:-

2. Tick borne relapsing fever

The disease is caused by a microorganism of the genus Borrelia. It is transmitted by the bite soft ticks of the genus Ornithodoros in many countries in the tropics and sub-tropics. The ticks usually feed quickly at night in or near houses and then leave the host.

3. Tick borne rickettsial infection

This group of diseases is caused by closely related Rickettsia microorganisms transmitted by tick bites or contamination of the skin with crushed tissues or faces of the tick, such as:-

- Spotted fever - caused by Rickettsia rickettsii and R. sibirica and due toR. conori, and R. australis.
- Q. fever - caused by coxiela burnetii.

The disease is transmitted mostly by Ixodes ticks, commonly, in the summer when the nymphs are abundant. Some rodents, especially mice, serve as reservoirs of infection while large mammals serve principally as hosts maintaining tick populations.

4. Tularaemia

Tularaemia is caused by the infectious agent francisella tularensis (pasteurella tularensis). The symptoms are head ache, chills, fever and the swelling of lymph nodes. The responsible tick species are anblyomma americanum and dermacenter.

Transmission takes place through the bites of ticks and deer flies, or as a result of handling infected animals such as rabbits and other game. Hunters and forest workers are at the highest risk of infection.

5. Tick paralysis

Hard ticks inject in to the body with their saliva certain toxins that can cause a condition in people and animals called tick paralysis. It is an acute intoxication characterized by elevation of temperature up to 40^0C and difficulty in swallowing and respiration. It occurs worldwide and is most common and severe in children aged up to two years.

6. Tick borne viral encephalitides:

It is a group of viral diseases causing acute inflammation of the brain,

spinal cord and meninges. The symptoms vary in severity with the type of disease. Severe infections may cause violent headaches, high fever, nausea, coma and death.

These diseases are transmitted by biting ticks and by the consumption of milk from infected animals. The diseases are usually transmitted by hard ticks (Ixodes species).

3.1.1.4. Prevention and Control Methods:

1. Self protection through the application of basic sanitation.

Personal protection measures and animal care in fields, forests, in the shed, stable and in other places that are infested with ticks should be taken. Children or adult who walk through tick infested area should remove all clothing as soon as they return to their home, and all attached or crawling ticks should be removed to minimize danger. Some times repellents can be used to prevent ticks from attaching to the body.

2. Application of Insecticides:

Spraying of appropriate chemicals over ticks directly in their natural habitats in forests and fields may control them. Large areas may be treated by ultra-low-volume spraying of liquid acaricide concentrates. Small areas may be sprayed by means of motorized knapsack spraying or mist blowers.

3.1.2. Mites Control.

Class - Arachnida
Order- Acarina

Family	Genus	Species	Common name
1. Trombiculidae	Trombicula	T. akamushi	Chigger mites
2. Sarcoptidae	Sarcoptes	S. scabies	Scabies mite.
3. Demodicidae	Demodex	D. follicle	Follicle mite
4. Dermanyssidae	Dermanyssus	D. gallinae	Hen mite.

3.1.2.1. General Features:

Mites are generally very small in size and barely visible. They suck the blood of man and other animals.

- *Trombiculidae biology and their medical importance:*

Adult trombiculid mites are about 1-2 mm in length, bright red or reddish-brown in color, and of velvety appearance. Larval trombiculids commmonly known as chigger or red bugs, are very small , being 0.15 - 0.3 mm in length, and ectoparasites of vertebrate and to a lesser extent to arthropod hosts, but the nymphs and adults are free living predator's feeding mainly on soil arthropods. After emerging from the egg, the larvae crawl on grasses or low laying vegetation and leaf litter to wait for an animal or human host. They attach themselves to the skin of reptiles, birds, mammals and humans walking or resting in the habitat. On humans they seek out areas where clothing is tight against the skin, the waist and ankles being the parts most commonly attacked. The larvae remain attached to the skin of the host for between two days and a month, depending on the species. They then drop to the ground and enter the soil to develop in to the harmless nymphal and adult stages.

Generally over 700 species have been described and about 20 of these are important either as a cause of dermatitis (scrab- itch) in man or as a vector of human pathogens.

Scrab-itch in man, which is the result of an allergic reaction to the saliva of the chigger, can be caused by many trombiculid species.

- **Prevention and Control measure**

1. Treatment of infected person with tetracycline or its derivatives.
2. Prevention of bites and application of repellents.

Biting can be prevented by avoiding infested terrain and applying repellents to skin and clothing. Chigger mites can be prevented by treating clothing, particularly socks or stockings, cuffs and collars with mite repellents. The most efficient chigger repellent is diethyl toluamide, but also dimethyl phthalate, dibutyl phthalate and benzyl benzoate are efficient.

3. Removal of vegetation:

The control of mites by killing them in their habitats is very difficult because of the patchy distribution of their population. It may be possible or advantageouse to remove vegetations that harbor larval mites by cutting or burning and then scrape or plough the top soil.

4. Application of insecticide:

Mite infested land (vegetation can be sprayed with suitable residual insecticides. Compounds like diazinon, fenthion, malathion, propoxur and permethrin are a suitable chemicals against mites.

- **Sarcoptidae biology and medical importance:**

The sarcoptids are skin parasites of warm blooded animals. They are between 0.2 and 0.4 mm long and virtually invisible to the naked eye. It has world wide distribution.

► **Life Cycle:**

Practically the scabies mite spent its life cycle on and in the skin of humans. In order to feed and lay eggs, fertilized females burrow winding tunnels in the surface of the skin. It takes about two weeks to complete the cycle.

The scabies mites are commonly found where the skin is thin and wrinkled, for instance between the fingers, on the sides of the feet and hands, the bends of the knee and elbow, the penis, the breasts and the shoulder blades.

► **Public Health Importance**

The scabies mite, sarcoptes scabies, infest mammals and cause an itching condition of the skin known as scabies. There are different forms of mites occurring on different mammalian host. Scabies is usually transmitted by close personal contact, as between people sleeping together, and during body contact. Transmission mostly takes place within families. Scabies occurs throughout the world in persons of all ages and social groups. In developing countries like ours, up to a quarter of the population may be affected. It is most common in young children.

► **Prevention and Control methods**

1. Treatmentofcases:

For the control of scabies mite acaricide such as benzyl benzoate 25% emulsion splash or painted over the body can be used. Treatment of all family members is necessary to prevent re-infestation.

► **Demodicidae and Its Medical Importance**

These mites commonly known as follicle mites. The members of the genus Demodex burrows into the hair follicles of mammals and feed on subcutaneous secretions. Treatment of this mite is rarely necessary because cleanliness is enough to get rid of the mite. But it can be noted that a case of scalp demodicidosis was easily cured with an ointment containing 10% sulphur and 5% peruvian balsam.

► **Dermanyssus Gallinae and Its Medical Importance**

This species is commonly known as the red mite of poultry, and is an obligatory blood sucking parasite with a wide host range amongst wild and domestic birds. In temperate regions it is an important pest of poultry, turkeys. This mite may also attack man, causing a sever irritation and it may cause a skin ailment resembling animal scabies.

3.1.3. Scorpion Control

Class - Insecta

Order - Scorpionida

Family	Genus	Species:
1. Buthidae	Buttus	B. occitanus

		B. androctomus australis
2. Diplocentridae	Diplocentrus	D. whitei
3. Scorpionidae	Opisthocanthus	Op. lepturus
4. Chactidae	Euscorpius	Eus. flavicandis
	Chactidus	Ch. suffusus
		Ch. limpidus
5. Vejovidae	Vejovis	V. spinigerus

3.1.3.1. General features:

Scorpions are relatively large heavily arachnids in which the prosoma is covered dorsally by a compact shield. They are carnivorous and occur most commonly in the warmer parts of the world. They are nocturnal and they feed principally on insects and other arthropods. Scorpion do not attack man spontaneously and even the most dangerous species can be allowed to walk over the back of the hand with little risk. Accidents occur commonly when scorpions hide themselves in clothing and when dark corners are being cleared of rubbish.

Scorpions have a long upturned tail and they can live in different habitats such as under stone, in crevices, under rubbish, under leaves, in barns etc. They are sensitive to climatic change and usually live alone. They feed on chilopoda, diplopoda, spider, etc. Ants and baboons are the dangerous enemies of scorpions.

The medical importance of scorpions varies considerably and is dependent on their habits and venom potency rather than on their size. The nature and effects of venom on man are not the same. In general there are two type of venom:-

1. The one that produces a local reaction of varying severity with only mild or with no systemic effects. There is very little danger of death from stings of scoropions with venom of this type.
2. The second type of venom is the production of neurotoxin and its effects can be lethal particularly in children.

Most scorpions under family Buthidae have a dangerous neurotoxin venom. But there appear to be a considerable biological differences between scorpions of family Buthidae. The venom of the north Africa and

middle eastern populations is much more toxic to man and in these regions a number of deaths were recorded to the sting of scorpions.

► **Treatment of scorpion sting**

Symptomatic medication has been reported to be of little value for the treatment of scorpion stings of the neurotoxic type and it can even been harmful because certain drugs can synergise the venom. Antivenins are very effective when administered early and in sufficient quantity.

3.1.4. Spider Control

► **Biology and Habits of Spider**

The specialized and microhabitats and food resources available in and around the house hold environment are often utilized by spiders. The basic structural features of houses and other buildings, such as the corners and overhangs adjacent to out door lights, and undisturbed areas, indoors provide adequate harbourage and hunting grounds for the predatory arthropods. Insects and other arthropods that invade household habitats are their foods.

The prosoma is joined to the opisthosoma by a narrow pedicel. The genital orifice is located on the suck-like opisthosoma. The openings of the abdominal silk glands are situated ventrally on the opisthosoma. Antennae and wings are absent. They exhibit gradual metamorphosis and have four pair of legs. Size seems to determine the number of eggs produced by the female. Some of the very large spiders produce thousands of eggs a time, while small ones rarely lay more than 12.

The copulatory procedure among spiders involves the transference of sperms to the female genital orifice by the use of the specially modified first pair of legs of the male. Copulation is a hazardous and some times fatal for the male.

► **Public Health Importance**

Spiders equip with a pair jaws (chelicerae) and possess venom glands. The immobilization of prey is assisted by the use of silk and by the

injection of venom in the body cavity of the captured animal. Spiders can not ingest solid food. They have a low rate of metabolism compared with other arthropods of equal body.

The danger of spiders bite is largely over stated. The majority of spiders, whether indoor or out door species, are harmless to man because their mouth part can not penetrate human skin or because their venom is not toxic to man. Of all spiders species the Lactrodactus mactans (black-widow-spider) and Loxoceles species are the most important spiders that have a neurotoxin and mouth parts are strong enough to threaten human life.

► **Control strategy**

The distraction of spiders hiding place in the indoor environment through proper house cleanliness may decrease the abundance of spiders. Removing spider egg sacs when they appear may also decrease their population. Application of insecticides to the food sources (insects) of spiders and the spider themselves.

3.2. Centipedes Control

Class - Chilopoda (Centipedes)

Order- 1. Scutigeromorpha
2. Scolopendromorpha
3. Geophilomorpha.

Family.	Genus	Species	Common name.
1. Scutigeromorphidae	Scutigera	Su. coleoptrata	House centipeds
2. Scolopendromorphidae	Scolopendra	Sco. cingulata	
		Sco. meorsitants	
3. Geophilomorphidae		Geo. epimorpha	

3.2.1. General Information:

Centipeds are elongated, many legged, one leg per segment, worm, like animals. They have one pair of antenna with gradual metamorphosis. Their distribution is world wide and have chewing mouth part.

They live in damp dark habitats such as under stone, in crevices of the upper layers of soil, in forest litter and under the bark of trees. Some are cave dwellers and a few are marine dwellers. The majority are nocturnal predators feeding mainly on insects and other small arthropods which they capture and kill with their poison claws.

For species of this group living in temperate zones are able to pierce human skin with their poison claws. The large scolopendromorphs which are abundant in tropical and subtropical regions are generally regarded as venomous. No centipede bite caused serious effects and many suffering centiped victims were quickly relieved after local anesthetics were injected in the vicinity of the bite.

3.3. Millipes Control

Class - Diplopoda:

The millipedes are elongated tracheate arthropods with a distinct head

and with a clear trunk composed of a large pair of legs. The head bears a single pair of antennae, a pair of mandibles and maxillae. They have bright color and simple eye-ocelli.

Millipedes are predominantly saprophagous and luck the poison claws of the centipedes. These species have a secretion which is unpalatable to predators and in the case of some large tropical species the secretion have been reported to have a strong caustic action. Pentazonia, colobognata, julida etc., are some examples of order diplopoda.

3.4. Crustacean Control

3.4.1. General Features:

Their body is divided in to prosoma and opisthosoma, and have 5 pairs of legs and 2 pairs of antennae. They have a compound eye- called ommantidia. Crustaceans are aquatic arthropods and breath by means of gills or through general body surface. Cyclops are tiny crustaceans of the family cyclopidae, also called water fleas. They are usually found in stagnant bodies of fresh water such as wells and ponds in poor agricultural communities in rural or peri-urban areas.

3.4.2. Public Health Importance:

1. Poisoning :

Many crustaceans particularly decapods are eaten by man and a number of them are known t cause poisoning when eaten raw due to the phenomena called biological magnification. Lobsters, crab and shrimps are good examples of crustaceans that cause poisoning.

2. Transmission of human parasite:

a. Lung fluke (Paragonimiasis)

The causative agent for the disease is paragonimus westermani and the decapoda species are the secondary intermediate host. The first intermediate host is snail. Men get infected by eating uncooked infected

river crabs and fresh water cray fish.

b. Diphyllobothriasis:

The responsible parasite Diphyllobothrium latum (broad fish tape worm of man) is acquired by eating fish that have swallowed cyclopoid capepods infested with the second stage of the developing worm.

C. Guinea-worm disease (Dracunculiasis):

Guinea worm disease is rarely fatal but is severely debilitating. The lower limbs are most commonly affected, but the worms, which are up to a meter in length, can emerge from any part of the body.

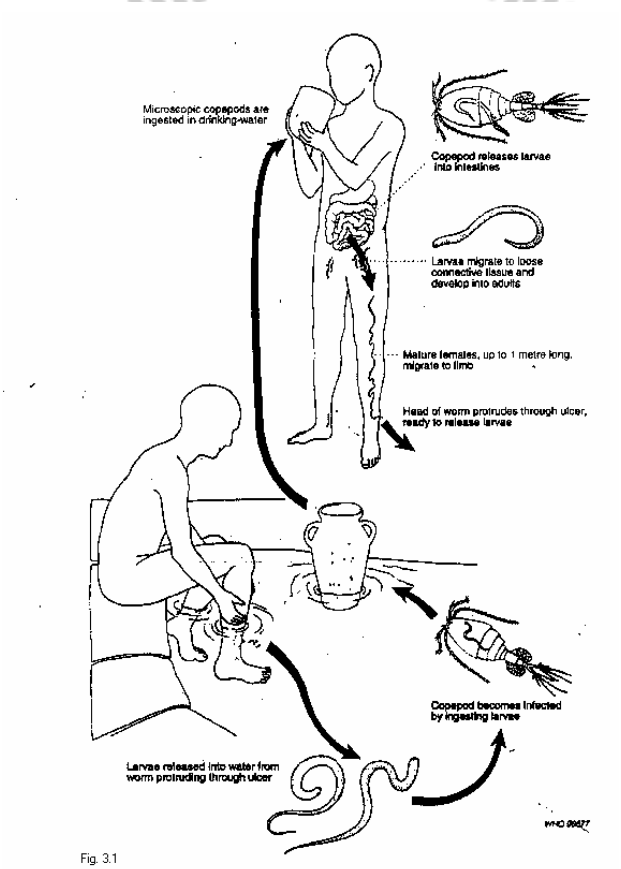


Fig. 3.1

Life cycle of guinea worm (by Taina Litwak for the United States Agency for International Development's VBC Project).

(Source: Jan A. Rozendaal: WHO 1997)

For the disease to be transmitted Larvae of the guinea worm enter the human body when people drink water contaminated with cyclops containing infective larvae. Cyclops infected with guinea-worm larvae also suffer from the infection and tend to sink to the bottom of the water. As a result, people in humid savanna areas in sub-saharan Africa are most likely to become infected during the dry season when water levels are lowest and they scoop to the bottom of ponds or wells in order to obtain water.

3.4.3. Prevention and Control Measures:

1. Cook food:

Avoid eating of uncooked crustacean to prevent the possible transmission of parasitic diseases and poisoning.

2. Avoid drinking of water from suspicious sources:

In guinea worm disease the only available treatment is to extract the worm. This has to be done very slowly to prevent the worm from breaking.

3. People with an emerging guinea worm should never put any part of their body in to water used for drinking.

4. Installation of safe drinking water supplies.

5. Filtration of drinking water.

6. Application of larvicides:

Cyclops and other crustaceans can be killed by treating water sources with temephos, an insecticide that is safe to apply in drinking water if used at the correct dosage.

7. Boiling of drinking water:

Boiling is a simple and effective method for killing Cyclops in drinking water.

- **Molluscus**

Many species of fresh water snail belonging to the family planorbidae are intermediate hosts of highly infective fluke (trematode) larvae of the genus schistosoma which cause schistosomiasis in Africa, Asia and the Americas.

The snails are considered to be intermediate hosts because humans harbour the sexual stages of the parasites and the snails harbor the asexual stages. People serve as vectors by contaminating the environment. Transfer of the infection requires no direct contact between snails and people.

Most intermediate hosts of human schistosoma parasites belong to three genera, Biomphalaria, Bulinus and Oncomelania. The species involved can be identified by the shape of the outer shell. The snails can be divided in to two groups by way of habitat.

1. Aquatic snails that live under water and can not usually survive else where (Biomphalaria, Bulinus), and
2. Amphibious snails adapted for living in and out of water
   E.g. Oncomelania

- **Life Cycle:**

All species of Biomphalaria and Bulinus are hermaphrodite, possessing both male and female organs and being capable o self or cross-fertilization. A single female specimen can invade and populate a new habitat. The eggs are laid at intervals in batches of 5 - 40 , each batch being enclosed in a mass of jelly-like material. The young snails hatch after 6 - 8 days, and reach maturity in 4 - 7 weeks, depending on the species and environmental conditions.

- **Medical Importance:**

1. Schistosomiasis:

Schistosomiasis is one of the most widespread of all human parasitic diseases, ranking second only to malaria in terms of its socioecomonic and public health importance in tropical and subtropical areas.

The transmission route of the disease is eggs are released into water

body from feces of an infected person; after the eggs hatch taken by snail host and continue the development inside the host. Then thousands of the new cercariae break out of the snail and swim in the water. The cercariae after being released into water, they must penetrate the skin of human being within 48 hours to continue their life cycle. Within seven weeks the young parasite matures to an adult male or female worm.

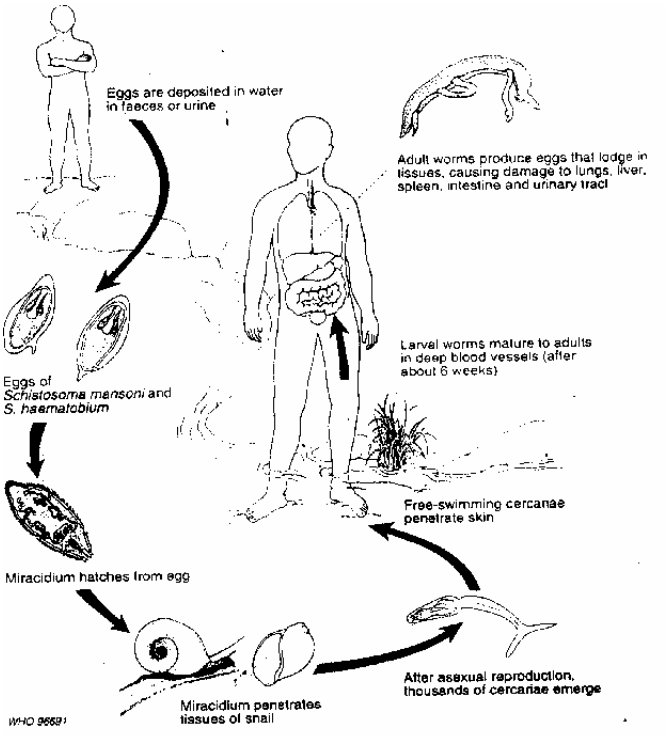


Fig. 3.2.
Life cycle of schistosomes (by Taina Litwak for the United States Agency for International Development's VBC Project).

(Source: Jan A. Ronzedaal: WHO 1997)

- **Prevention and control**

1. Detection and treatment of sick people
2. Safe disposal of human excreta through the provision and proper utilization of sanitary latrine.
3. Provision of safe drinking water:
   Individual protection from infection can be achieved by avoiding contact with unsafe water.
4. Snail control through environmental modification:
   Reduction of snail habitat by removal of vegetation; alternation of water levels and flow rates, etc. helps to reduce the number of snail host.

Review Questions

1. List at least two control methods against ticks.
2. What are the diseases or health problems caused by mites.
3. Write the medical importance of crustaceans.
4. Write the possible control and preventive measure against Guinea worm infection.
5. Write the transmission route of schistosomiasis and list the possible control technique for it.
6. Practical Exercise:
   Go to the field and collect insects and other arthropods regardless of their public health importance. Classify the collected arthropods by their class and order. Finally Sort out the public health importance insects from the collected species.

CHAPTER FOUR

Identification of Rodents of Public Health Importance

Learning Objectives

At the end of this chapter the student (reader) will be able to:

- Discuss the difference and similarity between black rats, brown rats and house mouse.
- Investigate the presence of rats and mouse in a given buildings.
- Identify the medical importance and possible control techniques against rats and mouse.

4.1 Rodent Control:

Class- mammalia
Order- Rodentia
Family-Muridae

Genus	Species	Common Name:
1. Rattus	R. rattus	Roof rat (Black rat)
	R. norvegicus	Norway rat (Brown rat)
2. Mus	M. musculus	Common house mouse.

4.1.1. General Feature:

Rodents are distinguished from all other mammals by their peculiar form of teeth arrangement, which is adapted for gnawing.

The house mouse is differentiated from the other rats by its smaller size and the presence of a notch on the inner side of the upper incisors.

Rats like human adapt to all kinds of climates, eats almost all kinds of foods that human eats and breeds at all seasons. In economic terms rat is one of the most destructive animals of human foods and properties. From public health point of view rats eats, destroy and contaminate food used for human consumption and is responsible for the spread of several important disease on people.

Rats are nearly omnivorous, but they prefer grains, if choice is given. They have world wide distribution. Normally rats attracted to indiscriminately dumped garbage, carelessly exposed food and other material. Average food intake of adult rat is about 28 grams of dry food and about 15 - 25 ml of water per day.

Rattus rattus and its species generally are black or dark brown in colour. It is smaller in size, weighing on average 230 grams. Its tail is longer than its head and body combined. They are a good climber of walls, ceilings, and upper structures. It nests in hollow spaces in walls, under floors, roofs, upper rooms, etc.

Rattus norvegicus are brown in colour. They are heavier and larger than rattus rattus, weighing about twice the weight of rattus rattus. Its nose is blunter and the tail is shorter. They lives in burrows, in the ground and sewers.

4.1.2 Characteristics and Habits of Rats and Mouse:

Generally there are different identification methods of one rat species from the other. The table shown below clearly identify one from the other based on some basic variables.

S.No	Character	Rattus rattus	Rattus norvegicus	Mus musculus
1.	Average adult weight.	8 – 12	16	1/2
2.	Fur	Black	brown	gray
3.	Body	Slender	Heavy set	Small
4.	Muzzle (mouth part, nostril)	Pointed	Blunt	Slender (sharp)
5.	Tail	Longer than body + head.	Shorter than body + head	Equal to body + head.
6.	Ears	Large and prominent.	Small closely set.	Very large.
7.	Fecula	Round and 1/2 of an inch.	Capsular and 3/4 of an inch.	Round and 1/8 of an inch.
8.	Sexual maturity.	3 - 5 months.	3 - 5 months.	11/2 month.
9.	Gestation period.	22 days.	22 days.	19 days.
10.	Number of gestation.	4 - 6 / year.	4 - 7 / year.	8 / year.
11.	Number of litter/ gestation	6 - 8	8 - 12	5 - 6
12.	Life span.	One year.	One year.	1 year.
13.	Harbourage	Above ground	Under ground.	Both.
14.	Home range.	100 – 150 ft.	100 - 150 ft.	10 - 30 ft.
15.	Feeding	Omnivorous	Same	Same.
16.	Water	15 -20 ml/ day	Same	Same.

4.1.3. Investigation of Rat infestation:

The presence of rat in a given house can be investigated by:-

1. Rat fecula (Dropping):
   A fresh fecula is soft, moist and bright in color while old fecula is dry, hard and fray to touch. Generally the color and size of rat fecula

depends on what the rat has eaten and the type of rodent species respectively.

2. Foot print and tail marks: For fresh fecula the food print and tail mark is clean and greasy, where as for old fecula it is old and dusty.
3. Rat run ways: if a given area is infested by rats there exist greasy markings on the pipe, beam, wire, floor, wall, rafter etc. Habitually rat follow the same run way between food, water and harbourage.
4. Distraction marks:
   Rat distract human properties like furniture, food and clothings due to their gnawing property. Naturally rat's incisors grow 4.5 - 5.25 inch per year, and in order to keep their teeth to functional size they gnaw all the time.
5. Burrow (shelters):
   - Floor and wall for rattus norvengicus.
   - Rattus rattus and mus musculus nest on trees and roofs.
6. Miscellaneous signs.
   - Rat odor.
   - Rat urine.

4.1.4. Rodent activities:

1. Climbing:- rodent are good climbers.
2. Jumping:- rodents jump vertically and horizontally about 3 ft (high jump) and 8 ft (long jump) respectively. They can also fall down 15-50 ft with out damage.
3. Stretching or reaching:- 13 inches. Therefore metal guards have to be 14 inch or above.
4. Swimming:- rat can swim in open surface water up to 1/2 mile distance. They can also swim in sewer lines.
5. Burrows:- rats are able to burrow 3 ft long and 1 - 6 ft depth.

6. Gnawing:-

   Naturally rats and mouse's incisors grow from 4.5 to 5.25 inch per year. Therefore, to keep their incisors to functional size, they need to gnaw regularly.

7. Sitting height:

   The sitting height of rodent is about 3.5 of an inch. Therefore, for successful control of rodents, bait container must be greater than 3.5 inch so that they feed at ease.

4.1.5. Rat Senses and habits:

1. Touch:

   The sense on touch of rodents is by a long hair on their muzzle called whiskers (vibrissae) which is located around nose and mouth area, and by tactile hairs (guard hairs). Tactile hair is a short hair that is found all over the body.

2. Vision:-

   Rodents do not have a keen (sharp) sense of sight. It is not well developed. They can identify things at 45 ft distance and they are color blind. These property of rodents make them a good candidate for rodenticide bait.

3. Smell:

   Rodents have keen sense of smell specially for opposite sex attraction.

4. Taste: not keen, it is therefore, advantageous for rat control. In that you can use any type of baits, such as decaying bait, bitter bait, sour bait etc. to control them.

5. Hearing:-

   a sharp sense of hearing, which is helpful in darkness to rats to escape from enemies. They can locate the source of sound with in 6 inch radius.

6. Balancing: - rodents have a great ability to keep their balance. This ability helps them for falling upright and bouncing at ease.

7. Vomiting:- rats do not vomit what they ate. This feature is practically advantageous from the stand point of controlling them. It is because any swallowed bait remains in the body of the rats.

4.1.6 Public Health Importance

Rodents are capable of transmitting several important diseases to man. Generally the role of rodents in transmitting disease to man can be grouped in to three categories.

- Those diseases or injuries which are directly caused by rats. This includes:-

A. Rat bite:

Bites inflicted by rats can cause serious injuries to the victims. Infants are usually affected by rats. In Asia particularly in India there are a number of serious rat bite records.

B. Rat bite fever:

It is a disease caused by an spirochaetal organism which may be harboured in the mouth, particularly on the gum of rats. The organism enters to the human body through the wounds inflicted by the rat bite. Rodents are not affected by the organism and therefore, they are a reservoir for the pathogenic organisms.

- Those diseases which are transmitted indirectly by foods or water contaminated by the rat's excreta and urine.

A. Salmonellosis:

It is one of the common food borne disease, and transmitted in various ways, one being through contamination of food by feces/ urine of rodents containing the salmonella organism.

B. Leptospirosis:

It is a spirochaetal disease caused by leptospira species. Man usually

get infected by handling or eating food contaminated with feces or urine of domestic and wild rodents, particularly rats and mice.

- Those diseases which spread by insects, specifically fleas, for which rats act as reservoir.

A. Plague:

Plague is a disease caused by agent Yersinia pestis. Urban plague may occur when rats living in and around human dwellings are infected. Rat fleas that normally feed on rats may occasionally feed on humans and thus spread the disease. The disease may be further transmitted from person to person by human flea.

B. Murine Typhus:

It is caused by Rickettsia typhi and occurs dominantly in rodents population, particularly among rats and mice. Humans become infected as a result of contamination from the dried feces and crushed bodies of the fleas. The disease is common in areas where people and rats live in the same building.

4.1.7. Rodent Prevention and control strategies:

Before selecting and applying a control method, it is necessary to make survey in order to determine the rat infestation, the species, population density, harbourage and food sources. After collecting the necessary data the following control methods can be applied.

1. Environmental Control:

The fundamental principles of controlling rats and mice lies on how we are successful in eliminating life supporting items. i.e., water, food and harbourage. Therefore, the specific methods are:-

- Proper storage, collection and disposal of solid wastes, particularly garbage.
- Good house keeping and maintenance of sanitary conditions in food premises, house holds and the neighbourhoods.
- Rat proofing of buildings (foundation, doors, windows etc) to avoid entrance and harborage.

Rat proofing is applied to structures and is designed to prevent rats from doing economical damage, and disease transmission. Rats enter buildings through drain-pipes, doors, windows, roots and building foundations. So, such places should be screened or built properly to avoid rats.

The chief refuge for rats in cities are markets, warehouses, slaughter houses, restaurants, bakeries, local cottage industries and dwellings. Such premises must often be inspected.

In the rural areas, it is important to take care of barns, and dwellings so as to make them rat-proofed.

2. Biological control of rats by the use of predators such as cats. Cats are often used to control rats and mice in most rural and urban centers of Ethiopia. However, this method is unacceptable on hygienic ground particularly in food premises.

3. Rat trapping:

There are two type of rat trap. The snap trap and the cage trap. The former is a type of baited trap and it kill rodents. It is the common rat trapping that people use at home. The latter type of trap used to capture or hold live rats is cage trap.

It is essential to remember the following points to make rat trapping effective:-

- Use traps in rat run ways, burrows etc.
- Fasten traps so that caught rats can not drag them in to inaccessible place.
- Block run ways with boards, boxes or other objects, after traps are set, so that rats will be forced to use the runways in which the traps are placed.
- Observe the tracking patches to determine whether or not rats are avoiding the traps.
- Camouflage traps with paper, board etc. This will help to eliminate avoidance of traps by rodents.

4. Rodenticides: It is generally classified into two.

- Single dose rodenticide (acute poisoning) which is normally meant for killing rodents within a short period of time after ingestion. Usually in less than 24 hours.
- Non-single dose rodenticides (chronic poisoning) :- such type of rodenticides are intended to be ingested at intervals for a period of days or weeks.

Rodenticides may be manufactured in powder, liquid and gaseous forms. Compounds of arsenic, strychnine, phosphorus, barium carbonate, A.N.T.U, etc. are some examples of single dose rodenticides.
Among chronic rodenticides warfarin (anticoagulant) and fumarin are good examples. Before control of rodents is begin, it is important to know where rodents burrows and run-ways are. To avoid unnecessary wastage of insecticides, the burrows should first be closed off, only those that are subsequently re-opened should be treated. Insecticidal dust should be blown in to each burrow with a duster. A patch of dusting power, 1 cm in depth, should be left around the opening. Patchs of dust 15-30cm wide should be placed along run-ways.

To Control urban outbreaks of plague or typhus, insecticides to kill rat fleas are applied at the same time as or a few days earlier than rat poisons. Suitable rat poisons are warfarin, coumafuryl, difenacoum, brodifacoum, coumatetralyl, bromadialone, chlorophacinone and zinc phosphide.

In places where food for human consumption is stored and in crowded areas, such as, markets, it is safer to use bait boxes in which the rodents contaminate themselves with the anti-flea dust before they die from eating the toxic bait. Bait boxes can be placed along rodent runs at intervals of 60 meters. A suitable bait consists of 100 gm of rolled oats mixed with rat poison.

Review Questions

1. Write the difference and similarity between black rat, brown rat and common house mouse.
2. Write at least four points that help to investigate the prsence of rats in a given building.
3. Write the public health importance of rats and house mouse.

CHAPTER FIVE

Arthropod and Rodent Control Methods:

Learning Objectives

At the end of this chapter the student (reader) will be able to:

- Discuss the different types of insecticides and differentiate one from the other.
- Practice the different methods of insecticide formulations and applications.
- Discuss the difference and similarity between insect chemosterilant, baits, attractants, and repellents.

5.1: Introduction

Insects and other arthropods control measures in use today fall in to two broad categories; namely-the chemical and biological control methods. In practice they may be used separately or in an integrated manner.

Insecticides are substances or an agent that kill insects and other arthropods. Theoretically an insecticide should have the following characteristics. It has to be cheap in terms of cost, available in large quantities at ease, chemically stable, non-flammable, easily prepared for use, non-corrosive, and non-odorous. However at present there is no such perfect insecticide that fulfills all the standards mentioned above.

I. The Chemical control of insects and other arthropods:

5.2: Type of Insecticide

Chemical insecticides are the predominant materials in use today to control insects. They are generally classified into seven categories based on their chemical composition (formula).

1. Inorganic insecticides

This is one of the oldest group of chemicals employed to control insects, but with certain exceptions, they are not in a widespread use today. One of these exception is the group of arsenical insecticides, the most common one is lead arsenate ($PbHA0_4$). It is insoluble in water and the arsenate of calcium, copper, zinc and manganese have a similar property with lead arsenate. Soluble arsenicals, like sodium arsenite, are incorporated in to dipping baths for the control of ectoparasites, or in to poison baits for different insects. Variouse fluorine compounds such as sodium fluoride (Na F), which is water soluble, barium fluosilicate (Ba Si F_6), sodium fluosilicate (Na_2 Si F_6) and sodium fluoaluminate
(cryolite), which are insoluble in water, have a similar insecticidal action as that of sodium arsenite.

Elemental sulphur and inorganic sulphur compounds have some insecticidal properties, but they better used as acaricides and fungicides. Lime sulphur, which is a mixture of calcium polysulphides and calcium thiosulphate, and mercurous chloride (Hg_2 Cl_2) are also have insecticidal effect under inorganic insecticides.

2. Botanical Insecticides

It has been known for many years that plant extracts have insecticidal properties which cover a wide range of chemical types. Alkaloids are one of the best known botanical insecticide, which are basic, cationic compounds containing nitrogen, often in a heterocyclic ring.

Those extracts known as sabadilla, Ryania and Quassia gives several insecticidal alkaloids. For example when the seeds of sabadilla is crushed and extracted with organic solvent yield a mixtures of several insecticidal alkaloids known as veratrin. Ryanodine is the principal alkaloid present in the stems and roots of the shrub Ryania speciosa,

while quassia is extracted from the food of the tree Quassia amara. These the above extracts have relatively a minor commercial importance today.

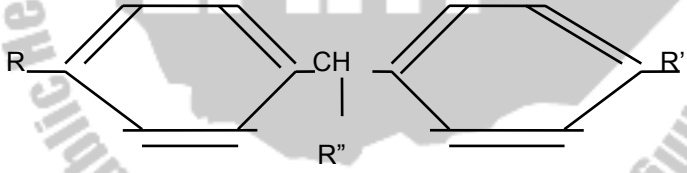
The insecticide based on Nicotine, Rotenone and Pyrethrum are much more familiar and of these, nicotine has been in use predominantly. It is extracted from the leaf of several Nicotiana species.

Pyrethroids are some what expensive to produce, and deteriorate rapidly on exposure to air. They have a wide use an insecticides, especially against house hold insects. They are most often formulated as aerosols and have a rapid paralytic or " knock-down" effects on insects. They are harmless to man when ingested or touched.

3. Organochlorine Insecticides:

DDT (Dichloro-Diphenyl-Trichloroethane) was the first commercially produced chlorinated hydrocarbone insecticide and is still one of the most important substances used in insect control.

DDT



Where: R = R'= Cl

R"= CCl_3

Dichloro-Diphenyl-Trichloroethane.

The toxic property of DDT, unlike some of the botanical insecticides, persist for some time after application, this is because it is non-volatile, insoluble in water and not particularly lead to oxidation.

Benzene Hexachloride (BHC) is also one of the organochlorine insecticides. The crude product is a mixture of about seven isomers, and it has unpleasant odour. Due to this unpleasant odour, BHC is best substituted by other product called Lindane, (which is similar with BHC)

Toxaphene (chemically quite different from BHC) , Chlordane, Heptachlor, are also widely used for the control of house hold insects.

Endosulphan, Aldrin, Dieldrin and Endrin (cyclodi-enes based on naphhalene), etc. are another examples of organochlorine insecticides.

4. Organophosphorous insecticides:

Tetraethyl pyrophosphate (TEEP) is the organophosphorus compound demonstrated by schrader of Germany. This compound has an oral M.L.C to rats of about 1.0 mg/kg, but because it is rapidly hydrolysed by moisture, it is rendered inactive within a few hours of application. Generally Dimefox, Durbsan, Couaphos, Dichlorvos, parathion, Diazinon, Malathion, Trichlorphon, fenchlorphos, etc. are some examples of insecticides under this group.

5. Carbamate Insecticides:

Generally carbamate insecticides are an insecticides that contains esters functional group in common in their chemical structure. Physostignine, Dimetan, carbaryl, butacarb, isolan are some of the representative insecticides under this

group. As with DDT, the first commercially produced carbamate insecticides is esters of dimethyl carbamic acid. Its earliest product was known as Dimetern.

6. Dinitrophenol Insecticides:

These insecticides have been known for a number of years to have insecticidal properties. All insecticides under this group have a phenol ring in common.

DNOC (Dinitro-ortho-cresol) , Dinex (A cyclohexyl phenol derivative), Dinoseb (A ethyl-n-propyl derivative) etc. are examples of this group of insecticides.

7. Organothiocyanate Insecticides

Organothiocyanates were originally developed as possible alternatives to the pyrethrins but have found only a limited market because the pyrethrins can be produced more easily and cheaply. There are two main

groups of insecticides, the various Lethanes and Thanite. The Lethanes are of moderate toxicity but Thanite is quite safe with an oral M.L.C of 1600 mg/kg. to rats. They all used as “knock-down”agents in aerosol formulations for household and dairy application and as sprays for the control of human lice and bed bugs.

5.3. Insecticide Formulation and Application:

The addition of substances (solvent or diluent) which enable a given chemical insecticidal to be used to the greatest advantage in any given situation is known as formulation. The active ingredients of insecticidal products are expensive to produce and it is toxic at low concentration. In order to apply small quantities accurately to the target area, there are many practical difficulties to the distribution of only a few chemicals on the area, therefore, to overcome these difficulties diluting the material until it reached a manageable volume is easy to operate.

Generally there are three types of formulation;- liquid, dry (dust) and gaseous formulations.

1. Liquid Formulations

Water, because of its relatively low cost and ease of availability, is most commonly used as a diluent for liquid formulations.

Unfortunately, many organic compounds are insufficiently soluble in water. To solve this problem insoluble solids may be formulated as wettable powders, it is a process which entails their being mixed intimately with an inert carrier, which is easily suspended in water. The application of such formulation could be by dipping, or by forcing out the liquids through fine nozzle so that it emerges as droplets (small diameter size suspend in the air while others drop).

2. Dry (dust) Formulation:

It should be noted that with dry formulations the diluent and insecicide are mixed at the time of manufacture rather than at the site of application. This helps in a saving of time. Dustare usually acceptable for

personal application when it is necessary to cntrol human ectoparasites. The disadvantage of dry formulation is dust diluents can be much more expensive than water and also diluents are bulky to transport.

3. Gaseous Formulations:

Certain insecticides which are solids or liquids at normal teperatures can be formmulated so that they can be dispersed or exert their toxic effects in the vapor phase. A heat source is usually required for volatilization and in some case this can be generated by the incorporation of pyrotechnic chemicals in to the formulation. Vapors produced by this methods cool in to aerosol - type droplets which eventually crystallize on cold surfaces if the active ingredient is a solid.

5.4: Dilution Formula for Mixing Insecticides

Technical grade insecticides (definition):- are an insecticides that exist in its purest commercial form. This insecticides must be made in proper strength solutions, emulsion, suspensions or dusts before application. Liquid sprays are often purchased as concentrated solutions or emulsifiable concentrates.

Concentrated solution, therefore, may be diluted with oil and emulsifiable concentrates with water to prepare a solutions or emulsions with appropriate strength. Dusts are often diluted with talc, pyrophylite of flour, wettable powders are mixed with water to form suspensions of desired concentration. The following formulae can be used to prepare a finished spray insecticides with desirable concentrations.

A. Formula Number 1**:** (Subtraction formula):- used for mixing liquids with liquids or solids with solids.

I. X = C - S, where: C = Percentage of the available concentrate.
S = Percentage of the finished spray or dust desired

X = Number or parts of diluent added.

II. X = C/S- 1.i.e., Available % - 1
Desired %

Example:- 1. Dilute 25 % lindane emulsified concentrate to 0.25 % finished spray emulsion.

Solution:

C - 1 = 25% - 1 Answer = 1 : 49.
S 0.5%

2. Make 50 gallons of 1% lindane spray using 25% lindane concentrate and water. How many gallons of lindane concentrate should be used?

B. Dilution formula Number Two: (" Sac " used for mixing liquids with liquids or solids with solids).

Q = S x A = (Disired) (Amount wanted)
C Available %

Where:- Q = Quantity o concentrate to use (gals or lbs)
S = % of active ingredient required in the finished spray or dust.
A = amount of spray or dust to be prepared (gals or lbs)
C = % of active ingredient in concentrate.

Example 1: Prepare 100 kg of 2% chloridane dust using talc and 5% chloridane dust.

Given: Solution:

S = 2% Q = S x A = 2% x 100 kg. = 40 kg = Active ingredient.
C = 5% C 5%
A = 100% The amount of diluent (talc) = 100 - 40 kg = 60 kg.

N.B: The result can be interprated as to get 100 kg of 2% chloridane dust add 40 kg of 5% chloridane dust o 60 kg of talc.

C. Dilution formula Number Three: ("SADSAC" formula) for mixing liquids with solids.

This dilution formula may be used to prepare a solution or suspension

using either the technical grade insecticide or a concentrate.

Q = S x A x D , where Q = quantity of concentrate to use. (lbs)

C S = % of active ingredient desired in finished spray.

A = Amount of spray to be prepared (gals)

C = Density or weight of diluent (lbs/gals)

Example:

1. Make 50 gallons of a 2.5 % DDT solution in deodorized kerosene. The kerosene weighs about 6.6 pounds per gallon. Use a technical grade DDT.

Given: Solution:

S = 25% Q = 2.5% x 50 gals x 6.6 lbs/ gals = 8.25 lbs.

A = 50 gals.

D = 6.6 lbs / gals

C = 100 %

N.B: To prepare 50 gallons of 2.5 percent DDT mix 8.25 pounds of DDT with sufficient kerosene to reach the 50 gallon mark on the drum or other container used.

2. Make 100 gallons of BHC suspension containing 1.25 percent BHC use the 75 percent water wettable BHC powder. The water weighs about 8.3 pounds per gallon.

Solution:

Q = 1.25 % x 100 gals x 8.3 lbs/ gal = 13.8 lbs. Therefore, to make 100 gallons of BHC suspension containing 1.25 percent BHC add 13.8 poundss of 75 percent water wettable BHC to a tank partially filled with water, while agitating the mixture until the 100 gallon level is reached.

N.B: The malaria control program of Ethiopia uses 133 gram of 75% water wettable DDT concentrate for every liter of water in order to prepare 10% waer wettable suspension, which is the normal finished spray.

5.5. Health Impacts of Insecticides:

The effect of insecticides on human health can be divided in to two categories.

A. Short term effects, including acute poisoning and illnesses caused by relatively high dose and accidental exposures, and
B. Long-term effects suspected to include cancer, birth defects, immunological problems. The long term health effects may be caused by very low doses of a variety of different chemicals.

According to World Health Organization (WHO) estimate that some one million people suffer acute pesticide poisoning and at least
20, 000 die each year. It is further estimated that two-thirds of this illness and death results from occupational exposures in developing countries where people use insecticides without proper wearing of protective clothing.

5.6. Classification of Insecticide by Mode of Action:

Insecticides can also be classified by their mode of action (ways in which insecticides actually kill insects) or by the ways in which they enter the insect system and cause them to death. This is not the best ways of classification, in that different formulation of the same chemical may penetrate an insect by more than one route.

1. Contact Insecticides (poisoning):

These are insecticides that are able to pass through his insect exoskeleton or egg shell on contact with the organism body wall or tarsi. Death of the insect is either due to the concentration of the poison or due to area of the insect body contaminated.

This contact insecticide may be in the form of air borne droples
(mist, fog) or particles which either fall directly on to the insect from the applicator or in to which tthe insect flies of its own accord. Aerosols are good examples of conact insecticide that has a rapid " knock down" effect .

Sulphur containing insecticides, mercury groups such as mercureous

chloride (calomel) and alkaloids are some representative examples of contact poisoning. Surface deposits on the other hand act as protectants in that they will control infestations which arise after application, and the duration of the deposit. Organochlorines are good examples of protectant insecticides.

2. Stomach poison insecticides:

These are type of insecticides (poisons) taken in by insects during the coarse of normal feeding activities. The poison must be swallowed to cause death. The death of victim depends on the concentration of poison and on the amount eaten. Mandibulate insects are conveniently controlled by applying toxicants to their natural food material or synthetic baits.

Inorganic insecticides, mainly the arsenicals, and lead, copper, calcium etc are good examples. Both organochlorine and organophosphorous in nature can also be used as stomach poisons. What is important here is, insecticides of this type must not have a repellant effect and must be absorbed from the gut of the insects.

3. Fumigant insecticides:

For this type of insecticide the external openings of the respiratory system are the main access points for fumigants although some may pass in across the general cuticular surface, particularly of the egg stage. The entry of the fumigant is thus independent of the structure of the mouth parts. Fumigants do not require an insect to move over a treated surface in order to exert their effect.

The main objective of fumigation is thus to get the fumigant in to the tracheal system, and to do so the spiracles required to be open during treatment.

5.7. Other Arthropod Control Methods.

5.7.1. Insect Chemosterilants:

It has been known for several decades that female insects fail to produce viable aggs after irradiation with x-rays. The technique involves the

liberation of millions of radioactively sterilized adults in to the natural population. This caused a drastic dilution of the breeding potential and led to the eventual extermination of the insects. Because of the high cost involved, and the inherent difficulties of handling a powerful insecticides are preferable than this technique to control insects.

5.7.2. Baits and attractants

Baits and attractants are a form of control where by insects are attracted to a selected spot on which they can be more easily eliminated. The two methods differ mainly in the degree of efficiency and refinement of the attracting substances. Efficiency being determined by the smallest quantity which will attract the greatest numbers from the widest area. Trimedlure, Methyl engenol are good examples of baits and attractants.

5.7.3. Repellents

These are substances which, when used singly or in mixtures have the effect of keeping insects away. Repellents must be safe, ecomonic and not too unpleasant to use. Their efficiency depends on their ability to deter the greatest number of species from feeding for the longest period.

Safety from toxic effects is essential since they are most often applied in quantity to the skin surface or clothing. Therefore, any irritation which arise from and their degree of cosmetic acceptability with determine how pleasant they are to use. Aromatic substances such as comphor, cadarwood oil, are a good personal repellent. Indalone, Dimethyl phthalate, Rutgers etc, are some additional examples of repellents.

5.7.4. The Biological Control of Insects

In the absence of enemies and with unlimited food and space available, the increase with time in numbers of a reproducing organism will theoretically follow an exponential curve. However, it is a very rare occurrence in nature that all the food or space available to a species within its geographical range is exploited, indicating that factors are in existence which regulates numbers below the maximum reproductive potential.

The biological components of the ecosystem, on the other hand, can react in this way, the numbers of parasites, pathogens or predators of a species being directly influenced by the numerical size of the host or prey population. Biological control in the present context is the control of insect pests by the use of such predatory and parasitic organisms. In practice this may involve the exploitation of biological agents already present in a locality by encouraging their natural increase at the expense of the pests and / or by artificially augmenting their numbers from natural or laboratory bred populations.

Apart from rare exceptions little practical use is made of biological control on a commercial scale in the world.

5.7.5. The Integrated Control of Insects

Although chemical and biological control methods have been discussed separately here, one of the most promising aspects of modern pest control practice has been the combination of the best features of both systems.

The need for an integrated system has arisen from the shortcomings of each method. Chemical insecticides are essentially drastic and short-term in their effects and result in the deposition of toxic materials on foodstuffs and livestock. Moreover, they often have a broad spectrum of activity and can so alter the biotic components of the ecosystem as to cause the emergence of new problems. Biological agents on the other hand are safe to use but long-term in action and may permit an insect to transmit diseases before they exert their effect.

The correct use of integrated systems presupposes that a great deal is known about the behaviour of the organisms which are found in the target area and involves the very careful use of insecticidal chemicals.

Review Questions

1. List the different types of chemical insecticides and try to differentiate

one from the other.

2. Write the types of insecticides formulations and discus each.
3. Prepare 50kg of 5% chlordane dust using talc and 10% chlordane dust.
4. What do you know about insect chemosterilant, baits and attractants and repellents, and how do these methods control insects and other arthropods.

CHAPTER SIX

Equipment for Insecticidal sprays:

Learning Objectives

At the end of this chapter the student should be able to:

- Describe the different types of manually operated and power operated sprayers.
- Discuss the possible safety measures during insecticide handling.

6.1. Introduction

Generally in the market there are different types of insecticidal sprayers (equipments) use for different chemical formulations. Some of the basic sprayers are listed below:

6.2. Equipments for liquid Application

Equipments for chemical application can be sub-divided in to manually operated and power operated equipment's.

6.2.1. Manually operated- sprayers:

1. Hand-carried sprayers:

These sprayers are both held and operated in the hand or hands. They are usually constructed of brass, mild steel, stainless steel or plastic. The liquid capacity varies from 1/4 pint (0.15 litre) to 1 gallon (4.5 litres), but the usual size varies from 1to 2 pint (0.5 - 1 litre).

Fig. 6.1. Continous or Compression hand sprayer.

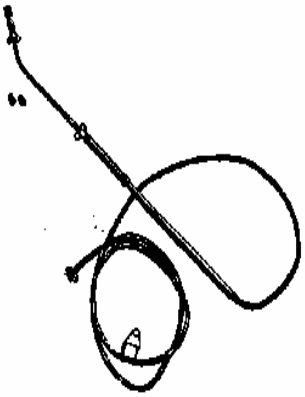


Fig. 6.2. Bucket sprayer with trombone pump.

(Source: Equipment for Vector Control: WHO-1964)

According to the method of operation, hand carried sprayers are divided in to intermittent sprayers and continuous or compression sprayers. The formers are those operated by a simple pump, which
may be either a solid piston or a plunger type with a cup leather. and the latter type of sprayers operate on the same principle as the well known knapsack sprayer. The container is filled to approximately two-thirds of its capacity and the remaining air space is then compressed by means of a small built- in air pump of the plunger type. The container has to be sufficiently robust to withstand the pressure required to expel the liquid contents from the nozzle via a suitable trigger control valve.

2. Bucket sprayers:

The container for this type of srayer is a bucket or similar convenient receptacle, such as empty oil can or drum. The materials of construction are usually brass or plastic or a combination of the two. The pumps used are:-

i. Lance, trombone or slide pump:

In here, the pump is operated with hands, one hand steadying and directing the spray and the other operating the pump. These pumps are usually double-acting , i.e., pressure is applied to the liquid on both the forward and backward strokes. The pumps are nearly always continuous in action, but occasionally a single acting pump is employed, in which case the spray production is intermittent.

ii Stirrup pump:

These are of two type: the plunger or piston type pump that may be used in which there is a suction valve and strainer at the lower end. This is lowered in to the liquid in the bucket and held in place during operation by placing the foot on the flat stirrup provided.

The second version of this pump is fitted with a length of suction hose and strainer intake which enables it to be used with a much deeper container than is possible with the first type.

3. Knapsack or shoulder-slung sprayers:

There are different types of knapsack sprayers, but almost all have the same sprayer unit and one is differ from other only in the method of carrying the sprayer. Generally they are subdivided according to the method of operation.

i Lance, trombone or slide pump:

The same type of pump as described under bucket sprayers us used in conjunction with either a knapsack or a shoulder-slung container. The containers may be made of plastic materials, which may be either flexible or rigid, or from metal. The flexible plastic types are usually shoulder slung and are often used in conjunction with a pump of simple manufacture which may also be made of a plastic material. These type are inexpensive sprayers intended only to last for a limited period of use (one season).

ii Lever-operated plunger pump:

A conventional plunger pump is either mounted on the outside of the

container or placed inside the container and immersed in the liquid content. The pump is operated by hand lever, which may either be so placed that in use it comes under the arm and is moved up and down by the hand, or it may pass over the shoulder and have a short chain or rod with a handle at the end which is pulled and released to operate the pump.

iii Lever operated diaphram pump:

The pump may be mounted externally on the container, in which case it is usually placed with in the protective skirt around the bottom of the container, or it may be mounted inside and immersed in the liquid contents.

The operating lever of this type is invariably of the under arm pattern, and it is uncommon to find provision for changing the lever from one side to the other. A small air vessel is again provided to even out the pump impulses and to maintain spraying pressure between the pump strokes.

4. Compression sprayers:

The essential feature of this type of sprayer is that the container is a pressure vessel. Normally, the container is filled with the liquid to be sprayed to about three quarters of the total capacity. The container is then closed and compressed air is forced in to the space above the liquid by means of a plunger type pump. It is this stored pressure which expels the spray liquid from the bottom of the container through a hose to the cut-off valve, lance, and nozzle. The capacity of the container varies from 1 - 6 gallon (4.5 - 27 litres).

5. Stretcher or pole-carried sprayers:

These sprayers are designed to be transported from place to place between two persons, either carried with the hands by the stretcher- type handles provided, or carried on the shoulders by poles placed through lungs or loops on the sprayer. The container is usually separate and is often provided locally or improvised. The pumps are usually of the plunger, solid-piston, or diaphragm type. These sprayers designed for

operation from a fixed position with one or more hoses of lengths up to about 60 ft (18 meter) . The pump has a hand lever which is usually double acting.

6. Barrow sprayers:

These type of sprayers are mounted in a light wheel barrow frame, with single or double wheels, so that they can be either pushed or pulled in to the vicinity of the area in which it is desired to spray. The container capacity ranges between 10 - 45 gal. (45 - 200 liters). The three pumps, the plunger, piston and diaphram type are used and operated by a hand lever.

6.2.2. Power operated sprayers:

Power operated sprayers are almost identical in design to the previously described manually operated sprayers, except that they all utilize power driven plunger, solid piston, diaphragm or rotary type pumps. When high pressures are required either the plunger or solid piston pump is used. Electric motor or internal combustion engines are used to power these type of equipments.

Power operated stretcher carried sprayer (2.2.3), power operated barrow sprayer (2.2.4) and tractor sprayers are good examples.

1. Tractor sprayers:

Tractor sprayer are of two type, i.e. the mounted type, in which the sprayer is attached to the tractor and completely carried on the tractor both in and out of operation, and the trailed type of tractor sprayer, which is larger than the mounted type and designed to be drown but not carried by a tractor.

2. Vehicle sprayers:

These type of sprayers are intended to be mounted on any suitable vehicle. The equipment is frequently provided with skids to facilitate loading. Some times the equipment is trailed behind the vehicle.

3. Air craft sprayers:

All equipment of the hydraulic type is included under this heading, the basic essentials being the container or containers, a pump, and a spray bar or boom to carry the nozzles. The container may be placed inside the air craft or may be carried externally as panniers on the fuselage, as is common practice on small rotary wing aircraft.

6.3. Choices of Applicator Selection:

The choices of applicator is usually carried out based on the size, durability, explode and spare part availability. The capacity of the tank is very important for choosing applicators. For easy operation the maximum recommended size of an application is 50 liter.

6.4. Safety Measure During Insecticide Handling:

Insecticides are toxic to both pests and humans. However, they need not be hazardous to humans and non-target animal species if suitable precautions are taken. Most insecticides will cause adverse effects if intentionally or accidentally ingested or if they are in contact with the skin for a long time. Insecticides particles may be inhaled with the air while they are being sprayed. An additional risk is the contamination of drinking water, food or soil. Care in handling insecticides, particularly in relation to spray man and people live in sprayed houses, should therefore, be routine practice and should form an integral part of any program involving the application of insecticides.

Special precautions must be taken during transport, storage and handling. Spray equipment should be regularly cleaned and maintained to prevent leaks. People who work with insecticides should receive proper training in their safe use. It is important to take in to consideration both the nature of the insecticide, including its formulation and the proposed method of application before use. The following factors may influence chemical hazards: type of formulation, type of

packaging, concentration of the insecticide, method of application, amount of surface or area to be treated dosage required, association of human or animal populations with treated surface or area, and the

species or animals exposed, their age, sex and condition.

The planning of a vector control campaigns must include provision for the safe transport and secure storage of insecticide concentrates, which should not be stored in rooms in which people live or in food storage. They should be stored out of direct sunlight and protected from rain and flooding. Protection against theft, misuse and unaccessibility to children must be noted.

6.5. Precautions

1. Insecticides should be packed and labeled. The label should be in English and in the local language, and should indicate the contents, safety instructions and possible measures in the event of swallowing or contamination.

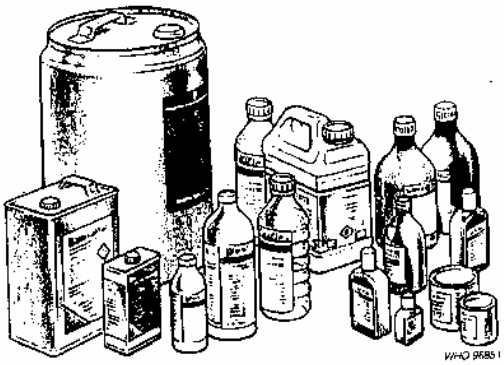


Fig. 6.5
Types of pesticide container (adapted from 2).

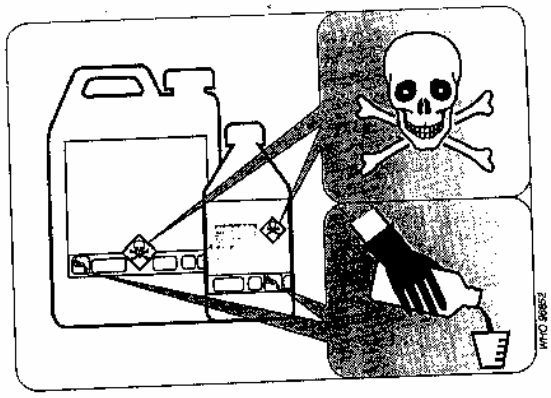


Fig. 6.6
look for warning symbol , pictograms and colour coding on labels (adapted from 2).

(Source: Jan A. Rozendaal: WHO 1997)

2. Store insecticides in a place that can be locked and is not accessible to unauthorized people or children.

3. Left over insecticide suspension can be disposed of safely by pouring it in to a specially dug hole in the ground or a pit latrine. It should not be disposed of where it may enter water used for drinking or washing, fish ponds or river.

4. Do not eat, drink or smoke while using insecticides. Keep food in tightly closed boxes.

5. Spray workers should wear, overalls or shirts with long sleeves and trousers, a broad-brined hat, a turban or other headgear and sturdy shoes or boots. The mouth and nose should be covered with a simple device such as a disposable paper mask, a surgical-type disposable or washable mask, or any clean piece of cotton. Furthermore, training in the safe use of insecticides should be given to the workers. The training should include the techniques of spraying, safety precautions, protective equipment, recognition of the early signs and symptoms of poisoning, and first aid measures.

6. Clothing should be kept in a good state of repair and should be inspected regularly for tears or worn areas through which skin contamination might occur. Protective clothing and equipment should be washed daily with soap, separately from other clothing.

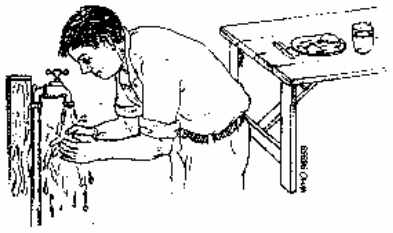


Fig. 10

Wash the hands and face before eating or drinking (adapted from 2).

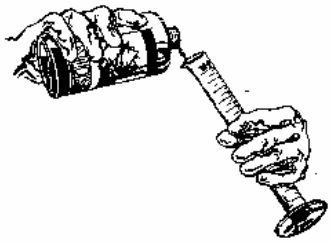


Fig. 6.11

Wear gloves when handling concentrates.

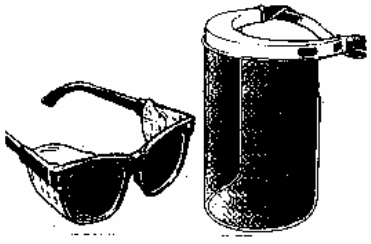


Fig. 6.12

Protective equipment for the eyes and face (adapted from 2).

(Source: Jan A. Rozendaal: WHO 1997)

Review Questions

1. List the different types of hand carried sprayers, Bucket sprayers and knapsack sprayers.
2. Write the difference and similarity between knapsack and compression sprayers.
3. List at least 4 safety measures (precautions) during insecticide handling.

GLOSSARY

1. **Aedeagus**:-is male sex organ of arthropods.
2. **Aerosol:** suspension of colloidal particles in gas.
3. **Appendages**: is any part of the body of insects or arthropods that is attached to the main structure. For instance, wing and legs are the appendages of insect thorax.
4. **Autogeny:** means spontaneous generation.
5. **Bilateral Symmetrical Body**: - is a body, which is divided in to two equal parts like that case of arthropods.
6. **Dichoptic :-** means a bit far apart.
7. **Complete** metamorphosis (holometabolous): type of metamorphosis by which an insect in its life cycle passes through egg, larva, pupa to reach to the adult stage.
8. **Holoptic:** nearer to each other.
9. **Dorsoventrally flattened insects**: - are insects that have a flat anatomical structure at the back and front side of their body.
10. **Epiphyic plants:** a non-parasitic plant that grows on another plant but gets itsnourishment from the air.
11. **Incomplete Metamorphosis (hemimetabolous):** type of metamorphosis by which an insect pass through egg, and nymph only during its life cycle to reach to adult.
12. **Integument**: - is the enveloping membrane of insect body.
13. **Larvicides:** chemical agents that specifically used to kill the larvae of insects (arthropods).
14. **Lymphadenopathy**: - is the enlargement of lymph nodes.
15. **Lymphatic filariasis**: is a disease caused by filarial worm which affects usually Lymph vessels at lower extremities.

16. **“Lyre” shape:** U-shape.
17. **Laterally flattened insects**: - are insects that have a flat anatomical structure at the right and left side of their body.
18. **Minimum lethal concentration**: - is the minimum concentration of a chemical that has a lethal effect on experimental animal.
19. **Myiasis** :- is an affection due to the invasion of the tissues or cavities of the body by the larvae of dipterous insects.
20. **New World:** the western hemisphere or countries or regions in the Western hemisphere**.**
21. **Non-residual Insecticide:** an insecticide that can’t stay in the environment for long period of time after spraying.
22. **Old World:** the Eastern hemisphere; the World of Europe, Asia and Africa.
23. **Respiratory Trumpet**: is a breathing tube that is located on the cephalothorax of mosquito pupae that used to take in air from the atmosphere.
24. **Rodenticides**: - are chemical substances or agents that normally kills rodents.
25. **Residual Intecticide:** an insecticide that can stay in the environment for longer period after application or spray with out changing its chemical property.
26. **Reservoir:** a living or non-living things where disease causing microorganisms or agents normally live, multiply and transferred to organisms.
27. **Rodent:** any of several mammals, as rats, mice, rabbits, squirrels, etc characterized by constantly growing incisors adapted for gnawing or nibbling.
28. **Savanna habitat:** a habitat where there are grass land which characterized by scattered trees, specially in tropical or subtropical regions.

29. **Scutellum**: - a structure that located in between thorax and abdomen of some insects.
30. **Transovarian transmission:** transfer of disease causing agent from adult animal, particularly of insects to the egg and when the egg reach to adult stage, become infective.
31. **Twi-light:** is a light after the sun-set and before dark.
32. **Zoonosis**: is a disease, which can be transmitted from animals to humans.

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