1. INTRODUCTION

Arthropods comprise the most numerous and varied of living things in the environment of man. Some of them are man's allies, but the majority of arthropods are either of no use to man or are his most dangerous enemies. They destroy man's crops and his food reserves; some which live close to man acts as vectors or carriers of disease.

Medical Entomology: A study of the arthropods of medical importance. It is an important branch of preventive medicine.

ARTHROPODS OF MEDICAL IMPORTANCE

Class Insecta	Class Arachnida	Class Crustacea
1) Mosquitoes: Anophelines Culicines	1) Ticks: Hard tick Soft tick	1) Cyclops
2) Flies: Houseflies Sandflies Tsetse flies Blackflies	2) Mites (chiggers): Leptotrombidium Trombiculid mites Itch mite	
3) Human lice: Head & body lice Crab lice		
4) Fleas: Rat fleas Sand fleas		
5) Reduviid bugs		

DISTINCTIVE CHARACTERS OF ARTHROPODS OF MEDICAL IMPORTANCE

Class	Insecta	Arachnida	Crustacea
1) Body Divisions	Head, thorax Abdomen	Cephalothorax Abdomen	Cephalothorax & abdomen
2) Legs	3 pairs	4 pairs	5 pairs
3) Antennae	1 pair	None	2 pairs
4) Wings	One or two pair; some are wingless	None	None
5) Where found	On land	On land	In water

ARTHROPOD BORNE DISEASES – constitute a major health problem in India.

Arthropod	Diseases transmitted
1) Mosquito	Malaria, Filaria, Viral Encephalitis (eg Japanese Encephalitis), Viral fevers (eg – Dengue, West Nile) Viral Haemorrhage fevers (eg- Yellow fever, Dengue Haemorrhagic fever)
2) Housefly	Typhoid & Paratyphoid Fever, Diarrhoea, Dysentery , Cholera , Gastroenteritis, Amoebiasis, Helminthic Infestations, Poliomyelitis, Conjunctivitis, Trachoma, Anthrax, Yaws etc.
3) Sandfly	Kala- azar, Oriental sore , Sandfly fever, Oraya fever.
4) Tsetse fly	Sleeping sickness
5) Louse	Epidemic typhus, Relapsing fever, Trench fever, Pediculosis .
6) Rat flea	Bubonic plaque, Endemic typhus, Chiggerosis, Hymenolepis diminuta
7) Black fly	Onchocerciasis
8) Reduviid bug	Chagas disease
9) Hard tick	Tick typhus, Viral Encephalitis, Viral fevers, Viral Haemorrhagic fever (eg: Kyasanur Forest Disease) , Tularemia, Tick paralysis, Human babesiosis
10) Soft tick	Q fever , Relapsing fever
11) Trombiculid mite	Scrub typhus, Rickettsial pox
12) Itch mite	Scabies

13) Cyclops	Guinea worm disease, Fish rape worm
14) Cockroaches	Enteric pathogens

TRANSMISSION OF ARTHROPOD BORNE DISEASES

Three types of transmission cycles are involved in the spread of arthropod-borne diseases.

1) **DIRECT CONTACT**: In this method arthropods are directly transferred from man to man through close contact eg: Scabies and Pediculosis.

2) **MECHANICAL TRANSMISSION**: The infectious agent is mechanically transported by a crawling or flying arthropod through soiling of its feet or proboscis; or by passage of organisms through its gastrointestinal tract & passively excreted. eg: Diarrhoea, Dysentery, Typhoid, Food Poisoning and Trachoma by the housefly.

3) **BIOLOGICAL TRANSMISSION**: The infectious agent undergoing replication or development or both in vector & requires an incubation period before vector can transmit.
   This may be of three types

a) **Propagative** – the agent merely multiplies in vector, but no change in form. eg: Plague bacilli in rat fleas.
b) **Cyclo-propagative**: The agent changes in form and number. eg: Malaria parasite in anopheline mosquito.
c) Cyclo-developmental: the disease agent undergoes only development but no multiplication. Eg: Microfilaria in culex mosquito and Guinea worm embryo in cyclops.

The factors which influence the ability of vectors to transmit disease are

1) Host feeding preferences
2) Infectivity, that is ability to transmit the disease agent
3) Susceptibility, that is ability to become infected
4) Survival rate of vectors in the environment

5) Domesticity, that is degree of association with man
6) Suitable environmental factors

SOME IMPORTANT DEFINITIONS

1) **Vector**: an arthropod or other invertebrate which transmits infection by inoculation into or through the skin or mucous membrane by biting or by deposit of infective materials on the skin or on food or other objects.

2) **Extrinsic incubation period**: the period of time necessary for the development of the disease agent in the arthropod host. eg: Malaria and Filaria it is 10 to 14 days.

3) **Definitive / Primary host**: is a host in which the sexual cycle of the agent occurs eg: mosquito is the definitive host in Malaria.

4) **Intermediate / Secondary host**: the host in which asexual cycle of the agent occurs eg: mosquito in Filaria and cyclops in Guinea worm disease.

5) **Infestation**: the lodgement, development and reproduction of arthropods on the surface of the body or in the clothing eg: Louse infestation.

6) **Trans-ovarial transmission:** the infectious agent is transmitted vertically from the infected female to her progeny in the vector.

7) **Trans-stadial transmission:** transmission of the disease agent from one stage of the life cycle of the vector to another stage of life cycle. eg: nymph stage to adult.

2. MOSQUITO

INTRODUCTION:

Mosquitoes constitute the most important single family of insects from the standpoint of human health. They are found all over the world.

There are 2 important Tribes of mosquitoes found in India

1. Tribe Anophelini
2. Tribe Culicini

The Tribe anophelini contains only one genus, Anopheles

The Tribe culicini has 15 genera, the important ones are i) Culex
ii) Aedes
iii) Mansonia

CHARACTERISTICS FEATURES OF MOSQUITO:

Body of a mosquito consists of 3 parts: Head
Thorax and
Abdomen

HEAD: it is semi-globular in outline, and bears the following structures

i) a pair of large compound eyes
ii) a long needle like structure, called the proboscis with which the mosquito bites
iii) a pair of palpi, each a four – jointed structure, situated on either side of the proboscis
iv) a pair of antennae or feelers. The antennae are bushy in the male,
& not quite so in the female.

THORAX: it is large and rounded, having a pair of wings dorsally and 3 pairs of legs ventrally. The wings of the mosquito are characterised by a fringe of scales on the posterior border & the first, third & sixth veins on the wings are not branched. The buzzing noise which mosquitoes produce is due to the beating of their wings.

ABDOMEN: it is long & narrow & is composed of 10 segments, the last 2 segments are modified to form external genitalia

LIFE CYCLE OF MOSQUITO: There are 4 Stages – Egg, Larva, Pupa and Adult

1. **EGGS:** are laid on the surface of water, 100 – 250 at a time. Under favourable conditions, the egg stage of mosquitoes lasts for 1 – 2 days. The period that elapses from the moment a blood meal is taken until the eggs are laid is called the **"gonotrophic cycle"**, it is about 48 hours in hot & humid tropical areas.

2. LARVA: are free swimming creatures with an elongated body divisible into head, thorax and abdomen. It feeds on algae, bacteria and vegetable matter and passes through 4 stages of growth called "instars" with moulting between each stage. The larval stage occupies 5 – 7 days.

3. PUPA: it is comma – shaped in appearance, with a large rounded cephalothorax and a narrow abdomen. Two small respiratory tubes or trumpets project from the upper surface of the thorax. It is the resting stage in the life history of the mosquito and lasts for 1 – 2 days

4. ADULT: under favourable conditions of temperature & food supply the life cycle from the egg to adult is complete in 7 to 10 days. Life span of adult mosquito is about 2 weeks. The males are generally short – lived.

IDENTIFICATION FEATURES OF ANOPHELES, CULEX AND AEDES

MOSQUITO	ANOPHELES	CULEX	AEDES
Eggs	• Eggs are laid singly • The eggs are boat – shaped and possess lateral floats	• Eggs laid in small clusters or rafts • The eggs do not possess lateral floats	• Eggs laid singly • The eggs are cigar – shaped and do not possess lateral floats
Larvae	• Floats horizontally in the water • Have no siphon	• Suspended in the water with their head downward • Have siphon	• Suspended in the water with their head downward • Have siphon

	tube at the tip of its abdomen • Palmate hairs present on the abdominal segments	tube which is situated on the 8th abdominal segment • No palmate hairs	tube which is situated on the 8th abdominal segment • No palmate hairs
Pupae	Siphon tube is broad and short	Siphon tube is long and narrow	Siphon tube is long and narrow
Adult	• Wings spotted • Palpi long in both sexes • When at rest, inclined at an angle to surface	• Wings unspotted • Palpi short in female • When at rest, the body exhibits a hunch back • Also known as Nuisance mosquito	• Wings unspotted • Palpi short in female • When at rest, the body exhibits a hunch back Aedes mosquito has white stripes on a black body. Legs are striped or banded, that is why it is also called as “tiger mosquito”
Important species	An. Culicifacies An. Philippinensis (both found in plains) An. Fluviatilis An. Minimus (both in foot hill regions) An. Stephensi An. Sundaicus	Culex fatigans (found everywhere & around dwellings)	Aedes aegypti Aedes vittatus Aedes albopictus (found in & around human dwellings)

	(both in coastal regions)		
Breeding places	Clean water	Dirty water collections like stagnant drains, cesspools, septic tanks, burrow pits	Artificial accumulation of water like discarded tins, broken bottles, fire buckets, flower pots, coconut shells, earthen pots, tree holes
Biting time	Evening & night	Midnight	Day biters
Diseases transmitted	Malaria Filaria (not in India)	Bancroftian filariasis Japanese encephalitis West Nile fever Viral arthritis (epidemic / polyarthritis)	Dengue fever Chikungunya fever Rift valley fever Filaria (not in India) Yellow fever (not in India)

HABITS OF MOSQUITOES – are essential for control measures and proper understanding of disease transmission.

1) Feeding habits – the males never bite: they subsist on plant juices. The females are haematophagous, they require blood meal once in 2 to 3 days for the development of eggs. Some species are anthrophilic (prefer human blood) & some are zoophilic (prefer animal blood).

2) Resting habits – some species rest indoors (endophilia) & some rest outdoors (exophilia). The indoor resting places are dark corners of houses, upper part of walls, behind pictures & under furniture. The outdoor resting places are vegetation, shrubs, tree holes, cattle sheds & wells.

CONTROL MEASURES: The various methods of mosquito control are
1) Anti-larval measures

a) Environmental control
b) Chemical control
c) Biological control

2) Anti-adult measures
a) Residual sprays
b) Space sprays
c) Genetic control

3) Protection against mosquito bites
a) Mosquito net
b) Screening
c) Repellents

1) ANTI-LARVAL MEASURES

a) ENVIRONMENTAL CONTROL: most important step in reducing the number of mosquitoes is to eliminate their breeding places. This is known as source reduction. Comprises of minor engineering methods – filling
Levelling & drainage of breeding places
Water management such as intermittent irrigation

Species specific environmental control methods are

i) Culex – abolition of domestic and peridomestic sources of breeding such as cesspools and open ditches. Adequate collection, removal & disposal of sewage & waste water.

ii) Aedes - getting rid of water holding containers such as discarded tins, empty pots, broken bottles, coconut shells and similar other artificial collections of water.

iii) Anopheles - breeding places should be abolished by appropriate engineering measures such as filling and drainage.

iv) Mansonia - the aquatic plants (Pistia stratiotes and water hyacinth) to which the larvae attach themselves should be removed or destroyed by herbicides.

b) CHEMICAL CONTROL: commonly used larvicides are
Mineral oils
Paris green
Synthetic insecticides

i) Mineral oils: widely used are diesel oil, fuel oil, kerosene and fractions of crude oils. Special oils like mosquito larvicidal oil are also available. When applied on water, oil spreads and forms a thin film which cuts off the air supply to the mosquito larvae and pupae. The

usual application rate for oils is 40 to 90 litres per hectare. Since life cycle of mosquito occupies about 8 days. It is customary to apply oil once a week on all breeding places. Disadvantage – renders water unfit for drinking & kills fish.

ii) Paris green (copper acetoarsenite): is an emerald green, micro – crystalline powder practically insoluble in water. It is a stomach poison and to be effective it must be ingested by the larvae. Mainly effective on Anopheles larvae because they are surface feeders. For bottom feeding larvae it is applied as a special granular formulation. The recommended dose is 1 kg of paris green per hectare of water surface. At this dose paris green does not harm fish, man or domestic animals.

iii) Synthetic Insecticides:

INSECTICIDE	**DOSAGE (g / ha)**
Abate	56 - 112
Malathion	224 - 672
Fenthion	22 - 112
Chloropyrifos	11 - 16

c) BIOLOGICAL CONTROL: use of larvivorous fish like Gambusia affinis and Lebister reticulates. They can be used in burrow pits, sewage oxidation ponds, ornamental ponds, cisterns and farm ponds.

2) ANTI-ADULT MEASURES:

a) RESIDUAL SPRAYS – adult mosquitoes are commonly controlled by spraying houses with residual insecticides.

Insecticide	DOSAGE IN g / m^2	Average duration of effectiveness (months)
DDT	1 – 2	6 - 12
Lindane (gamma – HCH)	0.5	3
Malathion	2	3
Propoxur (OMS – 33)	2	3

b) SPACE SPRAYS: insecticidal formulation is sprayed into the atmosphere in the form of a mist or fog to kill insects. The common space sprays are

i) Pyrethrum Extract: is a nerve poison and kills insects instantly on mere contact. Pyrethrum is sprayed at a dosage of 1 oz of the spray solution (containing 0.1% of the active principle, pyrethrin) per 1,000 C. ft. of space. For domestic purposes, the hand gun with a fine nozzle is used & for large scale power sprayers or "aerosol" dispensers are needed. The result produced is temporary as it has no residual action.

ii) Residual Insecticides: new equipments used for ultralow volume space spraying. The most extensively used insecticides are malathion and fenitrothion for ULV fogging.

c) GENETIC CONTROL METHODS:

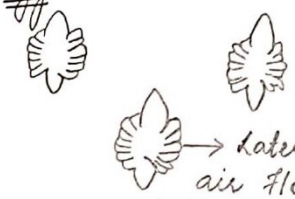
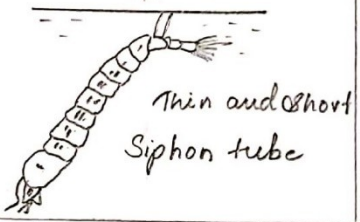
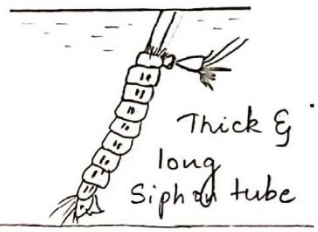
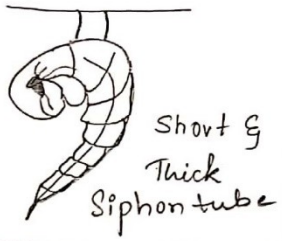
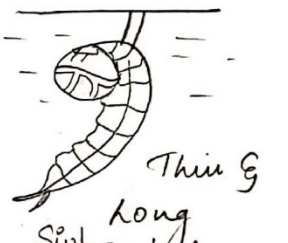
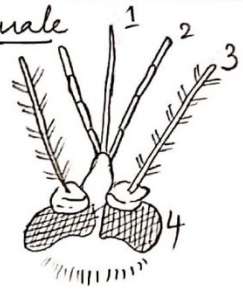
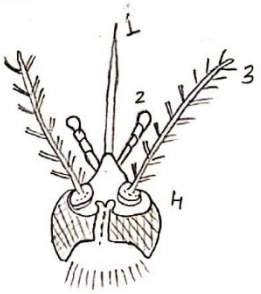
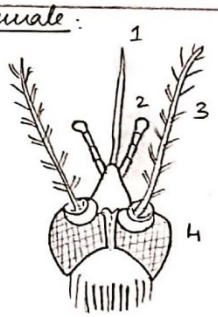
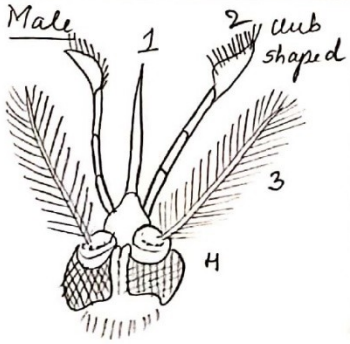
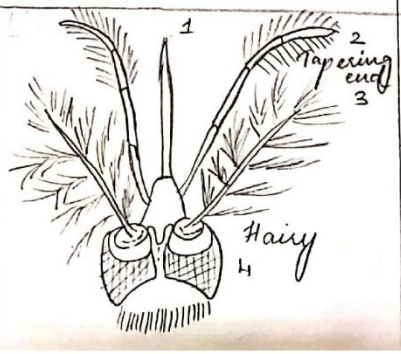
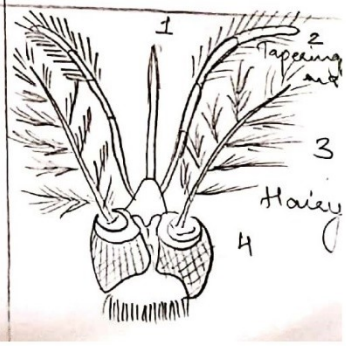
- Sterile male technique
- Cytoplasmic incompatibility
- Chromosomal translocations
- Sex distortion and gene replacement

3) PROTECTION AGAINST MOSQUITO BITES:

a) Mosquito net: offers protection against mosquito bites during sleep. Material should be white – for easy detection of mosquito. The best pattern would be rectangular. Size of the openings should not exceed 0.0475 inch in any diameter & number of holes in one square inch is usually 150.

b) Screening: Of buildings with copper or bronze gauze having 16 meshes to the inch is recommended. Aperture should not be larger than 0.0475 inch.

c) Repellents: Diethyltoluamide (deet) is an all-purpose repellent, effective against Culex fatigans for 18 to 20 hours. Others used are indalone, dimethyl phthalate, dimethyl carbate, ethyl hexanediol, etc. Repellents are used mainly for application on the skin, & they offer short duration of protection.

ANOPHELES	AEDES	CULEX
Egg :  	 Cigar shaped Singly placed	 in clusters / raft
Larva : Floats 	Bottom Feeders :  	Bottom Feeders : 
Pupa :  	 	
Female  	Female.  	Female : 
Male  	 	

3. HOUSEFLY

1. **INTRODUCTION**

- Houseflies are the commonest & most familiar of all insects which live close to man. They occur in abundance all the year round in India. Housefly belongs to the class Insecta. Regarded as a sign of insanitation; their number as an index of that insanitation.
- Important houseflies found in India are Musca domestico, M. vicinia, M. nebulo and M. sorbens.

2. **IDENTIFICATION**

- Mouse-grey in colour.
- Pair of large compound eyes.
- The thorax is marked with 2 to 4 dark longitudinal stripes.
- A pair of wing and three pairs of legs.

3. **CHARACTERISTIC FEATURES OF HOUSEFLY**: Body is divided into Head, Thorax & Abdomen.

a) Head has a pair of antennae, pair of large compound eyes and a retractile proboscis, adapted for sucking liquid foods. Eyes in male: close together; In female: set apart widely.
b) Thorax is marked with 2 to 4 dark longitudinal stripes & bears a pair of wing and three pairs of legs. Each leg is provided with a pair of pads, to walk on highly polished surfaces. The legs and the body are covered with tenent hairs (numerous short and stiff hairs) which secrete a sticky substance.
c) Abdomen is segmented; shows light and dark markings.

4. **LIFE CYCLE**: Four stages: egg, larva (maggot), pupa and adult.

a) EGG:

- The female lays from about 120 to 150 eggs at one sitting in moist decaying organic matter such as human and animal excreta, manure heaps, garbage and vegetable refuse, rubbish dumps containing organic matter, ground where liquid wastes are spilled; 600 to 900 eggs during her life time.

- eggs are pearly-white in colour; measuring 1 mm long.
- Readily seen by the naked eye.
- eggs hatch in 8 to 24 hours; during summer, in India they may hatch within 3 hours.

b) LARVA (MAGGOT):

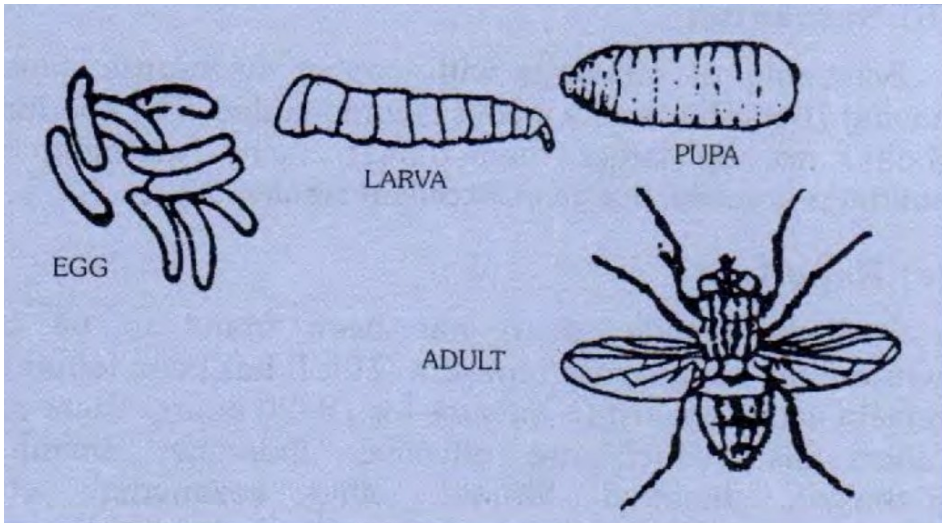
- Larvae or maggots measure 1 to 2 mm in length at birth; 12 mm in length when full grown.
- White, segmented and footless with a narrow anterior end, and a broad posterior end.
- Eat voraciously and moult twice in the course of development.
- The larvae resent light; bury themselves under manure heaps.
- When about to pupate, they migrate to dry outer regions.
- This stage lasts from 2 to 7 days, may be prolonged in cold weather.

c) PUPA:

- Dark brown; barrel shaped; measure about quarter of an inch.
- This stage lasts for 3 to 6 days; in winter months, may be prolonged.

d) ADULT:

- The complete life cycle from egg to adult may take 5 to 6 days during summer in India, but at other times it may take 8 to 20 days.
- Life span about 15 days in summer and 25 days during winter.



5. **DISEASES TRANSMITTED**: Flies transmit disease by mechanical transmission, vomit drop & defecation. They transport micro-organisms on their feet & hairy legs.

- Typhoid and Paratyphoid fevers
- Diarrhoeas and Dysenteries
- Cholera and Gastroenteritis
- Amoebiasis, Helminthic infestations
- Poliomyelitis,
- Conjunctivitis, Trachoma,
- Anthrax, Yaws

6. <u>HABITS:</u>

1) **Feeding habits** – housefly does not bite. It cannot eat solid foods; it vomits on solid food to make a solution of it & sucks in a liquid state. Adult flies are found on sputum, faeces, discharges from wounds & open sores.
2) **Restlessness** – the fly is a restless insect & moves back & forth between food & filth.
3) **Vomit drop** – the fly vomits frequently. The vomit drop is often a culture of disease agent.
4) **Defecation** – the housefly has the habit of defecating constantly all the day.
5) **Resting habits** – rest on vertical surfaces & hanging objects.
6) **Dispersal** – up to 4 miles.

7. **<u>FLY CONTROL MEASURES</u>**:

a) **<u>Environmental control</u>**: to eliminate their breeding places.

- Storing garbage, kitchen wastes and other refuse in bins with tight lids, pending disposal.
- Segregating dry and wet wastes in blue and green coloured bins respectively at the point of generation in home.
- Efficient collection, removal and disposal of refuse by incineration, composting or sanitary landfill.
- Provision of sanitary latrines, e.g., pit latrine, septic tanks, water-seal latrines and sanitary system.
- Stop open air defecation.
- Sanitary disposal of animal excreta.

b) **<u>Personal hygiene</u>**:

- Keep kitchen and surroundings clean.

- Cooked food at home should be kept covered.
- Hands should be washed before preparing food and eating.
- Wash hands after visit to toilet
- Keep finger nails trimmed & clean.

c) **<u>Insecticidal control</u>**:

- <u>Residual sprays</u>

For susceptible flies - DDT (5%), methoxychlor (5%), lindane (0.5%), or chlordane (2.5%) sprayed at about 5 litres per 100 square metres of surface.

For resistant flies - Diazinon (2%) dimethoate (2.5%), fenthion (2.5%), malathion (5%), or ronnel (5%). The addition of sugar to insecticidal formulations enhances their effectiveness.

- <u>Space sprays</u>

- Space sprays containing pyrethrin and Dichloro diphenyl trichloroethane (DDT) or Hexa chloro cyclohexane (HCH). Pyrethrin and DDT are applied at the rate of 3.3 g. per 1,000 cu. ft. for routine treatment of dwellings. Applied indoors or outdoors using hand or power sprayers. Little or no residual action. Produce only a temporary effect on adult fly populations; consequently, repeated applications are necessary.
- Indoor space treatment: is done when as many flies as possible are indoors, e.g. in the evenings.
- Outdoor space treatment: Space treatments should be applied when fly densities are at a peak, for example in the morning. Daily treatments over a period of, say, two weeks may reduce the density to a level where further control can be obtained by treatments at longer intervals, e.g. 1–2 weeks.

- <u>Larvicides</u>:

- Insecticides such as 0.5% diazinon, 2% dichlorovos, 2% dimethoate or 1 % ronnel applied at the rate of 28 - 56 litres per 100 sq. metres. Used for the treatment of fly breeding places.

- <u>Baits</u>:

- May be Solid or liquid.

- Poisoned solid baits containing 1 or 2% diazinon, malathion, dichlorvos, ronnel and dimethoate.
- Liquid baits containing 0.1 to 0.2% of the same insecticides and 10% sugar water.
- The cheapest bait is made by mixing 3 teaspoons of commercial formalin with one pint of water or milk to which is added a little sugar.

- Cords and Ribbons:

- Cords and strips impregnated with diazinon, fenthion, or dimethoate. These are hung like festoons from ceilings. The period of effectiveness is 1 to 6 months.

d) **Fly papers:**

- Made by mixing 2 lbs of resin and one pint of castor oil which should be heated together until the mixture resembles molasses. This should, while hot, be smeared on paper by using an ordinary paint brush. The adhesive mixture can also be applied to strips of wire and hung up in places where flies abound.

e) **Protection against flies:**

- Screening of houses, hospitals, food markets, restaurants and all other similar establishments will give considerable relief from houseflies. Screens with 14 meshes to the inch should be used.

4. SANDFLY

INTRODUCTION:

- Sandflies are small, flying, biting, blood sucking dipterans found in sandy areas. They are 1.5 to 2.5 mm in length and light or dark brown in colour. Their bodies & wings are densely clothed with hair.
- About 30 species of sandflies are recorded in India. Among them the important ones are – Phlebotomus argentipes, P. papatasii, P. sergenti & Sergentomyia punjabensis.

IDENTIFICATION:

- Dark brown in colour with hairy body & smaller than mosquito in size.
- It has a pair of lanceolate shaped wings and a pair of long hairy antennae.
- It has 3 pairs of long, slender legs out of proportion to the size of body.
- Secondary vein of the wing divides twice.

CHARACTERISTIC FEATURES OF SANDFLY:

- Body is divided into head, thorax and abdomen.

Head:

- Has a pair of long, slender and hairy antennae, palpi and a proboscis.
- Only female sandflies bite, while males live on plant juices.

Thorax:

- Has a pair of wings and 3 pairs of legs.
- Wings are upright, lanceolate in shape and densely hairy.
- Second longitudinal vein of the wing branches twice, with first branching in the middle of the wing. This is characteristic feature of genus Phlebotomus.
- Legs are long, slender and out of proportion to the size of body.

Abdomen:

- Has 10 segments and is covered with hair.

- In female the tip is rounded, while male have claspers attached to the last segment.

LIFE CYCLE: It has the following four stages:

Egg:

- Eggs are laid in damp, dark places in vicinity of cattle sheds and poultry.
- Eggs are comparatively large and torpedo shaped with longitudinal wavy lines on outside.
- Eggs hatch within 7 days.

Larva:

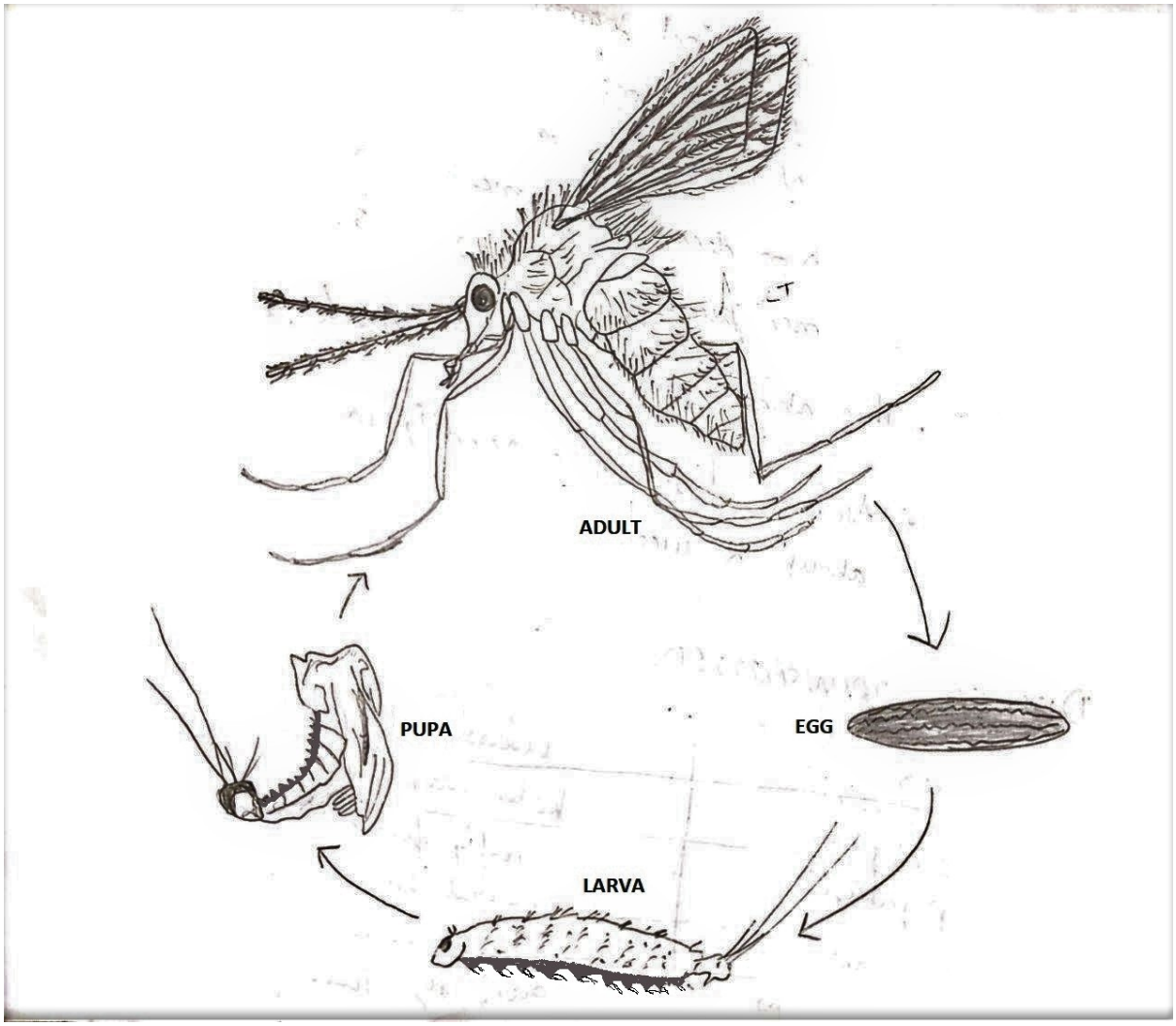
- Larva are hairy maggots with distinct head, thorax and abdomen.
- Have 4 instar larval stages.
- In the last abdominal segment, they have 2 pairs of long, stout hairs. Among them one pair is remarkably long.
- They feed on decaying organic matter & become pupa in about 2 weeks.

Pupa:

- They are 3 mm long and club-shaped.
- The head and neck are curved backwards.
- This stage lasts for about 1 week.

Adult:

- Average life span of a sandfly is about 2 weeks. There are troublesome nocturnal pests. Their bite is irritating & painful. They infest dwellings during night, & take shelter during day in holes & crevices in walls, holes in trees, dark rooms, stables & store rooms. The female require a blood meal every 3^{rd} or 4^{th} day for oviposition.
- They hop from place to place and are incapable of flying long distances.
- They are generally confined within 50 yards of their breeding place.



DISEASES TRANSMITTED:

Kala Azar, Sandfly fever, Oriental sore

CONTROL OF SANDFLIES: Control is easy as sandflies do not move long distances from their site of breeding.

1) Insecticides: spraying should be done in the human dwellings, cattle sheds & other places.

INSECTICIDE	DOSAGE REQUIRED	EFFECTIVE PERIOD
DDT	1 to 2 g/m^2	1 to 2 years
Lindane	0.25 g/m^2	3 months

2) Source reduction:

- Removal of shrubs and vegetation within 50 yards of human dwellings.
- Filling up of cracks and crevices in walls and floors.
- Location of cattle sheds and poultry at a fair distance from human habitation.

3) Personal protection:

- Sandfly net impregnated with permethrin can be used. The net should have 45 mesh / inch.
- Not walking in barefoot & Using gumboots and repellants to leg.

5. RAT FLEA

Introduction: Fleas are small, bilaterally compressed wingless insects with a hard chitinous exoskeleton and covered with backwardly directed bristles. They are blood sucking ecto–parasites of mammals and birds.

Types of fleas: More than a thousand different species of fleas have been described; some 37 species are known to occur in India.

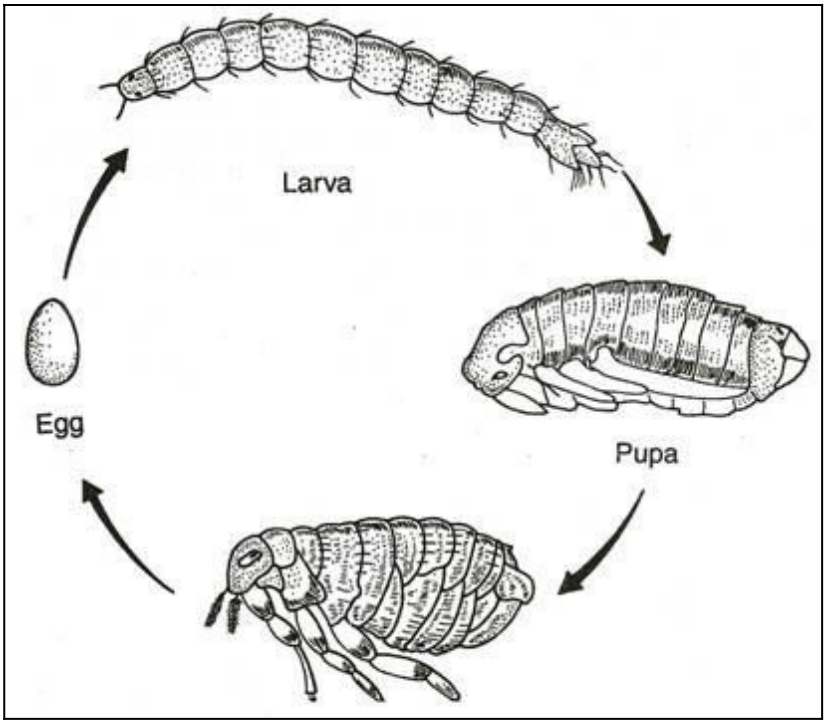
1. Rat fleas (oriental)	Xenopsylla cheopis X. astia X. braziliensis
2. Rat fleas (temperate zone)	Nosopsylla facciatus
3. Human fleas	Pulex irritans
4. Sand fleas (Jigger or chigoe fleas)	Tunga penetrans
5. Dog and cat fleas	Ctenocephalus canis Ctenocephalus felis

Characteristic features: Body of a flea is divided into head, thorax and abdomen.

- Head: Conical in shape. It is attached to thorax without neck. It has short, piercing mouth parts whXxxsich are conspicuous and project downwards from the head.
- Thorax: It is divided into prothorax, mesothorax and metathorax. There are three pairs of spiny strong limbs attached to thorax. No wings.
- Abdomen: It has 10 segments. In male, there is a coiled structure in abdomen which is the penis. In female, there is a short, stumpy structure in the posterior part of the abdomen called the spermatheca.

Life Cycle: There are 4 stages in life history namely egg, larva, pupa & adult

- Egg: Small (0.5 mm), ovoid and white in colour. They are deposited among the hairs of the animal host or in and near the nest of its host. A female may lay up to 300 to 400 eggs in its lifetime – 2 to 6 or even more at a time. Eggs are hatched in 2 to 7 days.
- Larva: Small, legless caterpillars, whitish in colour and bear sparse long hair. They are found in the dust and debris, in or near the nests of the host. They feed on organic matter and the blood in the faeces of the adult flea. There are 3 larval stages; the last stage spins a cocoon. The duration of the larval stage is 2 weeks.
- Pupa: Develops inside a cocoon. Lasts 1 to 2 weeks.
- Adult: The life cycle of a flea is completed within 3 weeks. Life span is 30 days. Infected fleas may live for 1 year.



Habits

- Found on their hosts and in the nests, burrows of their hosts. They are also found in the dwellings, on the ground, in cracks & crevices and under carpet.
- Both sexes bite and suck blood. They feed at frequent intervals.
- Cannot fly, but can make vertical jumps up to 4 inches and horizontal jumps up to 6 inches.

Diseases transmitted:

1. Bubonic Plague
2. Endemic typhus
3. Chiggerosis
4. Hymenolepsis diminuta

Modes of transmission: 1. Biting 2. Mechanical transmission 3. Faeces

Blocked Flea: Some fleas which ingest plague bacilli become blocked due to the multiplication of plague bacilli in their proventriculus (stomach). Fleas affected in this way are called 'blocked' fleas.

a) Completely Blocked Flea: the blockage of the food passage renders the flea unable to obtain further blood meals. Because of hunger, the flea tries to bite, it will not be able to do so & dies.

b) Partially Blocked Flea: If the proventriculus (stomach) is partially blocked, because of hunger, the flea begins to bite more ferociously & makes frantic efforts to suck blood. Each time it bites, instead of sucking blood, it injects large number of plague bacilli into the wound, thus more effective transmission of disease and it also lives longer.

Flea Indices: Indices used in flea surveys are

i. General Flea Index: Average number of fleas of all species found per rodent.
ii. Specific Flea Index: Average number of fleas of each species found per rodent.

iii. Percentage Incidence of Flea Species: Percentage of fleas of each species found per rodent.

iv. Rodent Infestation Rate: Percentage of rodents infested with various flea species.

Control of Fleas

1) **Insecticidal Control**: Most commonly used is 10% Dichloro Diphenyl Trichloro ethane (DDT) dust. As the rodent pass over the dust, they pick it up on their fur where it kills the fleas. If resistant to DDT or HCH, Carbaryl or 2% Diazinon or 5% Malathion are used.

   Application:

   i) The sprays should be applied to floors & walls up to a height of 1 ft.

   ii) Patch dusting with insecticidal powder is done over rat runs, under gunny bags, and other harborage places.

   iii) insecticidal dust is blown into the rodent burrows with dust blowers at 30 g per burrow.

2) **Repellents**: Diethyltoluamide & benzyl benzoate are efficient flea repellents. Clothing impregnated with diethyltoluamide repels fleas for more than a week.

3) **Rodent Control**: the important anti-rodent measures are:

   i) Environmental Sanitation measures like proper storage, collection and disposal of garbage; proper storage of food stuffs; construction of rat proof buildings, godowns & warehouses; elimination of rat burrows by blocking them with concrete.

   ii) Rodenticides are of two types – single-dose (acute) and multiple-dose (cumulative). The first type is lethal after single feeding, while later requires repeated feedings over a period of three or more days.

   The commonly used single dose rodenticide is Zinc phosphide. It is used in the ratio of 1 part to 10 parts of wheat or rice flour and mixed with a few drops of edible oil. Rats are killed within about 3 hours. Multiple-dose poisons are warfarin, diphacinone, coumafuryl and pindone. As

anticoagulants, they cause internal hemorrhage and slow death in 4 to 10 days.

iii) Fumigation destroys both rat and rat fleas. Fumigants used are calcium cyanide (cyanogas), carbon disulphide, methyl bromide & sulphur dioxide. Cyanogas is used for fumigation of rat burrows extensively in India. It is prepared in powder form and is pumped into burrows by a special foot pump called “Cyanogas pump”. About 2 ounces of poison are pumped into burrows after closing the exit openings and burrow are sealed promptly with wet mud. On contact with moisture, the powder gives off hydrogen cyanide which is lethal to both rat and rat fleas.

iv) Trapping It is recommended that the number of traps laid should be at least 5% of the human population. Traps are usually baited with indigenous foods of the locality. Captured rats must be destroyed by drowning them in water.

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6. LICE

Introduction: Lice are small wingless ecto-parasites of mammals and birds. They bite severely and are annoying pests. Human lice occur in all parts of the world wherever standards of hygiene are low, but people in colder climates are affected more frequently than those in warmer regions.

Infestation by lice is called pediculosis. It can cause dermatitis due to scratching and secondary infection

The lice that infest man are of three kinds:

- head louse (Pediculus capitis)
- body louse (Pediculus corporis)
- pubic or crab louse (Phthirus pubis).

Characteristic features of Head and body lice:

The head and body lice differ very little in structure except in their habitat. The head lice inhabit the hairs of the scalp, and the body lice occur mainly in the seams of clothing and on the bodies of the hosts. The body of a louse is flattened dorso-ventrally, and is divided into head, thorax and abdomen.

HEAD: The head is pointed in front and bears a pair of 5-jointed antennae. The mouth parts are adapted for sucking blood.

THORAX: The thorax is a fused mass and is shaped somewhat like a square. Three pairs of legs are attached ventrally to the thorax. The legs are strongly developed and are provided with claws which help the insect to cling to the hair and clothing.

ABDOMEN: The abdomen is elongated and consists of 9 segments. The last abdominal segment is pointed in the case of male, and bilobed in the case of female.

Life history: There are three stages in the life history of lice:

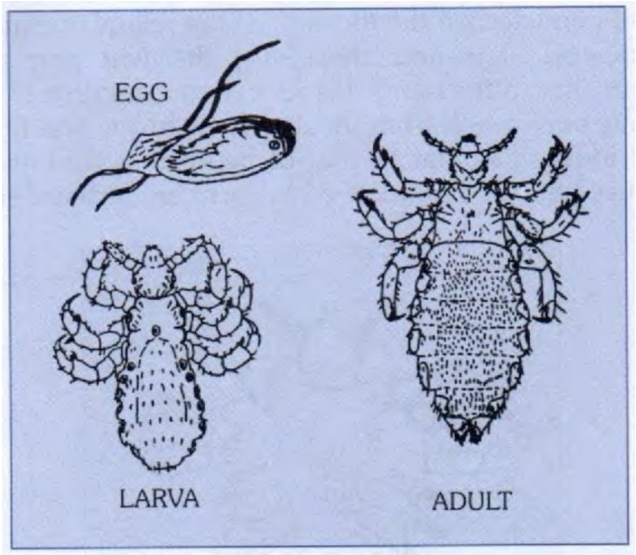
- Egg,
- Larva
- Adult.

EGG: The eggs, called "nits" are laid singly or in groups, firmly attached to the hair or seams of clothing by a cementing substance. The eggs are small, white ovoid bodies, pointed at one end and truncated and pitted at the other end. A

female lays up to 300 eggs, at the rate of 4 to 9 eggs a day. The eggs will hatch in 6 to 9 days.

LARVA: The larva looks very much like an adult, except for its smaller size. It feeds on the host and develops into an adult after passing through 3 moults. The larval stage may take 10 to 15 days.

ADULT: The entire life cycle from the laying of an egg to the appearance of the adult louse takes about 15 to 17 days. Life span of Adult lice is 30 to 50 days.



Dissemination of pediculosis

(1) DIRECT CONTACT: Lice are disseminated by close contact with infested person. Overcrowding provides an excellent opportunity for the direct transference of lice from one person to another. Children get easily infested at school when their heads come together at work or play.

(2) INDIRECT CONTACT: Lice may also be acquired from clothing, bedding, combs or brushes used by lousy persons. Lice have been seen to be blown by puffs of wind from heavily infested persons.

Diseases transmitted:

1. Epidemic typhus

2. Relapsing fever

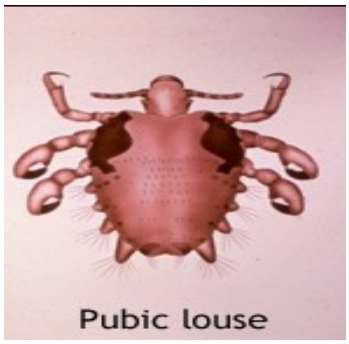
3. Trench fever

Characteristic feature of Crab or pubic louse:

It is generally found in the pubic and perineal region, but at times it may occur in the other parts of the body as well. It adheres close to the skin, and its removal is a matter of difficulty. The crab louse is readily recognized by

- Its small size and square body
- Head impacted on the thorax
- Enormous & powerful legs and claws
- first pair of legs slenderer than others
- its extreme inertness. It does not move very much from the site of its birth.

The life cycle of crab louse is similar to that of head or body louse. They do not act vector for any disease.



Control of lice.

1) INSECTICIDAL CONTROL:

(a) For head and crab lice:

- Lotion containing 0.5% malathion. The lotion should be left on for 12 to 24 hours then the hair can be washed. Malathion, if correctly used, will kill lice and nits.
- Dust containing 5% carbaryl is also effective as louse powder.

(b) For body Lice:

- A powder containing 1% malathion.
- Dust containing 5% carbaryl may also be used.
- **How to use:** The powder is applied to the inner surface of the clothing as well as socks and the body of the persons.

"Mass delousing" of large numbers of people is carried out with hand operated dusters. The powder is blown down the neck of the shirt, up the sleeves, and into the loosened trousers from several angles at the front and back. About 50

g. of the insecticidal powder are required for one person. Normally a single application will eradicate an infestation, but a second application may be made in 7 days to kill late hatching lice.

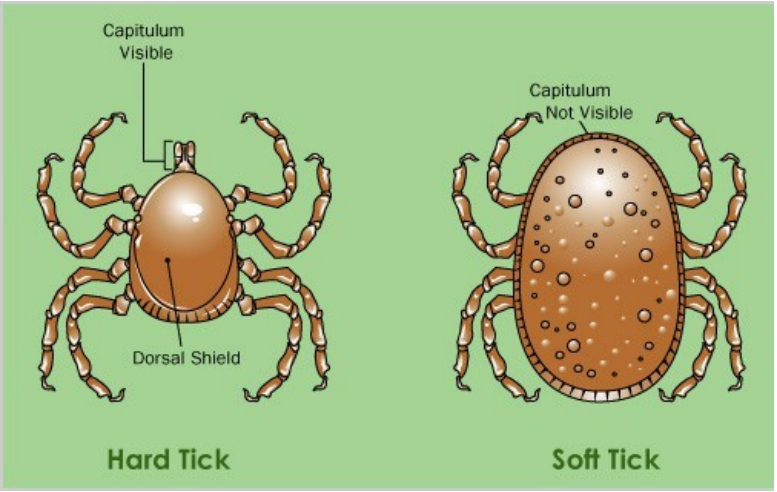
(2) PERSONAL HYGIENE:

- Take regular bath, change and launder the clothes. A daily bath with soap and water is essential in a country like India to prevent lice infestation.
- Women with long hair should wash and clean their hair frequently.
- Clothing, towels and sheets should be washed in hot water and soap and pressed with hot iron. Autoclaving of clothes and bedding in steam sterilizers may be required for body louse control.
- Health education
- Improving living standards.

7. TICKS

1) Introduction: Ticks belong to the order Acarina of the phylum Arthropod. They are blood-sucking ecto-parasites on vertebrate mammals (Human, dog, cattle, etc). They are oval in shape and not distinctly separated into head, thorax and abdomen. They have four pairs of legs, and no antennae. Male are generally smaller than female.

- Ticks are of two types: Hard tick (Ixodidae), Soft tick (Argasidae).



2) Comparison of hard and soft tick:

Characteristic	Hard Tick	Soft Tick
1) Scutum (chitinous shield)	Covers the entire back in male; a small portion in front in female	Absent.
2) Head	Situated at the anterior end.	Lies ventrally; cannot be seen from above
3) Feeding habits	Cannot stand starvation; feed night and day.	Can stand starvation for a year or more.
4) Location	Always found on their hosts.	Hides in cracks and crevices in day time and emerge at night to feed on the host.
5) Important species	Dermacentor andersoni, Haemophysalis spinigera	Ornithodorus moubata

6) Diseases transmitted	- Kyasanur Forest Disease - Tick typhus - Viral encephalitis - Viral fevers - Tularemia - Tick paralysis - Human babesiosis.	- Kyasanur Forest Disease - Q fever - Relapsing fever

3) Life cycle: There are four stages; Egg, Larva, Nymph & Adult.

a) Egg

- Hard ticks lay several hundred to thousand eggs at one sitting, after which the female is exhausted and dies.

- Soft ticks lay in batches of 20 – 100 over a long period.

- Eggs are deposited on the ground; hatches in 1 – 3 weeks.

b) Larva

- Possesses 3 pairs of legs.

- Lies in wait among grass and herbiage till a suitable host appears to which it attaches itself and has the blood meal.

- It then drops off the host, moults to become nymph.

- the duration of larval stage is 3 to 13 days

c) Nymph

- Resembles the adult in having 4 pairs of legs, but has no genital pore.

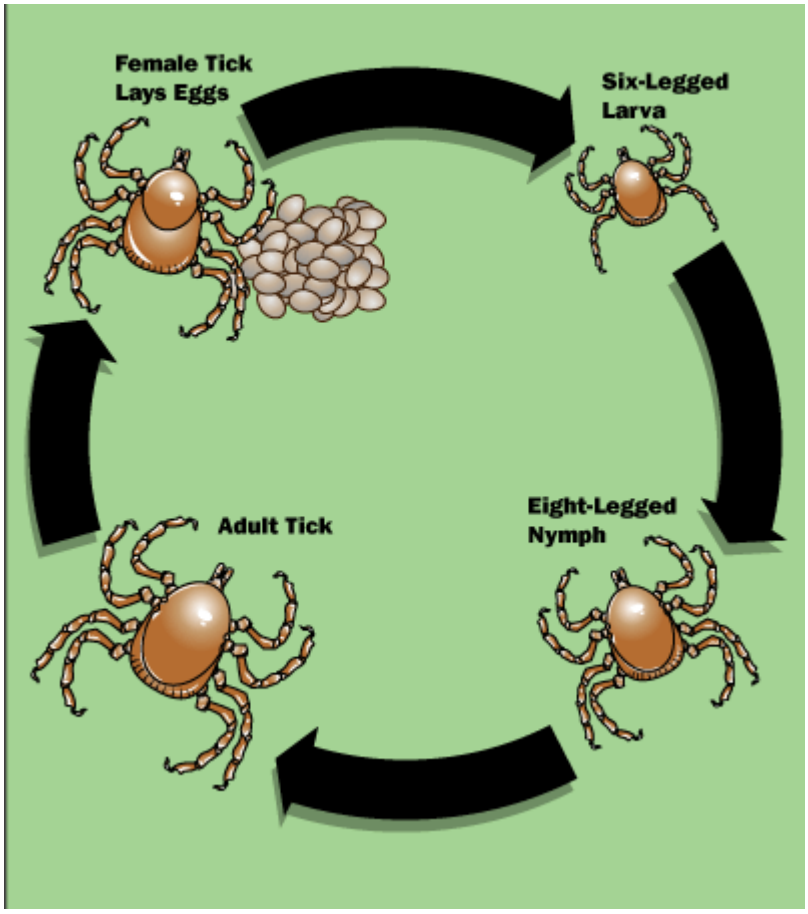
- all are blood suckers; attach to suitable hosts for a blood meal.

- Hard ticks: 1 nymphal stage; Soft ticks: 5 nymphal stages in life history

d) Adult:

- Hard tick: Duration of lifecycle from egg to adult – 2 months; soft tick – 9 to 10 months.

- adult ticks may live for a year or more. Soft ticks live longer than hard ticks.



4) Control of ticks

a) Insecticidal control: 5% DDT, 2.5% Chlordane, Dieldrin, Lindane, Malathion, Toxaphane at rates of 1 to 2 lbs. per acre. Either dusting or spray formulations can be employed. Animals may be freed of ticks by treating them with insecticidal sprays or dusts.

b) Environmental control: Cracks and crevices in grounds to be sealed; particularly near buildings and paths.

c) Personal protection measures of workers: Protective clothing impregnated with insect repellents (indolane, diethyltoluamide and 25% benzyl benzoate) to be used by workers. Persons working in tick infested areas should be trained to examine themselves for ticks and to remove promptly any ticks found on their person.

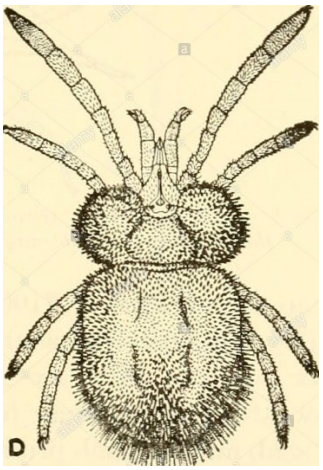
8. MITES (CHIGGERS)

Mites belong to Phylum arthropod. They are blood sucking Ecto-parasites of vertebrate and animals. Having 4 pairs of legs and body is not well demarcated into head, thorax, and abdomen. From the public health standpoint two mites are important. 1) Trombiculid mite and 2) Itch mite.

1) TROMBICULID MITE

A) INTRODUCTION: Spider – like arthropods. Live in forests, grasslands and vegetation of low damps. In larval stage, they attach to animals and humans causing itching.

B) Important species are Leptotrombidium deliense & Leptotrombidium akamushi.



C) LIFE CYCLE: Has 4 stages; namely egg, larva, nymph and adult.

1) EGG – laid singly, hatch in about a week
2) LARVA – Small, pale orange in colour with 3 pairs of legs. It attacks vertebrate host. When gorged with blood it drops down to the ground for moulting. Stage lasts for 1 – 2 weeks.
3) NYMPH – Brick red in colour with 4 pairs of legs. It lives on vegetable juices. Stage lasts for 1 – 3 weeks
4) ADULT – Has 4 pairs of legs and first pair being the largest. The life span is 6 months and adult male lives in soil.

D) DISEASES TRANSMITTED: Scrub typhus and Rickettsial pox.

E) CONTROL OF TROMBICULID MITE:

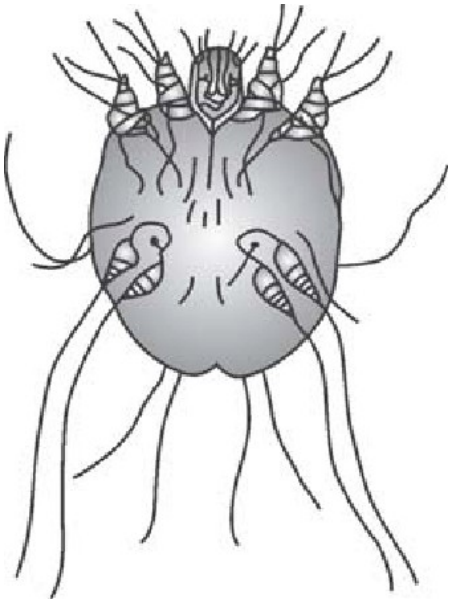
a) Insecticidal control: 5% DDT, 2.5% Chlordane, Dieldrin, Lindane, Malathion, Toxaphane at rates of 1 to 2 lbs. per acre. Either dusting or spray formulations can be employed.
b) Environmental control: Cracks and crevices in grounds to be sealed; particularly near buildings and paths.

2) ITCH MITE

A) INTRODUCTION: A small globular arthropod, dirty white in colour and visible to the naked eye. Female parasite burrows into the epidermis, where it breeds and causes the condition known as scabies or itch.

SCIENTIFIC NAME: Sarcoptes scabiei or Acarus scabiei

B) GENERAL DESCRIPTION: The itch mite measures about 0.4 mm and body is shaped like tortoise. It is rounded above and flattened below. No demarcation of body segment. Body surface is thrown into folds and is covered with short bristles. The parasite has two pairs of legs in front, and two pairs behind. The front legs end in long tubular processes known as suckers and the hind legs end in long bristles.



C) LIFE CYCLE: Has 4 stages; namely egg, larva, nymph and adult.

1) EGG - Female lays eggs upto 30 at the rate of 2 – 3 /day in burrow within stratum corneum and ultimately dies. The eggs hatch into larvae in 3 – 4 days.

2) LARVA - Three legged, comes out of burrow to surface and bore into the hair follicles where vesicles are formed. The larvae mature into nymphs in about 3 days.
3) NYMPH - develops into adults in 6 – 8 days.
4) ADULT - duration of life cycle is 10 – 15 days; life span of mite is 1 – 2 months.

D) MODE OF SPREAD: 1) Close contacts and 2) contaminated clothes.

E) COMMON SITE OF LESION: Hands, wrist, extensor aspect of elbows, axillae, buttocks, lower abdomen, feet, ankles, palms in infants.

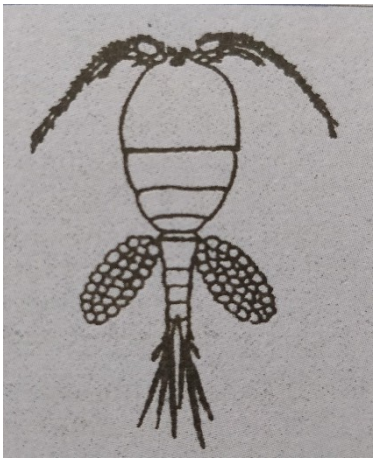
F) CONTROL OF SCABIES: to treat all members of the affected household simultaneously whether or not they appear to be infected. The effective sarcopticide are; Benzyl benzoate – 25%, HCH (linden) - 0.5 to 1%, Gamma amino butyric acid – 5%, Tetmosol - 5%, Sulphur ointment – 2.5 to 10%.

APPLICATION METHODOLOGY: Patient should take a good scrub bath with soap and hot water. The medication should be applied with a paint brush to every inch of body below the chin including the soles of the feet and allowed to dry. In the case of babies, head must also be treated. Repeat it after 12 hours and after a further 12 hours' patient can take bath. All the clothes, bedsheets, are changed and washed and dried under sun.

9. CYCLOPS

Introduction: Also known as water flea. It belongs to the family Crustacea. It's a fresh water harbour and swims in water with characteristic jerky movements. The average life span is 3 months

General characteristics:



It is a tiny arthropod not more than 1 mm size in length. It has a pear shaped semi-transparent body, a forked tail, 2 pairs of antennae, 5 pairs legs and a small pigmented eye.

Diseases transmitted

1) Dracunculiasis or Guinea worm disease.
2) Fish tape worm or Diphyllobothrium latum infestation.

Control of cyclops:

I) Physical:

a) Straining – straining of water through piece of fine cloth
b) Boiling – Cyclops are readily killed by heat at 60^0 C

II) Chemical:

a) Chlorine – 5 ppm strength destroys Cyclops and larvae of Guinea worm also. The excess chlorine needs to be removed by dechlorinating agents.

b) Lime – 4 g per gallon of water is efficient for killing cyclops.
c) Abate is efficient in killing Cyclops at a concentration of 1 mg / L

III) Biological:

a) Barbel and Gambusia fish feed on Cyclops.

IV) Environmental measures:

a) The permanent method of controlling Cyclops in drinking water is to provide piped water supply or tube wells in urban areas.
b) Abolition of step wells and provision of sanitary wells in rural areas.

10. DISINFECTANTS

DISINFECTANT: Usually a chemical agent (but sometimes physical) that destroys disease causing pathogens or other harmful microorganisms, but might not kill bacterial spores.

Properties of an ideal disinfectant:

1. Broad spectrum antimicrobial activity
2. Fast acting
3. Not affected by the presence of organic matters like blood, sputum, etc
4. Nontoxic
5. Not corrode instruments & metallic surfaces
6. Easy to use
7. Environmental friendly
8. Residual effect on treated surface
9. Cost effective

DISINFECTION: Thermal / Chemical destruction of pathogen and other types of microorganisms.

Types of disinfection:

Concurrent disinfection: Application of disinfective measures as soon as possible after the discharge of infective material from the body. The agent is destroyed as soon as it is released from the infected body. Eg: disinfection of urine throughout the course of illness

Terminal disinfection: Application of disinfective measures after the patient has been removed by death, discharge or to a hospital. Eg: spraying of floors and walls of a room

Pre-current (prophylactic) disinfection: Doing disinfection even before the contamination (prophylaxis). Eg: disinfection of water by chlorine.

Classification of disinfectants:

Natural	Physical	Chemical	Miscellaneous
1. Sunlight 2. Air	1. Burning 2. Hot air 3. Boiling 4. Autoclaving 5. Radiation	1. Phenol & related compounds 2. Quaternary Ammonia compounds 3. Halogens & their compounds 4. Alcohol 5. Formaldehyde 6. Metals 7. Oxidizing agents 8. Lime 9. Ethylene oxide	1. Microwave 2. Ultraviolet radiation 3. Ozone

NATURAL AGENTS:

1) **Sunlight:** Pre-requisite: Direct and continuous exposure to sunlight for several hours. MOA**:** UV-C radiations in sunlight kill or inactivate microorganisms by destroying nucleic acids and disrupting their DNA, leaving them unable to perform cellular functions. It causes coagulation of the protoplasm of the bacteria.

Uses**:** used in disinfection of linen, bedding and furniture

Advantage: lethal to most of the bacteria and some viruses

Disadvantage: seasonal & less effective.

2) **Air:** MOA**:** kill or inactivate microorganisms by drying or evaporation of moisture of organisms

Uses: used in disinfection of linen, bedding and furniture

Advantage: lethal to most of the bacteria and some viruses

Disadvantage: less effective

PHYSICAL AGENTS:

1) **Burning:** best done in incinerator. Burning / incineration is aided by addition of sawdust, paper and kerosene.

Uses**:** disinfection of contaminated dressings, swabs etc.

Advantage: efficient because it can burn up to 90% of the total waste generated. No nuisance of odour or noise

Disadvantage: The emitted gases from incinerator are dangerous and can cause air pollution

2) **Hot air**: done in hot air oven. Temperature is 160-180^0 C for at least 1 hour to kill spores

Uses: glassware, syringes, swabs, dressings, sharp instruments

Advantage: can be used in microbiological labs and dental units to sterilize Cultural Medias and dental instruments

Disadvantage: No penetrating power, so not suitable for bulky articles such as mattresses. No suitable for plastic & rubber articles.

3) **Boiling:** boilers are used. Boil for 15 min at a temperature of about 90^0 C.

Uses: small instruments, linen stained with blood, pus or faeces, gloves, bedpans

Advantage: simplest and easiest method

Disadvantage: not kill spores and viruses. Slow process, unsuitable for thick beddings & woolen materials

4) **Autoclaving:** Generate steam under pressure which is the most effective sterilizing agent. Works at the same principle of pressure cooker. It attains a temperature of 122^0 C under 15 lbs / sq. inch pressure.

Uses: linen, dressings, Gloves, syringes, culture media etc

Advantage: destroy all microorganisms including spores.

Disadvantage: not suitable for plastics and sharp instruments

5) **Radiation**: by ionizing (gamma) radiations. Things should be kept in a plastic bag before radiation.

Uses: bandages, dressings, catgut and surgical instruments

Advantage: great penetrating power with little or no heating effect

Disadvantage**:** very costly. Requires special packing & equipment

CHEMICAL AGENTS

1) **PHENOL AND RELATED COMPOUNDS:** MOA: Inactivation of enzyme system of microorganisms. Denaturates protein and disrupting cell membrane
   A) **Pure phenol / Carbolic acid:** Oldest known disinfectant.
      Used as a standard to compare the germicidal activity of disinfectant.

   B) **Crude phenol**: mixture of phenol and cresol. It is a dark oily liquid. Effective against gram positive and negative organisms and certain viruses.

   Uses: 5% strength for mopping floors and cleaning drains, 10% strength for disinfection of faeces.
   Advantage: not readily inactivated by organic matter.
   Disadvantage: Its effect is greatly weakened by dilution. Slowly effective against spores and acid- fast bacteria

   C) **Cresol**: all-purpose general disinfectant
      Uses: 5 to 10% strength for disinfection of faeces and urine.
   Advantage: 3 to 10 times as powerful as phenol, yet not toxic.
   Disadvantage: oxidized by long exposure to air. Can cause irritation of skin. Ingestion can cause liver and kidney damage

   D) **Chlorhexidine**: It is a skin antiseptic. Highly active against gram positive organisms.

   Uses: cream and lotion containing 1% for burn and hand disinfection

Disadvantage: inactivated by soap and detergent.

E) **Hexachlorphane**: anti-septic highly active against gram positive bacteria, but less active against gram negative organism.
Use: incorporated in soap preparation.

Advantage: compatible with soap and cumulative effect on skin.
Disadvantage: slow in action.

F) **Dettol** (chloroxylenol): Dettol is a relatively non-toxic antiseptic and can be used safely in high concentrations. It is active against streptococci. 15 minutes is the contact time

Uses: 5% is used for instruments and plastic equipments.
Disadvantage: inactivated by organic matter and worthless against some gram-negative bacteria.

G) **Cresol emulsions**: cresol emulsified with soap is "saponified cresol". Lysol, Izal & Cyllin are cresol emulsions. Lysol contains 50 to 60% cresol.
Use: 2% for disinfection of faeces.

2) **QUATERNARY AMMONIA COMPOUNDS**: MOA: irreversibly binds to phospholipids and proteins of the microbial membrane, thereby impairing permeability

A) Cetrimide (Cetavlon): Actively bactericidal against vegetative gram-positive organisms, but much less so against gram negative organisms.
Used in 1 – 2% strength.
Uses: Skin disinfection and wound cleansing. Also used in minor burns.
Disadvantage: it has a soapy feel.

B) Savlon: combination of cetavlon and chlorhexidine. Savlon 1 in 6 in spirit is more effective than savlon 1 in 20 aqueous solutions. Contact time 20 min
Uses: skin cleansing, clinical thermometers and plastic appliances

3) **HALOGENS AND THEIR COMPOUNDS:** MOA**:** Disruption of oxidative phosphorylation. They destroy the cellular protein, nucleic acid and cell membrane of microorganisms

A) **Bleaching powder (chlorinated lime):** It is a white amorphous powder with a pungent smell of chlorine A good sample of bleaching powder contains about 33% of "available chlorine". Kills organisms in a strength of 1 – 3%. Contact time 1 hour.

Uses: disinfection of water, faeces and urine; and as a deodorant.

Advantage: inactivate greater than 99.999% of pathogens including cryptosporidium and mycobacterium. Action is rapid

Disadvantage: It is an unstable compound and loses its chlorine content on storage, exposure to air, light and moisture. Its action is brief.

B) **Hypochlorites**: carries 60 – 70% of available chlorine. They have a broad spectrum of antimicrobial activity.

Uses: disinfection of water

Advantage: do not leave toxic residues, unaffected by water hardness, inexpensive and fast acting, remove dried or fixed organisms and bio-films from surface

C) **Chlorine tablets**: It is available in the market under various trade names (eg, halazone tablets). These tablets are manufactured in various strengths. A single tablet of 0.5 g is sufficient to disinfect 20 L of water. Kills bacteria, viruses, funguses, tuberculosis bacteria and spores.

Uses: disinfection of water

Advantage: good in disinfecting small amount of water. They retain chlorine longer and so exert a more prolonged bactericidal effect

Disadvantage: loses its chlorine content on storage.

D) **Iodine solutions**: Active against bacteria, viruses and fungus. A contact time of 20 to 30 min is needed for effective disinfection.

Uses: Antiseptic on skin, disinfection of water in swimming pools & emergency disinfection of water.

Advantage: lethal to spore-bearing organisms. Readily available, cheap and quick in action

Disadvantage: element is physiologically active (too much iodine can cause thyroiditis and goiter)

E) **Iodophores:** It is a combination of iodine and a solubilizing agent or carrier. The widely used is povidone iodine (Betadine)

Use: skin disinfectant, disinfecting blood culture bottles and medical equipment

Advantage: non-irritant. No staining of skin.

Disadvantage: stored in cool & dry place.

4) ALCOHOLS:

A) Ethyl and isopropyl alcohol: Pure alcohol has no disinfective action. When combined with water to 60 -70% volume it is bactericidal, fungicidal, virucidal and tuberculocidal

Uses: hand washing and skin disinfection.

Disadvantage: expense, flammability, evaporate rapidly, stored in cool areas.

5) FORMALDEHYDE (FORMALIN): highly toxic and irritant gas which precipitates & destroys protein. Effective against vegetative bacteria, fungus and many viruses. Used as 2 to 3% strength.

Uses: disinfection of rooms, blankets, beds, books & other valuable articles.

Disadvantage: Slow effect against spores/ and acid fast bacteria.

6) Oxidizing agents:

A) Potassium permanganate: It is a purplish black crystalline powder that colors everything it touches through strong oxidizing action.

Uses: disinfection of aquarium, swimming pools, fruits and vegetables

B) **Hydrogen peroxide**: **MOA**: it liberates toxic free hydroxyl radicals which attacks membranes, lipid, DNA, and other cellular components. It is bactericidal, virucidal, sporicidal & fungicidal.

Uses: 3% solution used for cleaning wounds and discharging ulcers. It is used in hospital setting to disinfect surface

Disadvantages: quick decomposition of it in water

C) **Para-acetic acid**: Produced by reacting hydrogen peroxide with acetic acid. MOA: powerful oxidizing agent. Broad spectrum and not deactivated by catalase and peroxidase.

Advantage: It breaks down to environment friendly residue, therefore can be used in non-rinse applications

Disadvantage: presence of acetic acid it can cause potential microbial regrowth. Corrosive to skin and mucous membrane

7) **Metals:**
   A) **Silver:** used in prophylaxis of conjunctivitis in newborn, as a topic agent in burns & bonding to indwelling catheters.
   B) **Iron and copper** - disinfection of water, reusable medical devices & incorporated into medical devices.

8) **Lime:** It is used in the form of fresh quick lime or 10-20% aqueous suspension known as "milk of lime". Contact time 2 hours.

Uses: disinfection of faeces and urine, as lime wash, it is used for treating walls. As a deodorant, lime is sprinkled in cattle sheds and stables and in public places where urinals and latrines are located.

Advantage: Cheap

Disadvantage: can cause severe burns on the contact surface and is explosive if it gets in contact with water

9) **Ethylene oxide:** Heat-sensitive articles may be sterilized at 55 – 60^0 C by ethylene oxide which kills bacteria, spores and also viruses. Water vapour is also often added to the mixture since it increases the efficiency of the gas.

Uses: to sterilize fabrics, plastic equipment, cardiac catheters & books

Disadvantage: Ethylene oxide is explosive; therefore, it is mixed with carbon dioxide. The process is difficult to control.

MISCELLANEOUS

A) Microwave: Microwaves are radio-frequency waves, which are usually used at a frequency of 2450 MHz. The microwaves produce friction of water molecules in an alternating electrical field. The intermolecular friction derived from the vibrations generates heat.

Uses: disinfection of soft contact lenses, dental instruments, dentures & urinary catheters.

Disadvantages: must only be used with products that do not melt

B) UV radiation: MOA: it damages the DNA of pathogens. The wavelength of UV radiation ranges from 328 to 210 nm. Its maximum bactericidal effect occurs at 240-280 nm. Bacteria and viruses are more easily killed by UV light than the bacterial spores.

Uses: disinfection of drinking water, air, titanium implants and contact lenses.

Advantage: nontoxic and environment friendly

Disadvantage: the radiation is not very penetrating, so organism to be killed must be directly exposed to it. No effect on chemical quality of water.

C) Ozone: MOA: oxidizes components of bacterial cell wall, enzymes, proteins, DNA and RNA.

Use: Drinking water disinfectant.

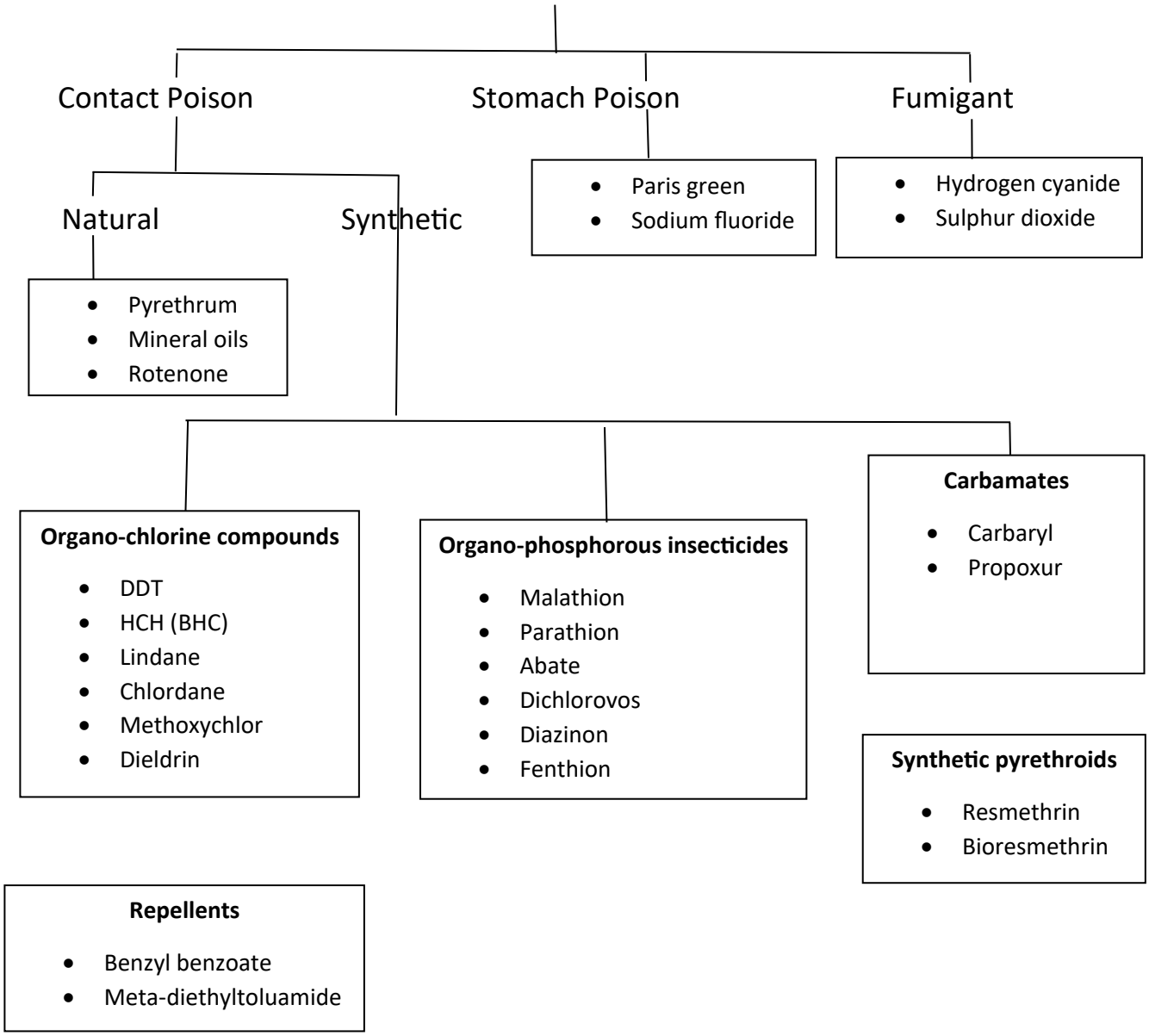
Advantage: rapid acting.

Disadvantage: highly unstable & no residual effect.

11. INSECTICIDES

Definition: Insecticides are substance or mixture of substances intended to kill, repel or otherwise prevent the insects.

Classification of Insecticides: **INSECTICIDES**



1. Dichloro-diphenyl-trichloroethane (DDT)

1. History: First synthesized in 1874 by German chemist, Ziedler. In 1939, insecticidal properties were discovered by Paul Muller.
2. Group – Organochlorine.
3. Properties – white amorphous powder, insoluble in water but dissolves in organic solvents.

4. Mode of Action – contact poison (acts on the nervous system). Permeates into the insect body through the cuticle leading to paralysis of legs and wings and finally convulsions and death.
5. Active Ingredient – 70 to 80% para-para isomer.
6. Dosage – 100 to 200 mg per square foot area, residual action lasts for 18 months.
7. Formulation of choice
   5% suspension of DDT at the rate of 1 gallon per 1000 sq feet.
   As a dust, 5 to 10 % strength is used for the control of lice, fleas, ticks and bugs.
8. Limitations – environmental pollutant, takes hours to kill, resistance.

2. Benzene Hexa Chloride (HCH)

1. Also known as hexachlorocyclo-hexane or gammexane or hexidol
2. History: discovered by Michael Faraday in 1825.
3. Group – Organochlorine.
4. Properties: it is a white or chocolate coloured powder with a musty smell and irritating to the eyes, nose and skin.
5. Mode of action – kills insects by direct contact, also kills by its vapour effect
6. Active Ingredient: Gamma isomer is the most active constituent. HCH contains 13 to 16% of the gamma isomer. Pure HCH containing 99% of the gamma isomer is called lindane or gamma HCH.
7. Dosage – 25 to 50 mg per sq ft and residual action lasts for 3 months.

3. Malathion

1. History: has been used in public health and agriculture since World War II (1945).
2. Group – Organophosphorus.
3. Properties: Yellow or clear brown liquid with an unpleasant smell.
4. Mode of action – kills insect by direct contact. Acts on the nervous system of insects.
5. Dosage – 100 to 200 mg per sq ft, every 3 months.
6. Formulation of choice - Used as low volume spray for killing adult mosquitoes.

4. Abate

1. Also known as Temephos.

2. History: has been in use since 1969.
3. Group – Organophosphorus.
4. Properties: Brown viscous liquid, soluble in petroleum solvents. Due to low toxicity it has been used to control Anopheles stephensi in wells and domestic containers. Very effective larvicide.
5. Mode of action – kills insect by direct contact. Acts on the nervous system of insects.
6. Dosage - 1.0 ppm.

5. Propoxur (OMS 33)

1. Used as a substitute in areas where resistance has developed for both DDT and dieldrin.
2. Group – Carbamates.
3. Properties – white to tan crystalline powder with a faint, characteristic odour.
4. Mode of action – it's a contact poison and acts on the nervous system of insects.

6. Pyrethrum

1. Group – Natural

2. Properties: Insecticide of vegetable origin. Extracted from flowers of Chrysantheum cinerariafolium. Excellent space spray.

3. Mode of action – it's a contact poison, kills instantly on mere contact.

4. Active Ingredient – Pyrethrins 1 and 2, cinerins 1 and 2. All are nerve poisons.

5. Dosage - Sprayed at the rate of 1 oz of the solution per 1000 cu ft of space.

6. Formulation of choice

a) Ready to spray solution contains 0.1% of pyrethrins.
b) Doors and windows should be kept closed for 30 min after spraying.
c) Added together with DDT for synergistic action. Consist of pyrethrum extract (25% pyrethrins) – 1.6 % and DDT – 3% to be dispersed at the rate of 10 g per 1000 cu ft in treatment of aircraft.

7. Limitations – does not possess the residual action.

7. Synthetic pyrethroids: developed to replace natural pyrethroids.

1. Properties: 10 times more effective than natural pyrethroids. Most promising ones are tetramethrin, resethrin, prothrin and proparthin.

2. Mode of action – it's a contact poison.

3. Used as insecticide for treated nets

8. Mineral oils: Kerosene, crude oil, fuel oil is used to kill mosquito larvae and pupae.

1. History: first used as effective anopheline larvicide for malaria control in Florida in the early 1900s.
2. Group – Natural
3. Properties – mixture of aromatic, naphthenic and paraffinic structure.

4. Mode of action - Cuts off the air supply to them by forming a thin film on water.

5. Dosage - 40 to 90 L per hectare, applied once a week on all breeding places.

6. Limitations – renders water unfit for drinking and kill the fishes.

9. Paris green or copper acetoarsenite

1. Properties: emerald green, micro crystalline powder. Insoluble in water but soluble in ammonia and concentrated acids. A good sample contains 50% arsenious oxide.

2. Mode of action - stomach poison, kills mainly Anopheles larvae as they are surface feeders.

3. Dosage – 1 kg per hectare of water surface.

4. Formulation of choice - Applied as 2% dust made by mixing 2 kg paris green and 98 kg soapstone powder or slaked lime in a rotary mixer.

5. Advantage – does not harm fish, man or domestic animals.

Insecticide resistance: "the development of an ability in strain of insects to tolerate doses of toxicants which would prove lethal to the majority of individuals in normal population of the same species". Maybe due to biochemical or genetic factors.

1) In **biochemica**l the toxicant is converted into a non-toxicant form in the insect by various enzymes. Detoxification is mediated through glutathione S transferase and P450 mediated mono-oxygenase.
2) In **genetic** it is transmitted through genes, single or multiple. It is mainly due to over transcription of two cytochrome P450 encoding genes – Cyp6g1 and Cyp6g2.

Toxicity of insecticides

1.**Organo-chlorine compounds**: These include DDT, HCH, Dieldrin, etc. Among DDT, HCH and dieldrin, DDT is the least toxic. Dieldrin is 5 to 8 times as toxic as DDT and seen more frequently as it is absorbed through skin. The clinical features are increase nervous excitability, nausea, vomiting, headache, dizziness, tremors and convulsions. Median lethal dose is 250 mg per kg of body weight. The treatment includes

i. Termination of further exposure to poison – fresh air, wash the skin and mucous membrane with soap and water, gastric lavage according to need.
ii. Maintain patent airway, positive pressure respiration if it is falling.
iii. Supportive measures – maintain BP, hydration, control convulsions with diazepam, barbiturate, specially phenobarbitone.
iv. Purgative may be useful.

2.**Organophosphorus compounds and carbamates:** These include malathion, fenthion, parathion, abate, diazinon, propoxur, etc.

a) Mode of action - act by inhibiting cholinesterase enzyme which breaks down acetyl choline in striated muscle.
b) Signs and symptoms: Irritation of eyes, lacrimation, salivation, sweating, copious trachea-bronchial secretions, miosis, blurring of vision, bronchospasm, breathlessness, colic, involuntary defecation and urination. Fall in BP, bradycardia or tachycardia, cardiac arrhythmias, vascular collapse. Muscular fasciculations, weakness, respiratory paralysis. Irritability, disorientation, unsteadiness, tremor, ataxia,

convulsions, coma and death. Death is generally due to respiratory failure.

c) Treatment
    I. Termination of further exposure to poison – fresh air, wash the skin and mucous membrane with soap and water, gastric lavage according to need.
    II. Maintain patent airway, positive pressure respiration if it is falling.
    III. Supportive measures – maintain BP, hydration, control convulsions with diazepam.
    IV. **Atropine** is the specific antidote, in doses of 1 to 2 mg IM and repeated at 30 min interval if required.

ZINC PHOSPHIDE

Rodents are classified into two group

1. Domestic Rodent ex: Rattus rattus
2. Wild Rodents ex: Tatera indica

Rodents and diseases

1. Bacterial: Plaque
2. Viral: Hemorrhagic fever
3. Rickettsial: Scrub Typhus

Mode of Transmission

1. Directly through rat bite
2. Contamination of food or water
3. Through rat fleas

Anti Rodent Measures

1. Sanitation Measures: Proper storage, collection and disposal of garbage
   Proper storage of food stuff
   Construction of rat proof buildings
   Elimination of rat burrows
2. Trapping
3. Rodenticides: Types include
   I. Acute / Single Dose
   II. Cumulative / Multiple Dose
4. Fumigation
5. Chemosterilant

Zinc phosphide is an acute/single dose type of rodenticide which requires ordinary care while handling.

MOA: When moist the chemical slowly gives off phosphine whose garlic odour is repellent to man and domestic animals, but seems to have no effects on rats.

How it is used: It is used in ratio of one part to ten parts of wheat or rice flour and mixed with few drops of edible oil in order render it more attract to rats.

Precautions to be followed: Rubber gloves should be used while handling zinc phosphide as it is highly poisonous

Advantages: It is low cost, high effectiveness and good safety record.