Medical entomology for MBCHB 111 June 2016

Medical entomology:-

Study of insects and other arthropods such as ticks and mites, which affect the health and well-being of man by transmitting diseases. Such arthropods are said to be of medical importance and are thus studied by medical entomologists.

- Some of the insects or arthropods do not transmit any disease pathogens, but cause considerable nuisance and annoyance to man by their bites or stings which may be poisonous or provoke severe irritation
- Others, such as house-dust mites may induce allergies, while a few, such as scabies mites live in the superficial layers of man's skin and are thus true parasites

The arthropods outlined above may warrant attention of a medical entomologist; but the ones of great medical importance are those that transmit diseases such as malaria, sleeping sickness, arboviruses such as yellow fever, various types of filariasis e.t.c

Methods of disease transmission:-

An arthropod is termed to be a vector when it transmits disease pathogens from one animal to another – including man. The arthropod transmitting a disease pathogen is referred to as a vector

- Accidental/mechanical vectors
    - Mechanical transmission
- Biological vectors
    - Cyclical/biological transmission

      -Involves obligatory development and or multiplication of the disease pathogens in the arthropod before delivery to subsequent host

Classification of Arthropods

Arthropods can commonly be classified into different sub-groups as shown in the classification tree below. The phylum arthopoda is the largest of the animal phyla; there are numerous classes under it, but about five of these classes are medically important.

Classification	Man	Malarial mosquito
Kingdom	Animal	Animal
Phylum	Chordata	Arthropoda
Class	Mammalia	Insecta
Order	Primates	Diptera
Family	Hominidae	Culicidae
Genus	*Homo*	*Anopheles*
Species	*sapiens*	*gambiae, nilli, kingi, dancalicus, fenstus, smithi*

Why medical entomology?

In tropical countries, the largest group of diseases is probably insect-borne. It is therefore, important to know the habits of the insect vectors and how they transmit diseases. It is difficult to implement control measures of insects, without some knowledge of entomology and specifically medical entomology. Medical entomology is therefore concerned with the study of arthropods (especially of insects) that are of public health importance.

Some vector-borne diseases

1) **Transmitted by mosquitoes**

Malaria - Vectors: *Anopheles* mosquitoes - 500 million become severely ill with malaria every year and more than 1 million die.

Yellow Fever - Principal vectors: *Aedes simpsoni*, *Ae. africanus*, and *Ae. aegypti* in Africa, species in *Haemagogus* genus in South America, and species in *Sabethes* genus in France -200,000 estimated cases of yellow fever (with 30,000 deaths) per year.

Dengue fever - Vectors: *Aedes aegypti* (main vector) *Aedes albopictus* (minor vector); 50 million people are infected by dengue annually, 25,000 die. Threatens 2.5 billion people in more than 100 countries

Chikungunya virus - Vectors: mosquitoes *Aedes* aegypti

Zika virus - Vectors: mosquitoes *Aedes* aegypti

O'nyong nyo'ng – Vector: *Anopheles* mosquitoes

Lymphatic filariasis - vectors: mosquito species in genera:- *Culex*, *Anopheles*, *Mansonia*, and *Aedes*; affects over 120 million people.

Japanese encephalitis - Several mosquito vectors, the most important being *Culex tritaeniorhynchus*.

Rift Valley Fever (RVF) - Vectors: mosquitoes in the genera *Aedes* and *Culex*

West Nile virus - Vectors: vary according to geographical area; in the USA *Culex pipiens* (Eastern US), *Culex tarsalis* (Midwest and West), and *Culex quinquefasciatus* (Southeast) are the main vectors.

2) **Transmitted by Sand flies (Phlebotomus)**

Leishmaniasis - Vectors: species in the genus *Lutzomyia* in the New World and *Phlebotomus* in the Old World. Two million people infected.

Carrion's disease - Vectors: sandflies of the genus *Lutzomyia*.

3) **Transmitted by Tsetse flies (Glossina)**

Sleeping sickness - Vector: Tsetse fly, not all species. Sleeping sickness threatens millions of people in 36 countries of sub-Saharan Africa (WHO)

4) **Transmitted by Fleas**

Bubonic plague - Principal vector: *Xenopsylla cheopis*, at least 100 flea species can transmit plague.

5) **Transmitted by Black flies (Simulium)**

Onchocerciasis – river blindness; Vectors : *Simulium damnosum*, *S. neavei*

6) **Transmitted by Triatominae bugs**

Chagas disease - Vector: assassin bugs of the subfamily *Triatominae*. The major vectors are species in the genera *Triatoma*, *Rhodnius*, and *Panstrongylus*

7) Transmitted by Tabanid fly (Chrysops)

Loa loa filariasis - Vector: *Chrysops* sp.

8) Transmitted by Ticks

Tick-borne relapsing fever- Caused by a spirochete Borrelia *duttoni*; Vector: *Ornithodoros moubata*

Boutonneuse fever - caused by *Reckettsia conori*; Principal vector ; *Rhipicephalus sanguineus*

Lyme disease - Vectors: several species of the genus *Ixodes*

Alkhurma virus (KFDV) - Vector: tick

Kyasanur forest disease - Vector: *Haemaphysalis spinigera*

Babesia - Vector *Ixodes* ticks.

9. Transmitted Body lice

Louse-borne typhus (*Rickettsi prowazeki*)
Trench fever (*Rochalimaea quintana*)
Louse-borne relapsing fever (*Borrelia recurrentis*

MOSQUITOES

General biology:

- Mosquitoes are distributed worldwide, distribution including Temperate and Arctic regions of the World.
- Do not appear only in the Antarctic regions
- Exist up to 5,500m above sea level
- In temperate areas mosquitoes are not disease vectors but are pests - biting nuisance
- In the US high amount of money is spent on control of mosquitoes as biting pest

Description of mosquito

Classification:-

Family: Culicidae

Sub-family: **Anophelinae**	**Culicinae**	**Toxorhychitinae**
- Anopheles	-Culex	Toxorhychites
- Bironella	-Aedes	
- Chagasia	-Mansonia	
	-Eretmapodites	
	-Aedeomyia	
	-Hodgesia	
	-Culiseta	
	-Mimomyia	
	-Malaya	
	-Uranotaenia	
	-Lutzia	
	-Ficalbia	
	- Haemagogus	
	-Sabethes	

External morphology: *See photos*

- Mosquitoes possess only one pair of functional wings
- A pair of knob-like structures called halteres -represent the hind wings
- Are slender and relatively small insects
- Measure 4-6mm long - some species, however can be as small as 2 - 3mm while other may be larger (up to 10mm)
- legs are long and slender

Mouthparts (*see diagram*)

- are collectively known as proboscis
- proboscis in mosquitoes is elongate
- projecting forwards

The parts:

1. **Labium** - long flexible and gutter-shaped,
   terminates in a pair of small flap-like structures called **labella** -encircles all other components of the mouth parts
2. **Labrum** - is uppermost structure
   - slender, pointed and grooved along its ventral surface

   *Between the labium and labrum are 5 needle-like structures: -

3. **Maxillae** - toothed lower pair
4. **Mandibles** - finely toothed upper pair
5. **Hypopharynx** - single untoothed hollow stylet

Life History:

- Adult mosquito immerges from pupa mainly in the evening
- They shortly afterwards mate - one mating is enough for life
- Male inseminates sperms in female - the sperms are held in a receptacle called **spermotheca**
- Females produce eggs in masses which are fertilized by the sperms from the spermotheca
- **Note**:- male plugs the female with **gelatinous sperm plug** -preventing the female from mating with any other male.
- Only females feed on blood
- Males feed on sugar meals in flowers - nectar and related materials
- Females need proteins for development of the eggs

Feeding habits:-

- Mosquitoes bite man and many other animals
  - Some bite birds, exclusively transmitting viruses in birds
  - Others bite amphibians, reptiles and even fish -as mud fish
  - Choice of host is of epidemiological importance

- **When do mosquitoes feed?**
  - This depends on species - some feed by day while others feed in the night
  - Exact biting time range varies greatly with species
  - Biting period is of epidemiological importance

- **Where do mosquitoes feed?**
  - Inside or outside houses
  - Indoor /outdoor feeding is very important epidemiologically

- Feeding cycle (gonotrophic cycle)

  Unfed ——→ ***Blood fed (engorged)***

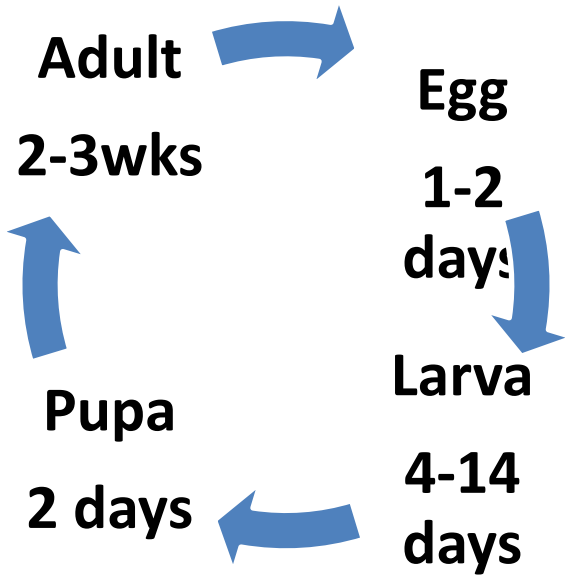
  - In the tropics after 24hrs blood meal is half digested and eggs start development - **mosquito is half gravid**
  - After 3 days from feeding, blood meal is totally digested and the eggs are fully developed ready for laying - **mosquito is GRAVID**

- **Where bloodfed mosquito rests when digesting blood meal and developing egg:-**
  In the gonotrophic cycle, a blood fed mosquito rests for 2-3 days while digesting the blood meal and eggs developing
    - Resting could be indoors – endophilic; or outdoors – exo-philic
    - Habit very important in mosquito vector control using Indoor Residual Spraying (IRS)

- **Where breeding takes place:-**

  - Variety of places and water bodies, e.g. swamps, storage tanks, domestic waste containers - tins, broken pottery, in animal hoof marks, tree holes, and even in banana axils- very small collection of water
  - These depend on the mosquito species

Development cycle: (see diagrams)



  - Speed of development depends on temperature
    - Slower in cold temperatures

    - Faster in warm tropical conditions
- Adults may live for 2 - 3 weeks in the tropics and several months in temperate region

- **How far do mosquitoes fly?**
    - 1 – 2 kms - mainly from breeding sites to feeding grounds
    - May be pushed by wind for many kilometers.

Important Biological Behaviour

1. **Blood meal source**

Anthropophagic ⟷ ***Zoophagic***
Feeding on man *feeding on other animals*

- Most mosquitoes have a tendency oscillating between anthropophagic and zoophagic behaviour
- If *Anopheles* species tends more towards anthropophagic feeding, it is a better vector of malaria and lymphatic filariasis
- **Most vector species are placed between the 2 extremes**
- Blood source habit is very important in vector-borne disease epidemiology

2. **Indoor/Outdoor feeding**

Endophagic ⟷ **Exophagic**
Feeding indoors *Feeding outdoors*

- Most *Anopheles* species feed on both ends
- Most malaria vectors are endophagic but also are exophagic
- This habit is very important in mosquito vector control using ITNs (Insecticide treated bed nets)

3. **Resting places after blood meal**

Endophilic ⟷ **Exophilic**
Resting indoors *Resting outdoors after feeding*

- Some endophagic mosquitoes are exophilic and vice versa
- This habit is very important in mosquito vector control - using IRS

Medical importance

1. Malaria transmission

- Only mosquitoes of the genus *Anopheles* can transmit *Plasmodium* species causing malaria in man:
  - *Plasmodium fulciparum* - (malignant tertian)
  - *P. vivax* - (benign tertian)
  - *P. malariae* (quartan malaria)
  - *P. ovale* - (ovale benign tertian)
- Because the **sexual cycle** of the malaria parasite occurs in the *Anopheles* mosquito vector, it is conventional to refer to the mosquito as the **definite host**, and man as the **intermediate host**

Life cycle of malaria parasite in the mosquito vector:

- Male and female gametocytes ingested by female mosquitoes during feeding on man
- Gametocytes pass to the mosquito's stomach where they undergo cyclical development which includes a sexual cycle termed **sporogony**
- Here only gametocytes survive in the mosquito's stomach, all other blood forms of malaria parasites are destroyed
  - **Exflagellation**: -male gametocytes (microgametocytes) extrude flagella which are the male gametes (microgametes) - the process is termed as Exflagellation
  - The microgametes break free and fertilize the female gametes (macrogametes) which are formed from the macrogametocytes (female gametocytes)
  - As a result of fertilization a **zygote** is formed
  - The zygote elongates to become an **ookinete**
  - The ookinete penetrate the wall of the mosquito's stomach (gut wall) to reach its outer membrane
  - In the outer membrane of the mosquito's stomach the ookinete becomes spherical and develops into an **oocyst**.
  - The nucleus of the oocyst divides repeatedly to produce numerous spindle-shaped **sporozoites**
  - When the Oocyst is fully grown (about 60 - 80µm) it ruptures to release thousands of sporozoites into the haemocele of the mosquito.
  - The sporozoites are carried in the haemolymph of the mosquito to all parts of the body but most of them end up penetrating into the salivary glands
  - At this stage the mosquito becomes **infective** and sporozoites can be inoculated into man the next time the mosquito bites.
  - Some 70,000 sporozoites are estimated to be in the salivary glands of an infective mosquito vector
- Speed of development of the malaria parasites in the vector (exogenous or extrinsic cycle) depends on temperature and the plasmodium species
  - Generally oocyts can be seen on the stomach walls of the vector about 4 days after the infective blood meal
  - Oocyts are fully grown and rupturing after about 8 days
  - Sporozoites are found in salivary glands after 9 - 12 days

- For *Plasmodium* species specific cycle period in the vector at for example 24^{o}C will be:

Plasmodium sp.	**Development time**
P. fulciparum	11 days
P. vivax	9 days
P. malariae	21 days
P. ovale	15 days

2. Filariasis vectors

Certain species of *Anopheles* are vectors of lymphatic filariasis especially in the rural environment. *An. gambiae* and *An. funestus* are very efficient vectors of *Wuchereria bancrofti* in Africa while other anopheline species also transmit *Brugia malayi* S.E Asia especially Malaysia. Culex quinquefasciatus is an efficient vector of bancroftian filariasis in urban environment.

Development in Vector

- Stars when the vector mosquito takes microfilariae in its blood meal from an infected person
- Some of the ingested microfilariae shade their sheaths in the stomach of the vector
- Bore through the stomach wall and migrate to the thoracic muscles to start development as L1 stage
    - Transform to short, thick and inactive sausage form of L1 in 4-5 days
    - Undergoes first moult giving rise to L2 (second larval stage).
    - L2 grows rapidly increasing in length and width, and undergoes a second moult to yield L3 larval stage at 9 - 10 days.
    - L3 grows very rapidly in length but not width becoming very active. This is the infective stage.
    - In 11 - 15 days the L3s move to the mouth parts - inhabit the labium
- During the mosquito's feeding on the next host the infective larvae in the labium are deposited on the surface of the skin at the point of bite
- The infective larvae find their way into the human body through the puncture made by the mosquito bite
    - Many infective bites are required for infection
- High humidity is required for survival of the infective larvae before penetration into the hosts body
- Transmission is more possible in the very humid areas

3. Transmission of Yellow Fever:

Typical transmission in Tropical Africa

Forest transmission

- Takes place in high trees within monkeys in the canopy
- The yellow fever virus circulates in monkeys.
- Transmission is by *Ae. africanus* which breeds in tree holes in the forest, and bites immediately after sunset when the monkeys go to sleep
- Transmits Yellow fever in monkeys in the forest canopy
- Transmission cycle may go on unnoticed for a long time especially in Africa where monkeys are tolerant to the virus

Transmission in plantations

- When monkeys from the forest canopy raid plantation for food, they come in contact with *Ae. simpsoni* which breeds in leaf axils in the bananas, and feeds at day time
- ***Ae. simpsoni*** feeds at lower level in banana plantations near forests
- The mosquito picks the virus infection from the monkeys raiding the plantations
- In the plantations it will bite man and transmit yellow fever brought down by the monkeys from the forest canopy

Domestic transmission

- Man goes home with the virus infection, gets bitten by ***Ae. aegypti*** in the domestic environment
- In the domestic environment the transmission of the virus takes place between **man -Vector - man** leading to an outbreak of yellow fever

4. Dengue haemorrhagic fever

- Virus transmitted by:
    - *Ae. aegypti* - throughout the Tropics
    - *Ae. albopictus* - in Asia
    - *Ae. polynesensis* - in the Pacific
- Four serotypes of Dengue fever virus exist
- These are Type 1, Type 2, Type 3 and Type 4
- Virus has an intrinsic incubation period (in man) of 4 - 5days
- Viraemia lasts 1 - 7 days
- Extrinsic incubation period (in mosquito vector) is 5 - 30 days
- Virus normally not zoonotic
- Dengue haemorrhagic fever has the following characteristics:
    - Infection is common in children
    - Infection commonly occurs in sequential infections involving different several serotypes

TSETSE FLY (GLOSSINA)

Classification (Glossina systemics)

Family: - Glossinidae

Genus: - Glossina

Species: - There are some 22 different species of tsetse flies living only in Africa.

Sub-species: - Species are further divided into subspecies
- All species and sub-species of tsetse flies total 30

Species Groups
- The 22 species of Glossina are arranged into three (3)groups
- The species groups distinguishable by the structure of the male genitalia
- The structures can be seen in fresh specimens using X10 hand lens.
- The groups include:-

1. Morsitans group
2. Palpalis group
3. Fusca group

Morsitans group: -

Glossina longipalpis
Glossina pallidipes
Glossina morsitans morsitans
Glossina morsitans submorsitans
Glossina morsitans centralis
Glossina swynnertoni
Glossina austeni

Palpalis group

Glossina palpalis palpalis
Glossina palpalis gambiensis
Glossina fuscipes fuscipes
Glossina fuscipes martinii
Glossina fuscipes quanzensis
Glossina tachinoides
Glossina pallicers pallicera
Glossina pallicers newsteadi
Glossina caliginea

Fusca group: -

Glossina nigrofusca nigrofusca
Glossina nigrofusca hopkinsi
Glossina fusca fusca
Glossina fusca congolensis
Glossina fuscipleuris
Glossina haningtoni
Glossina schwetzi
Glossina tabaniformis
Glossina nash
Glossina vanhoofi
Glossina medicorum
Glossina severini
Glossina brevipalpis
Glossina longipennis

Distribution

- Tsetse distribution is restricted to the African continent

The Morsitans group species

- Present in much of the Savannah (grassy woodland) of Africa
- Distribution is restricted by the cold winter but not hot dry conditions
- Distribution may be restricted by scarcity of game animals on which they feed

The Palpalis group species

- Limited to the very humid areas of Africa - mangrove swamps, rain forests, Lakeshores and gallery forests along rivers.
- Are riverine species

Description of Tsetse fly

Appearance

-*see diagram/picture of tsetse fly body*

- At rest the tsetse appears quite slim
- The wings are placed one over the other on the back
- Tsetse flies are nearly always some shade of brown or gray-brown

The body

- Made up of 3 main parts - Head, thorax and abdomen

-see diagram of body parts

Head: -

- With a pair of large compound eyes - each of the compound eyes is made of thousands of small units called **ommatidia**
- Compound eyes are capable of detecting moving objects at 137 meters

- Also with 3 simple eyes (ocelli) placed at the top of the head
- Simple eyes are also sensitive to light
- But real function not known

The antennae:

* *see diagram of antennae*
* 2 antennae are placed at the front of the head in a depression between the 2 compound eyes
* Each antenna has 3 segments; the 3rd segment is the largest and bears the ARISTA.
* The 3rd segment also has 2 small holes leading to the olfactory pits
  -can smell air
  -antennae are thus organs serving the sense of smell

The mouth parts

see diagram of mouth parts

- Are long narrow, and can pierce the skin of an animal for sucking blood as saliva is passed down the mouth parts into the animal being fed on.
- When fly is not feeding all mouthparts are held so that they point forwards from beneath the head.
- The parts:-
  - A pair of maxillary palps - sheath protecting the delicate proboscis or haustellum
  - Proboscis (Haustellum) - very narrow and made of 3 parts:

1. **Labium** – with toothed at the end for cutting through the skin
2. **Labrum** - tube through which blood is sucked
3. **Hypopharynx** - tube through which saliva is pumped

Thorax

- Covered by stiff cuticle
- Has 3 pairs of legs attached to underside
- 2 wings attached to the topside walls of the thorax
- Also has a pair of halteres just behind the wings.

The wing:

- see diagram of wing
- The characteristic **HATCHET CELL**.

The Halteres:

- Vibrate when insect is in flight
- Help the fly to steer
- Is a sense organ of balance

Abdomen

- Has seven visible segments
- In males there is an additional structure - the HYPOPYGIUM, folded beneath the last 2 segments

- *See diagram of abdomen*
- *See diagram of superior claspers*

Internal morphology

The alimentary canal:

- *See diagram of the alimentary canal*

- The food channel starts from the labrum, leading to the esophagus, via the proventriculus to the crop
- Proventriculus marks end of fore gut and beginning of mid gut.
- It is the source of the peritrophic membrane
- Membrane secreted by the epithelial cells of the anterior part of the proventriculus
- Produced as very delicate, soft and almost fluid structure
- Hardens as it passes down the gut to form a thin but relatively tough sleeve lining the mid gut.
- The junction of the four malpighian tubes separates the mid gut from the hind gut
- A slender pair of salivary glands originating from the head run the whole length of the tsetse fly body

- Anteriorly, the ducts from both glands unit in the head to form the common salivary duct which passes down the length of the hypopharinx.

The reproductive system (female)

See diagrammatic representation

- Note structure of advanced uterus, typical mammalian structure of ovaries
- Also note the spermathecae and the milk glands

Feeding habits

- Both males and females take blood meal

- Blood meal taken from a large range of hosts including man and a variety of domestic and wild mammals, and also reptiles and birds.
- Tsetse flies take blood meal about every 2-3 days in optimal conditions - period may be shorter in dry, hot conditions and even as long as 10 days in cool humid conditions.
- Feeding restricted to daylight hours.
- Vision plays important role in locating host.

Life cycle

Tsetse flies unlike other flies which lay eggs, deposit larvae, one at a time
Refer to structure of reproductive system of females

- Females are inseminated young
- They store the spermatozoa in the spermathaecae for rest of their life - repeat mating not necessary
- After insemination and after taking a blood meal a single egg in one of the ovaries completes maturation
- Passes down the oviduct to the uterus where it is fertilized by spermatozoa from the spermathecae.
- Egg hatches within the uterus after 3-4 days and empty egg shell passed out through the genital orifice.
- The larva in the uterus is nourished by secretions from the milk glands
- Regular and adequate blood meals are necessary for continuous production of secretions from the milk glands
- Larval development completed in 4-5 days at which time the 3rd and final instar larva is 8-9mm long.
- The 3rd instar larva wriggles out, posterior end first, from the genital orifice - thus birth can be termed a 'breech case'
- Females select suitable places for larviposition.
- Once larva is deposited it commences to bury under 2-5 cm of soil.
- After 15 minutes the 3rd instar larval skin contracts and hardens to form a reddish-brown or dark brown, barrel-shaped puparium - about 5-8mm long
- Pupal period may reach 4-5 weeks
- After pupal development is complete the fly immerges from the puparium, forces its way to the surface of the ground and flies away.

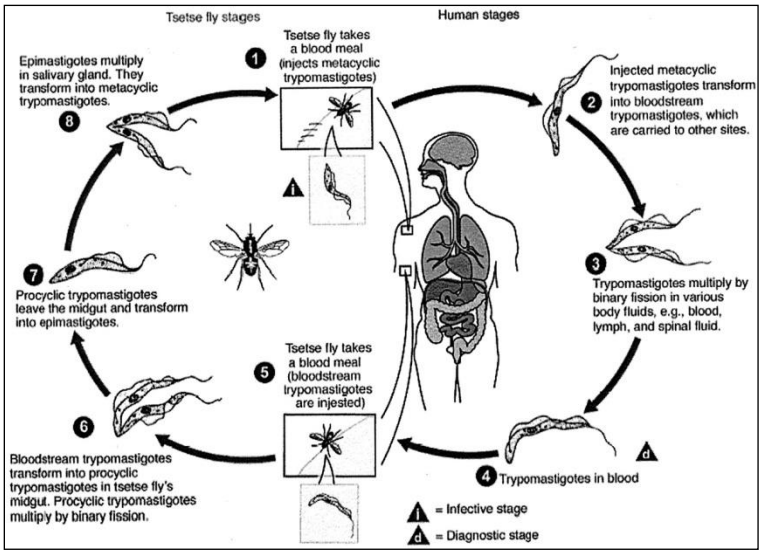
See diagrammatic representation of life cycle

Medical importance

- Probably any species of tsetse fly can transmit African human trypanosomiasis (HAT)
- But this is determined by the ability of the species to feed on man
- Many species rarely feed on man as well as on other mammals, reptiles and birds.

Life cycle of HAT parasites in the tsetse fly

- Trypanosomes sucked by male or female fly during blood meal from man or non-human reservoir
- Pass through the esophagus to the crop
- After feeding has ceased the trypanosomes in blood pass into the peritrophic tube lining the mid-gut.
- Blood gets digested in the mid-gut but trypanosomes are not destroyed. Instead they multiply.
- From the mid gut the trypanosomes migrate to infect the salivary glands, where they mature into infective metacyclic forms (Trypanomastigotes)
- The trypanomastigotes are injected into the host when an infective fly feeds on new host.



TRIATOMINE BUGS

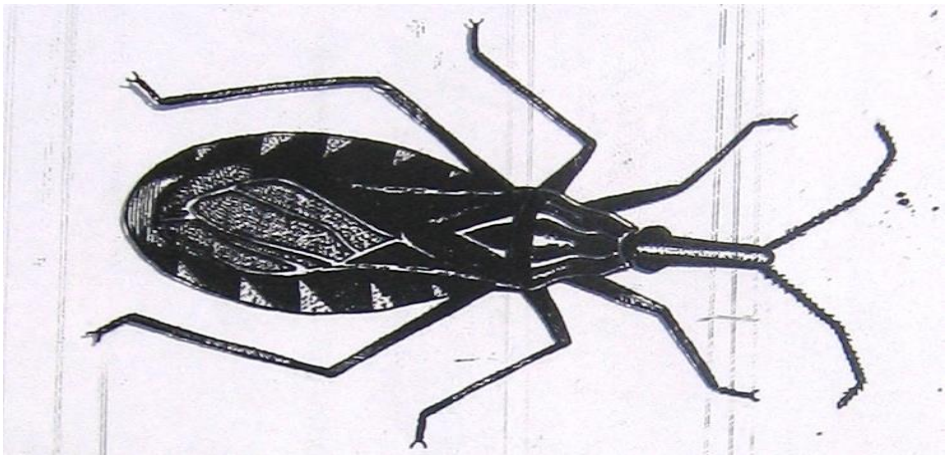
- Belong to the Family **Reduviidae**
- Sub-family **Triatominae**
- The Sub-family comprises of 14 genera and 111 species
- Species of medical importance include:
    - *Rhodnius prolixus*
    - *Panstrongylus megistus*
    - *Triatoma infestans*
    - *T. dimidiata*

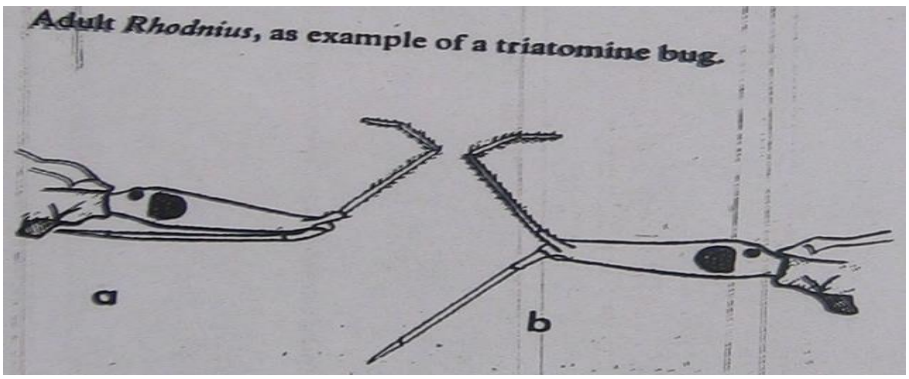
- All these are vectors of *Trypanosoma cruzi* (Chagas disease) in Central and south America

- The Triatomine bugs are mainly rural
- Natural habitats include nests and burrows
- Have adapted to the domestic environment in close contact with man

External morphology (*See diagrammatic representation*)

- The bugs vary in size - from about 0.5 - 4.5 cm, but most are 2 - 3 cm long
- Easily recognized by their long snout-like head



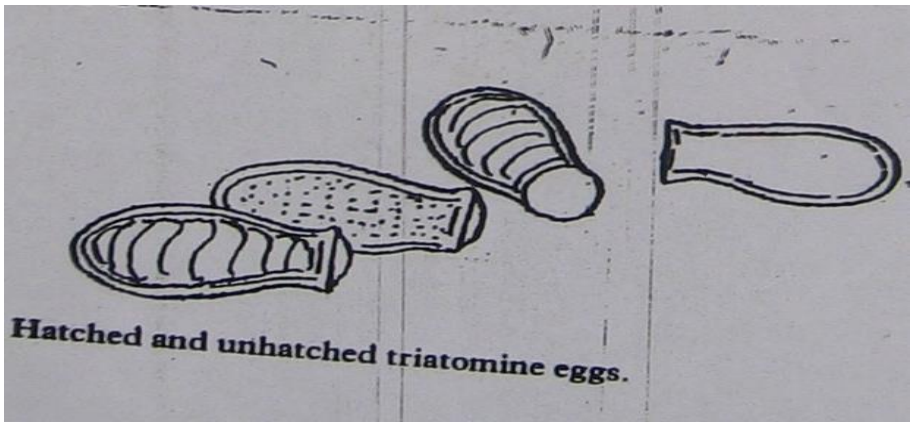


- The head bears a pair of prominent dark coloured eye and long and thin 4 segmented antennae
- The proboscis (or rostrum) relatively thin and straight, and as in bedbugs, lies closely appressed to the ventral surface of the head
- When taking a blood-meal the proboscis is swung forwards and downwards -just as in bedbugs
- Dorsal part of the 1st segment of thorax consists of a very conspicuous triangular pronotum
- The mesothorax and metathorax are completely hidden dorsally by the folded fore-wings (called hemielytra)
- Fore-wings are thickened at the basal end and membranous at the distal end
- The hind-wings are entirely membranous and are completely hidden under the hemielytra when bug is not flying
- The thorax has three long slender legs which end in a pair of small claws
- Abdomen more or less oval in shape - but covered by wings

Life cycle

Eggs:

- Deposited in or near the habitation of their hosts
  - Such as cracks and crevices in walls,
  - floors ceilings and furniture in houses
  - and in animal burrows



Hatched and unhatched triatomine eggs.

- The eggs are about 1.5 - 2.5 mm long
- Pink, yellowish or white in colour
- Have a smooth shell
- Are oval in shape but slightly constricted before the operculum
- Females lay a total 50 - 1000 eggs - usually 200-300
- The life cycle is hemimetabolous
- Small nymphs which resemble the adults but wingless hatch from the eggs after 10-15 days - incubation may extent to 30 or even 60 days

The Nymphs

- Newly hatched nymphs remain hidden in the cracks and crevices for a few days before they seek out blood-meals
- There are 5 nymphal instars each requiring at least one complete blood-meal
- Rudimentary wing pads start to appear in the 4th & 5th instars - only adults have fully functional wings

Habits

- Nymphs and adults of both sexes feed at night on their hosts
- Feeding is a lengthy process lasting 10-25 minutes or more
- Feed on exposed parts of the body including nose, around eyes and even mouth
- Bite is usually relatively painless
- Many triatomine bugs defecate during feeding - very important in transmission of Chagas' disease
- Many species also feed on a variety of wild animals such as armadillos, opossums, rats, marsupials, squirrels, skunks, iguanas, bats and also birds

Medical importance

- Triatominae are of medical importance as they are vectors of *Trypanosoma cruzi* the causative agent of Chagas' disease - American trypanosomiasis
- This is a zoonotic disease -essentially a disease of wild animals such as opossum, armadillo and many species of rodents
- Affects over 20 million people
- *T. cruzi* is transmitted through faeces

The parasite development

- Parasites are ingested with a blood-meal
- Undergo entire development in the gut of the bug
- After 9 - 17 days sometimes longer the infective metacyclic trypanomastigotes of *T. cruzi* are present in the lumen of the hind gut
- The metacyclic trypanomastigotes are passed out in faeces onto the skin of host
- Man becomes infected when the excreta is scratched in either abrasions in the skin, in the site of the bug's bite, or when it gets rubbed into the eyes or other mucous membranes

Control

- Insecticides
  - Residual indoor spaying on walls and roofs using HCH or dieldrin is effective against triatomine bugs.
  - Have developed resistance to DDT
  - Alternative insecticides include propoxur and malathion
- Improvement of housing
  - Smooth plastering of inside walls and floors
  - Replacing thatch with corrugated iron sheets or tiles

PHLEBOTOMINE SANDFLIES

Family: Psychodidae
Subfamily: Phlebotominae
Genera: *Phlebotomus*
Lutzomyia
Sergentomyia
Brumplamyia
Warileya

- There are over 600 species in the 5 genera
- Species in three genera - *Phlebotomus*, *Lutzomyia* and *Sergentomyia* suck blood from vertebrates
- The 2 genera - *Phlebotomus*, *Lutzomyia* are of medical importance as they contain species that are disease vectors

Distribution

- Genus *Phlebotomus*, occurs in the Old World especially the Mediterranean region and the Old World tropics.
    - *Plebotomus* species mainly inhabit semi-arid and savanna areas
    - Do not prefer forest areas

- The genus *Lutzomyia* is found only in the New World tropics

    - *Lutzomyia* species occur mostly in forested areas of Central and South America

- Genus *Sergentomyia* is confined to the Old World
    - *Sergentomyia* species commonly found in the Indian Sub-region
- Also occur in other areas as Africa and Central Asia

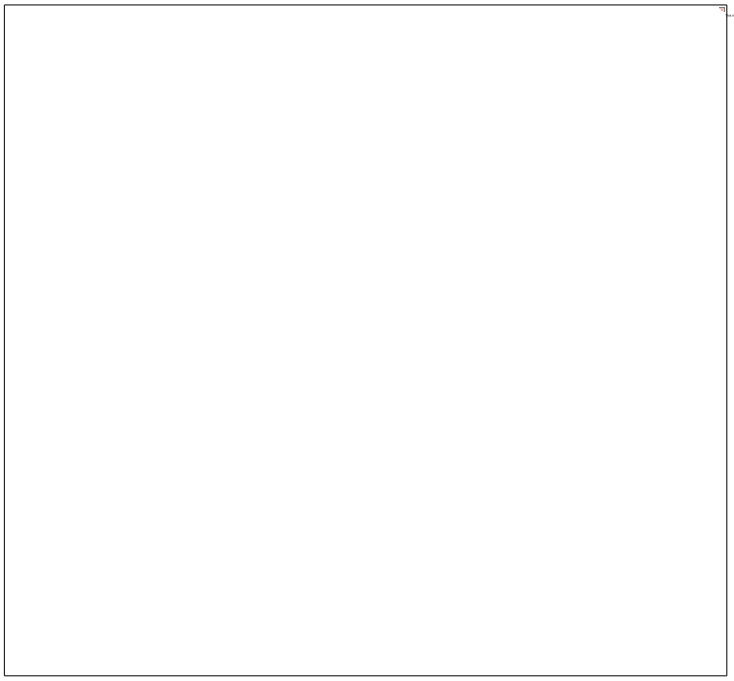
Sandflies are vectors of: -

1. Leishmaniasis
2. Sandfly fever- a viral disease
3. Bartonellosis (Carrion's disease) - a Parasitic disease caused by an organism called Bartonella

External morphology

Adult Phlebotomine Sandflies are easily recognized by:

- Their minute size - 2-3mm in length
- Hairy appearance - body very hairy
- Are dull colour - yellowish-brown to black
- Have long stilt-like legs
- The mouth parts are short and inconspicuous
- Are adapted for blood sucking



Wings

- Wings held up in the air at about 45^{o} when at rest
- Have simple venation
- Vein 2 in phlebotomine sandflies branches twice

Sex

- Males have genital claspers visible at end of abdominal segments
- Females have a more rounded up bottom

Life cycle

- Phlebotomine sand flies have a long life cycle
    - About 40 days in the tropics
    - About 120 days in the Mediterranean region
- Only females take blood meals

Eggs:

- Females lay about 15 - 100 egg singly
- Eggs laid in cracks, crevices and litter
- Egg are minute - 0.3-0.4mm long
- Are ovoid in shape
- Are usually brown or black and are patterned
- Require a moist microhabitat with high humidity
- Cannot withstand desiccation
- Egg hatch after 6-17 days under optimal conditions, but may be prolonged

The larva:

- Larvae are scavengers, feeding on organic matter as fungi, decaying leaves, semi-rotting vegetation, animal faeces and decomposing bodies of arthropods
- Larval habitat needs high humidity
- There 4 larval instars
- Mature larva will measure 3-6mm long
- Has a well defined black head
- Body is grayish or yellow and of 12 segments
- Body with characteristic **matchstick-like hairs** (bristles)
- The last abdominal segment bears 2 pairs of conspicuous hairs called the **caudal bristles**
- Larval development period is 19-60 days, depending on temperature and availability of food

Pupa:

- Pupa assumes an erect position in the habitat
- It has the remains of the larval skin with its match-stick-like bristles and the caudal bristles attached to the end of the pupa -characteristic for identification of sandfly pupa
- Adult emerges from pupa after 7 - 14 days

Adult behaviour

- Phlebotomine sandflies are weak flyers
- 74% of them may fly for only 250 meters
- Both sexes feed on plant juices and sugary secretions
- Females in addition, suck blood from a variety of vertebrates including livestock, dogs, rodents, snakes, lizards, amphibians and birds
- In the Old world many *Phlebotomus* species bite man
- In Tropical Americas *Lutzomyia* species feed on a variety of mammals including man
- Biting is usually restricted to crepuscular and nocturnal periods
- But biting may take place during the day in dark places and during overcast days
- Most species are exophagic, but a few are endophagic
- Due to their short mouth parts they are unable to bite through clothing
- Adults rest in sheltered , dark and humid places, but on dry surfaces
- Domestic and peri-domestic species may have endophilic habits after feeding e.g. *Phlebotomus papatasi*

Medical importance

Phlebotomine sandflies are important vectors of disease and in addition they are a biting nuisance and the bites can cause severe and intolerable irritation in sensitized people. They are vectors of:

1. Leishmaniasis
2. Sandfly fever
3. Bartonellosis

Leishmaniasis

- Diseases caused by Leishmania parasites
- Phlebotomine sandflies are the only known vectors
- The parasites are ingested by female sandflies with a blood meal
- In the gut of the fly the parasites develop a flagellum with which they attach to the gut wall
- Multiply within the insects stomach
- Migrate to the anterior part of the mid gut
- From there the parasites invade the oesophagus
- After 4 - 12 days the infective forms of the parasite are found in the insect's mouth parts
- From here the parasites are introduced to a new host during subsequent feeding

- Previous feeding of the female phlebotomine sandflies on plant juices aid the survival of the parasites in the insect's gut

SIMULIUM

Family: - Simuliidae
Generally referred to as **black flies**

Distribution: - Worldwide
Species: - About 1300 species
Genera: - Family has 12 genera
- Important genera include: -

1. Simulium
2. Prosimulium
3. Austrosimulium
4. Cnephia

Medically important species: -

1. *Simulium damnosum* complex - Africa
2. *Simulium neavei* complex - Africa
3. *Astrosimulium ochraceun* - South America
4. *Simulium metalicum* - South America

Morphology:

Size: - Quite small insects - 1.5 - 4mm long

- Relatively stout bodied
- Rather humped at the thorax
- Mainly black in colour
- A pair of large compound eyes
- In females eye separated on top of head - **Dichoptic**
- In males eyes occupy the whole head and touch each other on top of the antennae - **Holochoptic**
- Antennae are short and stout, and distinctly segmented

- Mouth parts short - do not penetrate deep in skin
- Only females bite
- Teeth on labrum stretch the skin and the rasp-like action of the maxillae and mandibles cuts through it and rupture the fine blood capillaries producing a small pool of blood.
- This method of feeding is suitable for picking up mf of *Onchocercer volvulus* - occurring in the skin.

Life cycle

Eggs: -

- Pale when laid but darken to a brown or black colour
- measure 0.1 - 0.4mm long
- More-or-less triangular in shape but with rounded ends and smooth shell.
- Laid in fast flowing streams
- Laid on sub-merged objects e.g. rocks, vegetation
- Batches of 150 - 800 eggs are laid in sticky masses or strings
- Hatch within 1 day but 2-4 days is common
- Hatching may take many weeks in cold temperate climate

Larva: -

- 6-8 larval instars
- Mature larva is 5-8mm long
- Distinct from all aquatic larvae
- Larva does not swim
- Are sedentary on submerged vegetation, rocks, stones and other debris
- Attachment is by the posterior hook-circlet (anal sucker)
- But larva may change position by help of the proleg
- Larvae are filter feeders
- Development takes 1-2 weeks depending on species and temperature - may over winter for several months

Pupa: -

- Mature larvae spin with silk produced by salivary glands, a protective cocoon
- Cocoon is slipper-shaped and brownish in colour
- Cocoon is firmly stuck to submerged substrata
- Pupa has a pair of prominent **filamentous respiratory gills**
- Pupal period in the tropics is 2-6 days
- Adults emerge rapidly to the water surface in a protective bubble of gas - which prevents it from getting wet.
- On the surface they immediately take to flight

Adult: -

- Both males and females feed on plant juices and sugary substances
- Only females take blood meals
- Biting occurs outdoors by day
- Engorged females shelter in vegetation
- Blood digested in 2-3 days in tropical conditions - 3-8 days in non-tropical depending on temperature
- Females may fly for considerable distance looking for blood meal e.g. 60-100km
- Dispersed by wind for as far as 300km

Medical importance: -

1. Can cause serious biting problem as bites can be quite painful and may result in intense irritation.
2. Vectors of Onchocerciasis
    - The only vectors of human onchocerciasis
    - Feeding habit of tearing and rasping the skin to rupture blood capillaries when obtaining blood meals makes them suitable to ingest the skin-borne mf of *O. volvulus*.

Development of parasite in Vector

- Stars when the vector species of Simulium takes mf in its blood meal from an infected person
- Some mf bore through the stomach wall and migrate to the thoracic muscles to start development as L1 stage.
- Transform to short, thick and inactive sausage form of L1 in 4-5 days.
- Undergoes first moult giving rise to L2
- L2 grows rapidly increasing in length and width, and undergoes a second moult to yield L3 larval stage at 9 - 10 days.
- L3 grows very rapidly in length but not width becoming very active. This is the infective stage.
- Infective larvae migrate to the base of the proboscis, and escape to the surface of the skin during subsequent feeding by the vector.
- They actively bore through the skin at the sight where vector is feeding to start development in human host

CHRYSOPS

Belong to a group of large biting flies referred to as horseflies

Family:- Tabanidae

- Many genera
- 3000 species
- Most important genera include:-
  - *Chrysops*
  - *Tabanus*
  - *Heamatopota*

- Chrysops mainly important vectors of Loa loa in West Africa- main vectors: -
  - *Chrysops silacea*
  - *C. dimidiata*

Distribution:
Chrysops are found in temperate and tropical areas of the world

External morphology:-

- Medium sized, 5-25 mm long
- Head large and semi-circular when viewed from above
- Conspicuous pair of compound eyes
- Sexed by examination of their eyes - females are **dichoptic** while males are **holochoptic**
- Antennae are relatively small but stout and consist of 3 segments, and have no **arista**
- Antennae longer than any of the other horseflies
- Mouth parts of females are stout and adapted for biting
- Do not project forwards but point downward from head.
- Only females take blood meals
- In life specimens when adults are at rest, wings stay open
- Wings with a brownish transverse band
- Abdomen usually broad and stout and dorso-ventrally flattened
- Abdomen covered by distinct coloured strips

Life cycle

Adult: -

- Males and females feed on naturally occurring sugar secretions but in addition females bit a wide range of mammals, and a wide range of amphibian & birds
- Also get blood meals from man

Eggs: -

- 100-1000 deposited mainly on underside of objects e.g. leaves, grass, vegetation, plant stems, twigs, stones
- Oviposition site overhangs larval habitats
- Larval habitats are mainly, muddy aquatic or semi-aquatic sites
- Eggs firmly glued on the substrate in upright position
- Are covered with coating that is impervious to water (water-proof)
- Egg measure 1-2.5mm long
- Are curved and about cigar-shaped
- Hatch in 4-14 days depending on temperature and species

Larva: -

- After wriggling out of eggs the young larvae drop down on the underlying mud or water
- Larvae are cylindrical and pointed at both ends
- Have a very small black head
- Have prominent raised tyre-like rings which encircle most of the body segments
- Segments 4 - 10 have psudopods
- Last segment has a siphon
- Larvae live in mud, rotting vegetation, humus, damp soil, shallow and muddy water
- Are scavengers- feed on detritus and a variety of dead decaying vegetable and animal matter
- Prolonged larval development - 1-2 years and up to 3 years in temperate species
- 4-11 larval instars
- Mature larva is 1- 6cm long
- Migrate to the periphery of the larval habitat to pupate

Pupa: -

- Partially buried in mud or soil
- 7-40mm long
- Brown and curved
- Ear-shaped spiracles laterally placed
- Pupal period lasts 5-20 days

Adult behaviour

- Feed during day light hours
- Feed especially in bright sunshine
- Locate prey by sight
- Are powerful flyers and may disperse for many kilometers

- Inhabit low lying marshy scrub areas or swampy woodlands - but some species are found in more open savanna and grassland areas
- Do not enter houses to feed but *Chrysops silacea* is an exception to this

Medical importance:

1. Vectors of *Loa loa* in the equatorial rain forests
   - Vector species include:-
     a) *Chrysops silacea*
     b) *C. dimidiata*.

2. Mechanical vectors of tularaemia (*Pasteurella tularaemia*) from horses, rabbits and other rodents to man - mainly *Chrysops discalis* in North America. This is a less important disease.

Loiasis:

- The only important disease transmitted to man by tabanids
- Disease caused by a parasitic nematode called *Loa loa*
- Disease occurs in the equatorial rain forests of West Africa, Southern Sudan and parts of Western Uganda
- Parasite produces diurnal periodic microfilariae which are found in the peripheral blood of man.
- When ingested by the tabanid - Chrysops - they undergo a developmental cycle in the fly.
- Mf penetrates the gut wall of the fly, and migrate to the **abdominal and thoracic fat bodies**
- In the fat bodies mf develop and moult twice to give the infective larvae in 10 - 12 days- development more or less same as the typical filaria larval development in the thoracic flight muscles in mosquitoes, *Simulium* and *Culicoides*.

Control

- Very few practical control measures available

HOUSEFLIES AND STABLEFLIES

- Belong to Family Muscidae
- There are many genera and species in the family
- Those important from medical point of view are:
  - Common housefly - *Musca domestica*
  - Other houseflies – *fannia* and *muscina*
  - Blood sucking stable fly - *Stomoxys calcitrans*

- Have a Worldwide distribution
- Non-biting flies are mechanical vectors of:
    - Cestodes
    - Nematodes
    - Faecal bacteria, protozoa and viruses
    - Biting stableflies can be mechanical vectors of trypanosomiasis

The common housefly (*Musca domestica*)

External morphology (see diagrams)

- Are medium sized non-metallic flies – 6 - 9mm long
- Colour varies from light to dark grey
- Have three-segmented antennae with **arista**
- The mouth parts (proboscis) specially adapted for sucking
    - Withdrawn into the head capsule when not in use
    - Can be extended vertically downwards in a telescopic fashion when the fly feeds
    - Proboscis ends up in a pair of oval-shaped fleshy labellae, having very fine channels called **psuedotrachae** through which food is sucked up
    - Each pair of legs ends in a pair of claws and a pair of fleshy pad-like structures called the **pulvilli**
        - Pulvilli are supplied with glandular hairs
        - These sticky hairs enable the fly to adhere to very smooth surfaces
        - The hairs are also responsible for the fly picking of up dirt and pathogens

Life cycle

Eggs

- Females attracted to decomposing materials for egg laying
- 75-100 eggs are deposited together or in separate batches in cracks and crevices or scattered over the surface
- 5-6 such batches may be deposited in a fly's lifetime
- Eggs are creamy white measuring 0.8-1.2mm long
- Are distinctly curved dorsally giving them a banana-shaped appearance
- Egg hatch after 6-12 hours
- Eggs cannot withstand desiccation- die when they dry out

Larvae (see diagram)

- Are white-creamy in colour
- 12-segmented cylindrical and maggot-shaped
- Have a pointed head end with a pair of small curved mouth hooks
- Posterior end has conspicuous spiracles shaped like a letter D
- Each spiracle has a thick outer wall called the **peritreme**
- Larvae feed on decomposing and decaying organic matter
- Undergo 3 larval instars
- Mature larva measures 8-14mm long

- Larval development completed in 3-5 days - may be longer (7-10days) in less favorable conditions

Pupa

- Prior to pupation the 3rd instar larvae migrate away from larval habitats to drier ground
- Larval skin contracts and hardens to form a dark brown barrel-shaped structure
- Puparium measures about 6mm long
- Stage lasts 3-5 days in warm weather
- May be prolonged to 7-14 days in cooler conditions

- Egg to adult takes about 49 days at 16^{o}C, 21 days at 20^{o}C, 16 days at 23^{o}C, 9-10 days at 30^{o}C and 8 days at 35^{o}C

Fannia species

- Flies in this genus resemble houseflies
- But are smaller (6 - 7mm long)
- Arista is devoid of any hairs **(see diagram)**

Life cycle

Eggs

- 50 -100 egg laid in man's food and also in urine-soaked bedding of man and animals, compost heaps, excreta and litter
- Eggs resemble those of housefly
- Hatch in 1-2 days

Larvae

- Are dorsoventrally flattened (see diagram)
- Have thin fleshy processes on the body segments
- Larval development takes 7-12 days

Pupa

- Puparium is brown in colour and similar in shape to the larva
- Puparial period is 7-10 days and adult flies emerge

- Life cycle is completed in 13-22 days in favorable conditions

The greater housefly (*Muscina stabulans*)

- World wide distribution
- Are about 7-10mm long

Life cycle

Eggs

- 150-200 egg laid scattered indiscriminately over the surface of decaying matter
- Hatch after 1-2 days

Larvae

- Resemble those of housefly
- Distinguished from those of housefly by structure of the posterior spiracles - almost circular and not D-shaped as in houseflies (see diagram)
- Peritreme encircles 3 crescent-shaped spiracular slits
- Young larvae are omnivorous scavengers
- As larvae mature they become predacious, feeding on any other fly larvae in the same breeding environment

Puparia

- Similar to that of *Musca domestica*
- Puparial period is 1-2 weeks

- Life cycle takes 4-5 weeks - may be shorter (20-25 days) in warmer weather
- Adults enter buildings to feed
- Behave in same way as *M. domestica*

FLIES AND MYIASIS

Myiasis is defined as invasion by dipterous fly larvae of organs, living, necrotic or dead tissues of the body of man or other vertebrate animals

- The larvae for some period, will feed on living, necrotic or dead tissues of the host's body, or on host's ingested food in the case of intestinal myiasis

- **Obligatory myiasis**- the larvae must live on a live host for at least a certain part of their life
    - E.g. larvae of *Cordylobia anthropophaga* are
    - obligatory parasites of man and other animals

- **Facultative myiasis**- Larvae are normally free-living, often attacking carcasses, but under certain conditions they may infect living hosts
    - E.g. species of *Calliphora*, *Lucilia*, *phormia* and *Sarcophaga* which normally breed in meat or carrion may cause facultative cutaneous myiasis in man by infecting festering sores and wounds

- There is no obligatory intestinal myiasis in man
    - Presence of maggots in the intestinal tract is due to accidental swallowing of egg or larvae on food
    - The maggots may survive for some time in the intestines

- There is no fly species which is adapted to cause intestinal myiasis in man
- But obligatory intestinal myiasis occurs in other animals

- **Facultative urinogenital** myiasis occurs in man
    - Usually involves larvae of *Musca* or *Fannia* species
    - Flies may be attracted by unhygienic discharge to lay egg near the genital orifices
    - When egg hatch the tiny larvae enter the genital tract
    - Much pain may be caused by larvae in this tract
    - Sometimes mucous and blood may be discharged

<u>Obligatory myiasis</u>

The non-metallic Calliphorids

1. *Cordylobia anthropophaga*

- Species is commonly known as the **tumbu** or **mango** fly
- Found only in Africa where it is widely distributed
- Adults are robust, relatively big flies (see diagram)
- About 9-12mm long
- Dull yellowish to light brown in colour
- Have 4 visible abdominal segments more or less equal in length

Life cycle

Eggs

- Females lay up to 100-300 eggs in batches on dry soil and sand
- Eggs are laid in places especially contaminated with urine and excreta of man, dogs, rodents and monkeys
- Also lay egg on underclothes and nappies of babies placed on the ground to dry
- Egg are whitish in colour and banana-shaped
- Hatch after 1-2 days

Larvae

- Larvae attach themselves directly on the host
- Or may attach temporarily to washed clothing placed on the ground to dry
- May also get transferred to man if clothing is not ironed before wearing
- Once on host, powerful hook-like mouth parts enable a larva to bury itself completely except for its posterior spiracles placed at the tip of the abdomen
    - Spiracles remain in contact with the air

- Newly emerged larvae can live as long as 9-15 days on the ground in absence of a suitable host

- The 1st instar larvae are minute and typical maggot-shaped
- 2nd instar larvae are club-shaped
- 3rd instar larvae are fat, broadly oval-shaped white maggots
    - measure 11-15mm long
    - are covered with numerous spicules (see diagram and picture)

- After 10-12 days the mature larva wriggles out of the boil-like swelling and falls to the ground where it buries itself and turns into puparium
- Adults emerge after some 10 days
- Readily enter houses where they may lay egg

Medical importance

- Larvae of *Cordylobia* cause boil-like (furuncular) swellings on most parts of the body
- These boils do not contain pus
- To extract the larva, the small hole in the swelling is covered with medicinal liquid paraffin
- This prevents the larva from breathing through its spiracles resulting in its wriggling a little further out of the swelling to protrude the spiracles
- In so doing it lubricates the pocket in the skin, and the larva can be extracted by gently pressing around the swelling

Metallic Calliphorids

- Include the New World screw-worms (*Cochliomyia hominivorax*) and the Old World screw-worms (*Chrysomyia benzziana*)

1. **New World screw-worms** (Cochliomyia *hominivorax*)

- Occurs in South-western USA through Mexicao to Argentina

External Morphology

- Adult flies are 8-10mm long
- Are metallic green to bluish-green in colour (see picture)
- Have three (3) distinct dark longitudinal strips on the dorsal surface of the thorax (see diagram)
- Dorsal bristles on the thorax not well developed

Life cycle

Eggs:

- Females of *Cochliomyia hominivorax* lay batches of 10-400 egg on the edges of 2-10 day old wounds

- Also on dried blood clots
- On diseased or healthy mucous membranes e.g. nasal passages, mouth, vagina
- On umbilicus in new-borne babies

- Egg hatch in 11-12 hours

Larvae:

- Newly hatched larvae are active and bury deeply into living tissues
- Feed gregariously
- Undergo 3 larval instars
- 3rd instar larvae formed after 2-3 days
  - 3rd instar larvae are 15-17 mm long
  - Typically maggot-shaped
  - Distinguished from those of housefly by presence of distinct bands of spicules on anterior margins of all body segments (see diagram)
  - Larvae tend to penetrate deeply into tissues
  - Infections near eye, nose and mouth can cause considerable destruction
  - Destruction is accompanied by putrid smelling discharge and ulceration
- Larvae mature after 4-8 days
- Wriggle out of wounds or passages
- Drop to the ground, bury in soil and pupate
- Adults emerge some 7-10 days later

2. **Old World screw-worm**

- Found in genus *Chrysomyia*
- Species *Chrysomyia benzziana*
- Larvae are obligatory parasites in living tissues
- Occur throughout the tropics

External morphology

- Adults very similar to *Cochliomyia*
- But with 2 distinct longitudinal thoracic strips (see diagram)
- Larvae also very similar to those of *Cochliomyia*

Life cycle

- Very similar to *Cochliomyia hominivorax*

M**edical importance of screw-worms**

- Both *Chrysomyia benzziana* and *Cochliomyia hominivorax* are obligatory parasites of living tissues and cause myiasis in man
- Larvae can cause severe damage and should be treated immediately

Facultative myiasis

The green-bottles (Lucilia)

External morphology

- Mostly metallic or coppery-green in colour
- A little smaller (10mm long) than *Calliphora*
- Distribution - Americas, Europe, Asia, Africa and Australia

Life cycle

- Females mainly lay eggs on meat, fish, carrion and decaying or decomposing carcasses
- Also oviposite on or near festering and foul-smelling wounds of man
- Mature larvae bury in soil and pupate
- Cause facultative myiasis - commonly intestinal myiasis

Sarcophagidae

Genera:- *Sarcophaga*
Wohlfahrtia

- Cause myiasis
- Sometimes called flesh flies
- World-wide in distribution

Sarcophaga

External morphology

- Are large hairy non-metallic flies, measuring 10 - 15mm long
- Have three (3) prominent black longitudinal dorsal strips on the thorax (see diagram)

Life cycle

- Adults do not lay eggs
- Deposit 1st instar larvae as tsetse flies
- Larvae deposited in batches of 20-40 on decaying carcasses, rotting food, excreta and wounds
- Larvae typical maggot-shaped
- Posterior spiracles situated in a deep pit (see diagram)
- Larvae of *Sarcophaga* not easy to differentiate from *Wohlfahrtia*
- If on wounds larvae do not cause much damage as they feed on necrotic tissues
- Used in **maggot therapy** for chronic wounds

NOT YET COVERED (Lectures being organized)

Cockroaches

- Are insects of the order Blattodea
- There are about 4,600 species.
- About 50 cockroach species out of these are associated with human habitats (domestic pests)
- Three species are pests of medical importance, including:-
    - *Blattella germanica* (the German cockroach)
    - *Periplananeta americana* (the American cockroach)
    - *Balatta orientalis* (the Oriental cockroach)
- They are common and hardy insects, and can tolerate a wide range of environments from Arctic cold to tropical heat.
- Cockroaches have a worldwide distribution
- Aid in transmission of various pathogenic viruses, bacteria protozoa and helminthes

a) *Periplananeta Americana*

b) *Blattella germanica*

c) *Balatta orientalis*

External morphology:

- Are usually chestnut brown or black in colour
- Measure about 1.5 – 4.5cm long
- Dorsoventrally flattened
- Have a pair of long filiform antennae
- Mouth parts are developed for chewing, gnawing and scraping
- Have two pairs of wings
    - In certain household species wings may be shorter in females than males
    - In female *Blatta orientalis* the wings are very small and non-functional

- The segmented body is more or less oval and completely or partly hidden from view by the folded overlapping wings
- In both sexes a pair of prominent segmented cerci arise from the last abdominal segment

Habits:

- Household cockroaches in the tropics hide during the day in almost any dark place i.e. cesspits, septic tanks, sewers, dust-bins, cupboards, drawers, behind refrigerators, cooking stoves e.t.c.
- They are nocturnal in habit – rarely seen during the day
- Are omnivorous and voracious feeders – any type of mans food is eaten
- Can eat anything including paper, clothes hair, shoes, dried blood, sputum, excreta, dead insects and almost any animal or vegetable matter
- May live for 5 – 10 weeks without water and for many months without food

Life cycle:

- Eggs are laid encased in a brown bean-shaped case or capsule called **ootheca**.
- Ootheca contains 14 – 48 eggs
- Cockroaches are often seen running around with an ootheca partly protruding from the tip of the abdomen
- The oothecae are deposited in cracks and crevices in the dark and secluded places
    - In some species the oothecae are cemented to the surfaces as underside of tables, chairs and beds
- A female may lay 4 – 90 oothecae in its life span of many months to a year
- Cockroaches have a hemimetabolous life-cycle:-
    - Nymphs hatch from eggs after 1 – 3 months
    - Young nymphs are very pale and delicate versions of the adults
    - Older ones are darker and resemble the adults
    - The nymphs are wingless, but wings develop in the later instars
    - In *Periplaneta americana* there are as many as 13 nymphal instars lasting 2 – 3 months in ideal conditions

Medical importance:

- Medical importance based on the cockroach's dirty habits of feeding indiscriminately on both excreta and foods, and their practice of excreting and regurgitating their partially digested meals over food

- Cockroaches have been suspected to aid in transmission of various illnesses as:-
  - Pathogenic viruses as poliomyelitis
  - Protozoa – *Entamoeba hystolytica*, *Trichomonas hominis*, *Giardia intestinalis* and *Balantidium coli*
  - Bacteria: - *Escherichia coli*, *Staphylococcus aureus*, *Shigella dysentariae*, *Salmonella typhi* and *S. typhimurium*.
  - Intermediate host to various nematodes – e.g. *Enterobius vermicularis*.
  - Have been found naturally infected by with Toxoplasma gondi and suspected to transmit the parasite to cats and possibly to man

LICE

ANAPLURA - contains the group of lice that infest man
Group comprises of three species:

1. *Pediculus capitis* - Head lice
2. *P. humanus humanus* - body lice - also referred to as *P. coporis*
3. *Pthirus pubis* - pubic lice

Body and head lice

- Are longer than the pubic lice
- Nearly the same in morphological appearance and difficult to separate
- Have claws at end of legs
- More or less world wide distribution
- Body lice are vectors of :
  - Louse-borne typhus (*Rickettsi prowazeki*)
  - Trench fever (*Rochalimaea quintana*)
  - Louse-borne relapsing fever (*Borrelia recurrentis*)

External morphology

- Adults are small grayish and wingless
- Have soft leathery integument
- Dorso-ventrally flattened
- Males measure 2-3mm and females 3-4.5mm
- Head bears a pair of inconspicuous eyes and a pair of short 5 segment antennae
- Three pairs of legs stout and well developed
- Have a thick tibia with a small thumb-like-spine on its inner side at the apex
- Have a short tarsus with a curved claw

Mouth parts

- Louse mouth parts are different from those of other blood sucking insects
- Do not constitute a projecting piercing proboscis
- Consist of a flexible, sucking almost tube like mouth - the **HAUSTELLUM**
- The haustellum is armed on the inner surface with minute teeth which grip the host's skin during feeding
- Needle-like stylets are thrust into the skin and saliva injected into the wound
- Blood is sucked into the mouth and passed into the stomach for ingestion

Biology

- Lice are hemimetabolous - nymphs and adults having same appearance and behavior
- Adults and nymphs live permanently on man
- Both sexes take blood-meals
- Feed 4 - 5 times a day
- Females lay 6 -9 eggs at a go and about 200-300 eggs in life of about 1 month
- Females lay eggs which are usually cemented at the base of the hair near the scalp for head lice or on the fabric for body lice
- Cementing material very sticky - hard to remove eggs
- When hatching the nymphs leave the egg shells (nits) stack in position
- Duration of egg stage is about 6-10 days
- But egg discarded on clothes away from warmth of the body may take 2 - 3 weeks

Nymph

- Lice pass through 3 nymphal instars
- Nymphs take blood-meal from man just as adults
- Nymphal stages last 7-14 days and louse becomes adult
- But nymphal duration depends on whether or not clothing is worn all the time
    - If removed at night nymphs are subjected to lower temperatures, thus slowed development

PUBIC LICE (*Pthirus pubis*)

- Pubic lice are generally smaller than body and head lice
- Measure 1-2mm
- Are easily distinguished from body and head lice
- In pubic lice there is less differentiation between thorax and abdomen
- Body is as broad as long
- In pubic lice the front pair of legs is much more slender than the other two pairs
- Have crab like appearance - sometimes referred to as crab louse

Life cycle

- Very similar to that of the *Pediculus*
- Egg take 6-8 days to hatch
- Nymphal stages last 10 - 17 days
- Female lays a total of 150 -200 eggs which are slightly smaller than those of *Pediculus*

- Eggs are cemented onto the coarse hairs of the genital and perianal region of the body
- Egg may be found on other areas of the body with coarse hairs
- Pubic lice are rarely found on the head
- Infestation is usually through sexual intercourse

Medical importance of Lice

1. **Pediculosis**
   - Presence of body, head or pubic lice on a person
   - The skin of people who harbor a large number of body lice may become pigmented and slough, a condition known as vagabond's disease

2. **Feeling 'lousy'**
   - Feeling of weariness, irritability or a pessimistic mood caused by repeated lice bite with injection of lice saliva in the individual

3. **Louse borne typhus**
   - Caused by *Rickettsia prowazeki*
   - Transmitted from one person to another by body lice
   - Ingested with blood meal from an infected person
   - The rickettsiae in the louse stomach will penetrate into the lumen cell where they multiply enormously causing the cell to distend and rapture
   - Raptured cell releases large number of reckettsiae in the louse gut
   - Man gets infected with typhus either by inhalation of the fine powdered dry faeces of the louse
   - Alternatively louse is crushed by persisted scratching and the reckettsiae in the gut are released to enter human body through abrasions

4. **Trench fever**

   - Caused by *Rochalimaea quintana*
   - Ingested by louse while feeding on infected man
   - The pathogens get attached to the walls of the gut cell and multiply - no penetration
   - After 5-10 days the louse faeces becomes infected
   - Man becomes infected by either crushing the louse, or by its faeces coming in contact with skin abrasions or mucous membranes

5. **Louse borne Relapsing fever**
   - Caused by a spirochaete *Borrelia recurrentis*
   - Transmitted by body lice
   - Ingested with blood-meal from an infected person
   - Spirochaetes in the gut pass across the gut wall into the haemocele
   - Multiply greatly, reaching enormous numbers
   - Man becomes infected by crushing the louse, and the spirochaetes entering the body through skin abrasions or mucous membranes

- Habit of crushing lice between finger nails or even with teeth can be very dangerous if louse is infected

Control of Lice

Body lice

- Body lice can effectively controlled by infested people changing and washing clothing in water hotter than 60^{o}C
- 10% DDT can be used to dust clothing
- 1% HCH powder used where lice are resistant to DDT
- Other insecticides for use include: Malathion, temephos (Abate), Carbaryl (Sevin) and propoxa (Baygon)

Head lice

- Shave hair
- 0.5% carbaryl emulsion
- Malathion emulsion
- Here insecticide emulsion is applied on the head and the hair washed
- This kills the adult lice the nymphs and even the eggs
- But insecticides used should be changed frequently - yearly to avoid development of resistance

Pubic lice

- Shaving hair
- Treatment with emulsion of insecticides

FLEAS

- There are some 3000 species and sub-species of fleas
- Belong to about 200 genera
- Only a few are important pests of man
- 94% of the known species bite mammals the remainder biting birds
- Fleas are generally distributed through out most of the world
- But a few have restricted distribution e.g. the plague flea in the tropics

External Morphology

- Adults are relatively small 1-4mm
- More or less oval insects
- Compressed laterally
- Vary in colour from light to dark brown
- Have no wings

- Three pairs of powerfully developed legs, with hind pair specialized for jumping
- Legs and most of body covered by bristles and body spines

Head

- Roughly triangular in shape
- Bears a pair of conspicuous eyes
- Also carries a pair of short three-segmented antennae -lie in depressions behind the eyes
- Mouth parts pointed downwards
- In some species the head also has a row of coarse, well developed tooth-like spines - the genal comb

Thorax

- Has three distinct segments
  - Prothorax
  - Mesothorax
  - Metathorax
- Posterior margin of the pronotum may bear the pronotal comb
- Above the middle pair of legs is located a sternite called the **mesosternum**
- The mesosternum in some species is divided into two parts by the **mural rod**
- These structures: the genal comb, the pronotal comb and the mural rod are used in classification of the flea species
- E.g. the presence of a mural rod and, combined with the absence of both the genal and pronotal combs, indicates the genus Xenopsylla
- Females have a distinct brownish spermatheca in the position of 6^{th} - 8^{th} abdominal segment

The alimentary canal (Adult fleas) (See diagram)

- Has spindle-shaped pharynx - through which sucked blood passes
- Pharynx is linked to a thin oesophagus
- The proventriculus is bulbous and provided internally with numerous backwardly projecting stiff spines (important in mechanism of plague transmission)
- Has relatively large stomach (mid gut)
- Distal end of the stomach is connected to the hind gut
- Hind gut continuos with a small dilated rectum

Life cycle (See diagram)

- Both males and females take blood-meals
- Females lay eggs in debris, cracks or crevices around the host's environment
- May lay up to 300-1000 eggs in small batches of 3-18 a day
- Egg hatch within 2-14 days
- Minute legless larvae emerge from the eggs

Larva

- With a small blackish head with very small pair of antennae
- 13 distinct but similar segments
- The segments end up in a pair of finger-like ventral processes- the **anal struts**

- Larvae very active and avoid light
- Feed on any organic debris including the host's faeces
- In some species the larvae are scavengers- feed on any dead insects
- Undergo three larval instars
- Larval period may last 10 -21 days but may be prolonged to more than 200 days in unfavorable conditions
- At end of larval period the larva spins a whitish cocoon around itself
- Cocoon made from silk produced by the larva's salivary glands
- Cocoon is sticky and is soon covered by fine particles of dust and organic debris
- Larva pupates within the cocoon

The pupa

- Pupal stage lasts 7-14 days in optimal conditions
- Adult emerges from the pupa on stimulation by vibrations caused by movement of host
- the life cycle from egg to adult emergence may take as short as 2-3 weeks under optimal conditions
- But may be considerably longer - up to 20 months

Medical importance

1. **Murine typhus**

- Caused by *Reckettsia mooseri*
- Parasite infects man when the infected flea faeces are scratched into the skin abrasions

2. **Plague**

- Caused by the plague bacillus *Yersinia pestis*
- Transmitted by *Xenopsylla cheopis*
- Bacillus taken up by the flea when feeding on infected person or rodent
- The bacteria reach the proventriculus and the fore gut
- Multiplies enormously and blocks the proventriculus
- Flea gets problem in feeding
- When it tries to feed the muscular pressure pushes some of the bacilli into the incoming blood-meal which is eventually regurgitated into new host - causing infection
- Flea with blocked proventriculus becomes starved and repeatedly bites in attempt to get a blood - meal in the process infecting many new individuals

Silvatic plague

- Plague is usually a disease of wild rodents
- Circulates within the wild rodents
- Kills and reduces number of rodents

- When the population of wild rodents is reduced fleas take on the domestic rodents which are in turn eliminated very fast
- In the domestic environment the fleas move to man as the next host
- This ends up in a plague outbreak in man

TUNGA PENETRANS (the jigger flea)

- *Tunga penetrans* is found in the tropics and sub-tropics
- Some times referred to as the **chigoe** flea
- Does not transmit disease to man but it is a nuisance because the females burrow into the skin
- Adults of both sexes are very small - about 1mm long
- Have very compressed thoracic segments and very weak legs

Life cycle

- Egg are dropped onto the floors of houses
- Hatch within 3-4 days
- Larvae inhabit dirty and dusty floors
- Larval development completed within 10-14 days in favorable conditions
- Pupal period 5-14 days
- Complete life cycle in as short as 18 days

Adults

- Adults - newly emerged are very agile
- Jump and crawl around until they locate a suitable host -mainly man
- Both sexes feed on blood
- Male leaves host after the blood-meal
- Female after being fertilized burrows into the skin
- Soft parts of the skin
- Burrows whole body except for the tip of abdomen bearing the anus, the genital opening and the large respiratory spiracles
- Continuos to feed in the embedded position
- The abdomen distends with developing eggs, and acquires enormous size
- On maturity 150-200 egg are passed out of the female genital opening, falling to the ground

Control of fleas

- Only a very small fraction of the flea population will be found on the host
- The rest including the eggs larvae and pupae in cocoons will be in the hosts environment
- It is thus more effective to treat the whole environment including
    - Beds

- Kennels
- Rodent burrows
- Rodent paths (runways)
- House floors

- These areas should be treated with either insecticidal powders or lightly sprayed with solutions of :
  - 0.5% HCH
  - 2% Malathion
  - 0.5% Diazinon
  - 2% Dichlorvos (DDVP)

- Insecticidal powders for flea control include :

  - 5-10% DDT
  - 1% HCH
  - 0.5% Dieldrin
  - These liberally applied to the floors of houses and rodent runways

TICKS

Classification:

Class: ARACHNIDA - Tick, mites and spiders
Order: ACARINA - Order contains ticks and mites
Family: 1. Argasidae (Soft ticks)
2. Ixodidae (Hard ticks)

ARGASIDAE (Soft ticks)
- Soft ticks (Argasidae) are distributed world-wide
- There are some 150 species belonging to 5 genera
- Medically important soft ticks belong to genus ***Ornithodoros***
- Most important vector species belong to the *Ornithodoros moubata* complex
- Are vectors of tick-borne relapsing fever caused by *Borrelia dutoni*

External morphology:
- Adult appears dorsally like a leathery skin
- Have no scutum
- Are flattened dorso-ventrally and oval
- The integument is tough, leathery and wrangled
- Mouth parts, termed **capitulum** ('false head') are situated ventrally
- The 4 segmented palps are leg-like
- Chelicerae have smooth, not denticulated, sheaths
- The powerful cutting chelicerae have strong teeth at their tips
- Together with the hypostome, the chelicerae penetrate the host during feeding

- The hypostome is toothed

- Have 4 pairs of well developed legs terminating in a pair of claws
- The coxal organs (glands) open between the bases of the coxae of the 1st and 2nd pairs of legs
- Males and females are very similar in external appearance
- Both sexes feed on blood and are disease vectors

Life cycle:

- Adult spends 10 - 30 minutes taking blood
- The tick takes a large blood meal 6-8 times its body weight
- The blood meal is essential for maturation of the ovaries and egg laying

Eggs:
- Female lays 15 - 100 eggs in batches scattered in different areas in or near the animal host's home
- Eggs are laid in cracks and crevices in walls, floors, furniture or in mud, dust and debris
- Are coated with a protective waxy secretion from the **Gene's** organ (coxal glands)
- Eggs are heat resistant and can remain viable for many months under adverse conditions
- Eggs usually hatch within 1-4 weeks
- Ticks have a hemimetabolous life cycle (larvae and nymphs superficially resemble adults)
- Eggs hatch in six-legged larvae

Larva:
- Are very active and search for host from which to take a blood meal
- Capitulum projects from body and can be seen from above
- Blood feeding lasts about 20 - 30 minutes
- Engorged larva drops from host to the ground
- After a few days the larva moults to produce an eight-legged nymph
- Larvae of *Ornithodoros moubata* complex differ from most other argasid ticks in that they do not take blood meals
    - Remain in egg shells after hatching
    - Moult to produce 1st instar nymphs which crawl from the egg shell to seek their 1st blood meal

Nymph:
- Nymph also active
- Seeks host and feeds for 20 - 30 minutes before it drops to the ground
- Undergo 4-5 nymphal instars
- Each nymphal stage requires a blood meal before producing the next nymphal instar

- Life cycle often take about 6 - 12 months depending on:
    - Tick species
    - Temperature
    - Availability of blood-meals

- Adult ticks can live for several years
- Up to 15 years in the laboratory
- Can remain alive for 5 years or more after a single blood meal
- Argasid ticks' larvae, nymphs and adults attach on hosts only for a short period during feeding, after which they drop off
- They may seek different host for subsequent blood-meal
- Are thus referred to as 'many-host' or 'multi-host' ticks

Medical importance

1. **Tick-borne relapsing fever**
    - Caused by a spirochaete *Borrelia duttoni*
    - Is the only important disease transmitted to man by soft ticks
    - Transmission of spirochaete:
        - Spirochaetes ingested with blood meal
        - Multiply in the gut and congregate along the gut wall of the tick's mid gut
        - Pass across into the haemocele where they can be found after 24 hours
        - In the haemocele spirochaetes multiply enormously and invade all tissues and organs of the tick's body
        - Within 3 days they are found in the salivary glands, the coxal organs and ovaries
        - In *O. moubata* complex the salivary glands in nymphs appear to be more heavily infected than those in adults
        - In contrast the coxal organs in nymphs are more lightly infected than in adults that seem to be more heavily infected
        - When either immature stages or adults of *O. moubata* complex feed on man, or some other host, saliva is injected into the bite - spirochaetes being introduced by this route
        - During feeding excess body fluids are filtered from haemocele by the coxal organs. Coxal fluid with spirochaetes in infected ticks (especially adults) is passed out through the opening of the coxal organs onto the skin of host
            - Spirochaetes will enter Host's body through the puncture of the tick's bite or through the intact skin
        - There is **transovarial transmission** of *B. duttoni* in the ticks
            - Female ticks get infected with spirochaetes which are passed to the eggs so that newly hatched larvae, nymphs of all instars and resulting adults of both sexes are infected

    - There is **transstadial transmission** where infection can be acquired by the larvae or nymphs and passed to the subsequent stages in the life cycle of the tick

IXODIDAE (Hard ticks)

- Hard ticks are distributed world-wide but occur more frequently in temperate regions than the soft ticks (Argasidae)
- There are about 650 species of hard ticks belonging to 13 genera
- Medically important hard ticks belong to genera ***Ixodes***, ***Dermacentor***, ***Amblyomma***, ***Haemaphysalis*** **and** ***Hyalomma***.

- Hard ticks are vectors of typhuses such as:
    - Rocky mountain spotted fever (*Rickettsia rickettsii*)
    - Boutonneuse fever (*R. conori*)
- They can also spread
    - Q-fever (*Coxiella burneti*)
- Many arboviruses
- Hard ticks also transmit tularaemia (*Pasteurella tularensis*)
- Cause tick paralysis

External morphology

- Hard ticks are flattened dorso-ventrally
- Are oval in shape
- Measure 3-23mm in length depending on species and whether unfed, or fully engorged with blood
- Females are nearly always bigger than males
- Capitulum ('false head') sticks out in front beyond the body outline and is visible from above
    - This distinguishes adult Ixodid from those of Argasid
- The palps are swollen and club-shaped
- The chelcerae have cheliceral sheaths covered with very small denticles
- Chelicerae are toothed at the ends
- Hypostome is also toothed
- Both hypostome and chelicerae penetrate host during feeding
- All hard ticks have a dorsal plate called **scutum** (shield)
    - In males scutum is large and covers almost the entire dorsal surface of the body
    - In females it is much smaller and restricted to the anterior part of the body, just behind the capitulum
    - In engorged females scutum is difficult to see

- In many species the posterior margin of the body has **festoons** - rectangular indentations
    - These may be difficult to see in fully engorged females
- Hard tick have 4 pairs of legs terminating in a pair of claws
- Are generally dark, but some species have coloured markings on the scutum and body and some times shiny patches of colour on the legs
    - Such coloured species are referred to as **ornate** species

Life cycle

- The Ixodidae ticks, as the Argasidae, have hemimetabolous life cycle
- There is incomplete metamorphosis involving larval and nymphal stage
- Adult Ixodid ticks remain attached to their hosts for long periods of 1-4 weeks
- When feeding is stopped the enormously engorged tick drops on the ground
- Seeks shelter under leaves, stones, detritus or buries itself in the surface soil
- Oviposition begins 3-6days after the female drops from the host

Eggs:

- Some 1000-8000 eggs are laid in gelatinous mass formed in front and on top of the scutum of the tick

- Some species may lay up to 20,000 eggs in an egg mass larger than the ovipositing female
- Oviposition may last 10 days or may extend for about 5 weeks
- Eggs are coated with a waxy secretion produced by Gene's organ
- Ixodid female lays only one batch of egg after which she dies
- Eggs hatch in 2-3 weeks or even several months into six-legged larvae

Larvae:-

- Are minute - about 0.5-1.5mm long
- Have toothed hypostome
- Remain inactive for a few days after which they swarm on the ground, climb vegetation and cluster at the tips of grasses and leaves '**questing**' - waiting for host to come by
- When host comes by the larvae climb on the host and crawl to their favoured sites for attachment
    - Site is commonly in ears and eyelids depending on species
- Chelicerae and hypostome are inserted deep into the skin of host and the larvae commence blood-feeding
- Remain attached to the host for 3-7 days and then drop to the ground
- Seek shelter among vegetation or under stones
- Take 2-7 days to digest blood meal
- After digestion they remain inactive for a few days before moulting to become nymphs

Nymphs:

- Are eight legged
- Crawl over the ground and climb vegetation and behave similarly to larvae (questing) in seeking for a suitable passing host
- Attach to suitable parts of host and begin to feed
- 5-10 days later they are fully engorged and drop on the ground to seek shelter
- Remain quiescent for 3-4 weeks while blood meal is being digested
- Nymphs moult afterwards to produce adult ticks - males or females
    - There is only one nymphal instar in the Ixodid tick's life cycle

Adult:

- Newly formed adult remains inactive for about 7 days
- Afterwards start questing for passing hosts
- Females take very large blood-meals - ingest 200 times its own weight
- Remain attached to host for 1-4 weeks
- On engorgement they drop to the ground and seek shelter

Behaviour and Habits

- Certain species of Ixodid ticks are more or less host specific
- But many species of medical importance are less specific and feed on a wide range of mammals including man
- Adults may live for 7 years

Three-host ticks:

- A different host is parasitised by larva, nymph and adult

- Moulting occurs on the ground
- Most Ixodid ticks have this type of life cycle
- Ticks of medical importance in this group belong to the genera *Ixodes*, *Dermacentor*, *Haemaphysalis* and *Rhipicephalus*.
- Ticks which feed on three hosts are more likely to become infected with pathogens and be potential vectors of disease

Two-host tick:

- In some species in particular many from the genera *Hyalomma* and *Rhipicephalus*, after the larva has completed feeding it remains on the host and moults to produce a nymph which then feeds on the same host
- Engorged nymphs drop off and moult on the ground
- Resultant adults feed on a different host
- This is a two-host feeding cycle which involves larva and nymph feeding on one host and the adult feeding on the second

One-host ticks:

- In a few species in the genus *Boophilus*, the larva, nymph and adult all feed on the same host
- Moulting also takes place on the same host
- The only stage that leaves the host is the blood-engorged female which drops on the ground to lay eggs
- The only way such ticks can transmit disease is through transovarial transmission
- One-host ticks are of little or no medical importance

Medical importance

1. **Tick paralysis**:
   - Not caused by any pathogens
   - Caused by various toxins contained in the female tick's saliva, which is continually pumped into the host during the long period the tick takes feeding on the host
   - Disease presents as an acute ascending paralysis affecting the legs with the result that the person cannot walk or stand, has difficulty in speaking, swallowing and breathing
   - Is due to paralysis of the motor nerves
   - Symptoms appear 5-7 days after commencement of feeding by female tick
   - May cause death of animals and also man as a result of respiratory failure
   - Characteristic in hard ticks

2. **Arboviruses:**
   - Transmitted by tick's bite and transovarial transmission commonly occurs

   Russian Spring-summer encephalitis (RSSE)
   - Viral disease associated with the Tiaga forest of Russia, Siberia, northern Asia and China

- Main vector is *Ixodes persulcatus*, In other areas *Haemaphysalis concinna* may be important
- After multiplication in the tick the virus accumulates in the salivary glands
- Infection is through the tick's bite
- Various small mammals and birds serve as reservoirs
- There is transovarial transmission in ticks

Tick-borne (Central European) encephalitis (TBE)

- Virus produces disease with similar symptoms to RSSE
- Occurs in central Europe from Scandinavia to the Balkans
- Principal vector are *Ixodes ricinus* and *Dermacentor marginatus*
- Various small mammals are reservoirs
- TBE virus accumulates in mammary glands of goats, sheep and cows
- People usually become infected not through tick bite but by drinking infected milk or eating cheese
- Both transstadial and transovarial transmission occurs in ticks

Kyasanur Forest Disease (KFD)

- disease occurs in tropical forests of Southern India
- Is spread by *Haemaphysalis spinigera*
- Small rodents, bats and birds may be reservoirs
- Monkeys are amplifying hosts
- Transstadial transmission occurs in ticks

Crimean-Congo haemorrhagic fever (CCHF)

- Occurs in Bulgeria, areas of Russia especially Crimea, Pakistan and in areas of West central and West Africa
- Transmitted by *Hylomma marginatum*, other species of *Hyalomma* and also *Amblyomma*, *Rhipicephalus* and *Boophilus* species
- The ticks occur on a variety of animals including birds which fly from Russia to Africa, Asia and Western Europe
- Transmission is by tick bite or crushing infected ticks, or accidental infection when shearing tick infested sheep
- There is transovarial transmission in ticks

3. Rickettsiae

Rocky Mountain spotted fever (RMSF)

- Disease also known as Mexican spotted fever, Sao Paulo spotted fever, American tick-borne typhus
- Causative organism is *Rickettsia rickettsii*
- *Dermacentor andersoni*, and *D. variabilis* are the vectors in North America
- Dogs, rabbits and small rodents also become infected
- Animals remain infectious only for a short time
- Ticks thus the main reservoir
- Incubation period in ticks is 9-12 days -infected tick becomes infective

- Transmission is normally through bite of any stage in the life cycle of the tick
- Infective tick must remain feeding on host for over 2 hours to inject sufficient *Reckettsia* to infect host
- There is transstadial and transovarial transmission in ticks

Siberian tick typhus (STT)

- Disease is similar to Rocky Mountain spotted fever
- Caused by *Reckettsia sibirica*
- Occurs in Russia, Pacific areas and the Japanese Islands
- Vectors include species of *Dermacentor*, *Haemaphysalis, Rhipicephalus* and *Hyalomma*.
- Infection by tick bite
- There is transstadial and transovarial transmission in ticks
- Mammals mainly rodents may serve as reservoirs

Boutonneuse fever

- Also known as Marseilles fever, South American tick typhus, Kenyan tick typhus, Indian tick typhus, etc.
- Caused by *Reckettsia conori*
- Symptoms in man similar to Rocky Mountain spotted fever
- Occurs in the Mediterranean region, Middle East, Crimean, India, Southern Asia and Africa
- Principal vector is *Rhipicephalus sanguineus*, the dog tick
- Most Ixodid ticks can transmit the pathogen
- Transmission is by tick bite
- There is transstadial and transovarial transmission in ticks
- Both ticks and rodents serve as reservoirs

4. Spirochaetes

Lyme disease:

- Caused by a spirochaete transmitted by *Ixodes dammini* in Eastern US mainly in deer
- In western US transmission is by *I. Pacificus*
- Symptoms include, arthritic pains in the joints
- Little is known of its epidemiology
- Disease is non-fatal
- There is transstadial and transovarial transmission in ticks

5. Tularaemia

- A bacterial disease caused by *pasteurella tularensis*
- Occurs in N. America, Europe, Japan and Asia
- Infects mainly rabbits, other rodents and even birds
- Spread by a variety of direct contact methods as handling infected animals, carcasses, drinking contaminated water eating raw meat
- Also transmission is by tick bite from various hard ticks

MITES

Class: ARACHNIDA - Tick, mites and spiders
Order: ACARINA - Order contains ticks and mites

There are 2 groups of medical importance

1. The *Sarcoptes* mites - (scabies mites)
2. Leptotrombidium mites - (Scrub typhus mites)

SCABIES MITES

- Belong to the species *Sarcoptes scabiei*
- Also referred to as itch mite
- Has World-wide distribution
- Occurs on man -commonly on skin especially on arms
- Common community problem in crowded areas

External morphology

- Female mite is just visible without the aid of a hand lens
- Measures 0.30 - 0.45mm
- Whitish in colour
- Disc-shaped
- Dorsally the mite is covered with numerous small peg-like protuberances and a few bristles
- Both dorsally and ventrally there are a series of lines across the body giving the mite a striated appearance
- Adults have 4 pairs of short cylindrical legs, divided in 5 apparent ring-like segments
- 1st 2 pairs of legs end up in short stalks called **pedicels** which terminate in thin-walled roundish structures often termed 'suckers'
- In females the posterior pair of legs do not have 'suckers' but end up in long very conspicuous bristles
- Adult males have the 'suckers' on the last pair of legs
- No distinct head
- Have short and fat palps and pincer-like chelicerae (mouth parts) protruding anterior from the body

Life cycle:

- Females burrow into the superficial layers of the skin and excavate winding tunnels at the rate of 1-5mm per day
- The mite feed of the liquid oozing from the dermal cells they have chewed
- Lay 1-3 egg a day in the tunnels

Eggs

- Egg hatch in 3-5days into small six-legged larvae
- Larvae look like miniature adults
- Larvae crawl out of the tunnels onto the surface of the skin
- Large number of the larvae die at the surface
- But a few manage to burrow into the skin or in hair follicle to form a **'moulting pocke**t'

- In 2-3 days the larvae moult in the pocket into eight legged nymphs

Nymphs

- Nymphs moult in the pocket into adults - male or female
- Females remain inactive in the moulting pocket until fertilized by a male
- After fertilization the mite enlarges in size to become a mature (ovigerous) female
- After fertilization the female commences to burrow through the skin
- After 3-5 days the new female starts to lay eggs in the tunnel
- Female mites rarely leave the tunnel
- Adult males spend most of their life wondering on the surface of the skin seeking females awaiting to be fertilized

- Life cycle from egg to adult takes about 11-28 days
- Females may live for1-2 months on man
- Away from man they live for 7-10 days in ideal conditions, but usually live for 2-4 days

Scabies

- Is a contagious complaint transmitted only by close contact
- Diagnosed by detection of the female mite's thin twisting tunnels
    - Tunnels easy to see on a light skinned person
    - Faeces deposited in the tunnels may be visible through the skin as pepper-like sports
- Mite can also be dissected from the tunnel and examined under x50 magnification
- An average of 11 female mites are found on a person
- Most patients have 1-15 female mite
- Only 3% may have more than 50 mites

The Scabies rash

- Is a follicula papular eruption that occurs on areas of the body not infected with burrowing mites
- Rash produced in response to the patient being sensitized
- It is an allergic reaction produced by mites

Treatment of scabies

- BB (Benzyl benzoate) emulsion 20-25% painted on patient's whole body from neck downwards
- 0.5% HCH (lindane) may also be used - one treatment usually enough

Prophylaxis

- Availability of plenty of water for washing

SCRUB TYPHUS MITES

- Are grouped within the Trombiculid mites
- There are more than 1200 species of trombiculid mites belonging to several genera

- Only a few species attack man
- Medically important species include:
    - *Leptotrombidium deliense*
    - *L. akamushi*
    - *L. fletcheri*
- These medically important species are found only in Asia

External morphology:

- Adults are small - 1.0-2.0mm
- Are reddish
- Covered dorsally and ventrally with numerous feathered hairs, giving them a velvety appearance
- Have four pairs of legs ending in paired claws
- Palps and mouth parts project in front of the body
- Nymphs resemble adults, but are smaller (0.5-1.0mm), and are less densely covered by leathered hairs
- Adults and nymphs do not bite man or animals
- Feed on small arthropods and their eggs
- Only larvae are parasitic on man and other animals
- The larvae responsible for the spread of diseases

The larvae;

- Are very small (0.15-0.3mm)
- But size may increase six fold when engorged
- Are usually reddish or orange in colour, but may be pale yellow to straw-coloured
- Have three pairs of legs terminating in a pair of claws
- Both legs and body covered with fine featured hairs
- Five-segmented palps and mouth parts are large and conspicuous- having appearance of a false head
- Dorsally on the anterior part of the body there is a rectangular or pentagonal-shaped scutum
- Scutum bears 3-6 setae
- On either side of the scutum there is a pair of eyes
- In medically important species there are 5 feathered setae on the scutum
- And in addition a pair of specialized feathered hairs known as the **sensillae** which arise from distinct bases

Life cycle

- Female mite lays 1-5 eggs each day, on the surface of damp soil or under leaves
- In hot climates overposition continues uninterrupted for a year
- In cold periods egg laying stops and adult hibernates
- After 5-7 days egg shell splits
- Larva does not emerge but remains within the egg shell and is called **deutovum**

The larvae

- After 5-7 days the larva crawls out of the egg shell, becomes very active, swam over the ground and climb on grasses and low lying vegetation and wait for host
- The larvae will attach to birds, mammals, including man walking through infested vegetation

- On the host, the mite larvae congregate in areas where the skin is soft and moist - such as the ears, genitalia and around the anus
- On man the larvae seek areas where cloth are tight against the skin -as around the waist and ankles
- The larvae pierce the host's skin with their powerful mouth parts and inject saliva into the wound which cause disintegration of the cells
- Larva normally does not suck blood, but the lymph and other fluid and semi-digested materials
- The larvae remain attached to the host for 2-10 days
- Engorged larvae drop to the ground and bury themselves just below the surface of the soil or underneath debris
- Concealed larva becomes quiescent and this stage is known as the **protonymph**
- After 7-10 days the protonymph moults to produce eight-legged reddish nymphs covered by feathered hairs
- The nymphs feed on soil-inhabiting arthropods
- After some days to 2 weeks the nymphs cease to feed and become inactive and are called **pre-adults**
- After 14 days pre-adults moult to give forth to adult mites

- The life cycle usually takes 2-3months but may be longer (8-10months)

Medical importance

1. **Nuisance**
   - Although some species of trombiculidae mite do not transmit disease to man their bite can cause intense itching and irritation commonly referred to as:
     - Harvest-bug itch
     - Autumnal itch
     - Scrub itch

   - Also if the mites are forcefully removed from skin, mouth parts remain and can promote further irritation

2. **Scrub typhus**

- Caused by *Rickettsia tsutsugamushi*
- Disease also known as **mite-borne typhus, Rural typhus, Japanese river fever or tsutsugamushi disease**
- Disease restricted to Asia where it occurs over a large area
- Disease was serious in troops in Asiatic-Pacific areas only second to malaria
- Disease has often been regarded as a zoonosis but experiments indicate that man is the most suitable host
- And the *Leptotrombidium* mites are the main reservoir
- Man becomes infected following the bite of infected larvae of *Leptotrombidium akamushi* and *L. deliense*.

- People get infected when they visit or work in areas infested by the mites - referred to as **'mite islands'** - patches of vegetation harboring large numbers of host seeking larvae of the mites
- Transovarial transmission occurs in the mites

INJURIOUS NON-PARASITIC ARTHROPODS

- Insect stings
  - Hymenoptera stings (Bees, wasps, and hornets)
- Scorpion stings
- Spider bites
- Centipede bites

Insect stings

- Result from Hymenoptera stings
- These include:-
  - Bees
  - Wasps
  - Yellow jackets
  - Hornets

  - Hymenoptera venoms may have direct toxic effects
  - But this is not seen in man unless in situations of many stings – usually hundreds
  - In Temperate countries, anaphylactic reactions to Hymenoptera stings are a commoner cause of death than direct effect of envenoming by any animal
    - E.g. in 1959 – 1972, 61 deaths occurred from insect stings in England and Wales, compared to only one resulting from adder bite

  - There are 40 – 50 deaths annually from Hymenoptera stings

  - In fact deaths due to Hymenoptera sting anaphylaxis are under reported – not commonly suspected as one of the causes of death in people found dead with indications of myocardial infarction or cerebrovascular accidents

  - Commonest and most severe Hymenoptera stings are caused by members of the families:-

    - Family Apidae within which there is species *Apis mellifera* – the honey bee

    - Family Vespidae, including

- wasps such as *Vespa vulgaris*
- American yellow jackets – genus *Dolichovespula*
- Hornets – genus *Vespa*

- The venoms are normally injected through a barbed sting
- Bees inject approximately 50µg of venom – total capacity of the venom sc and leave the sting embedded in the skin
- Wasps and hornets can sting repeatedly
- The venom contains
  - biogenic amines:-
    - Histamines
    - 5-hydroxytryptamine
    - Acetylcholine
- Enzymes
  - Phospholipase A
  - Hyaluronidase
- Toxic peptides
  - Kinins – in Vespidae
  - Apamin
  - Malittin
  - Anti-inflammatory compounds as mast cell degranulating peptides –in Apidae

Clinical features:-

In non-allergic people

- Venom produces local effects due to injection of biogenic amine mainly 5-hydroxytryptamine
- This is characterized by:-
  - Pain
  - Redness
  - Swelling
  - Whealing
  - Heat developed very rapidly but for just a few hours
- The local effects can be dangerous if airway is obstructed e.g. when the stings are on the tongue

- Fatal systemic stings can result from as few as 30 stings in children
- Adults have survived as more than 2000 stings of *Apis mellifera*
- Clinical effects of massive envenoming resemble histamine overdose and include:-
    - Vasodilation
    - Hypotension
    - Vomiting
    - Diarrhoea
    - Throbbing headache
    - Coma

Allergic effects

- Normally seen in 0.5% of the population who have become hyper sensitized with Hymenoptera venom
- Reactions to successive stings are increasingly severe
- Systemic symptoms include:-
    - Tingling scalp
    - Flushing
    - Dizziness
    - Wheezing
    - Abdominal colic
    - Diarrhoea
    - Tachycardia and visual disturbance developing within a few minutes of the sting
    - In the next 15 – 20 minutes the following symptoms may occur:-
        - Urticaria
        - Angioneurotic oedema
        - Oedema of the glottis
        - Profound hypotension
        - Coma
    - Patient may die within minutes

Treatment:-

- Remove embedded bee stings without squeezing
- Administer analgesic mainly aspirin
- Local antiseptics may be applied
- * topical anti-histamines should not be used as they promote sensitization
- In situations of severe systemic envenoming, life threatening effects of biogenic amines can be treated with adrenaline
- Adrenaline is also treatment of choice for sting anaphylaxis – given sub-cutaneously

SCORPION STINGS

- Scorpions fall in the Order Scorpionida
- Those capable of inflicting fatal stings to humans belong to the Family Buthidae
- The most deadly species include:-
    - *Androctonus australis* – N. Africa and Middle East
    - *A. crassicauda* – in N. Africa, Mid. East and Turkey
    - *Buthus accitanus* – Mediterranean region and Mid. East
    - *Leiurus quinquestriatus* –
    - *Parabuthus* – South Africa
    - *Tityus trinitatis* – Trinidad and Venezuela
    - *Bathotus tamulus* – India
    - *Centruroides sculturatus* – California, New Mexico, Arizona

- Painful scorpion stings are common throughout the tropics
- Fatal envenoming stings are common only in Mexico, Brazil, Trinidad, parts of North Africa, Middle East and India
    - In Libya there were 900 scorpion stings with 7 deaths per 100,000 population in 1979
    - In Mexico there are 1 – 2000 deaths per year from scorpion stings – incidence of 84 deaths per 100,000 annually
    - In Algeria there some 1260 stings with 24 deaths per year

Clinical features:-

- Very intense local pain
- Local swelling
- Redness
- Heat
- Systemic symptoms may develop within minutes of the sting, but may be delayed for 24 hours and will include:-
    - Autonomic nervous system excitation including
        - Dilated pupils
        - Hyper salivation
        - Profuse sweating
        - Hyperthermia
        - Abdominal distension
        - Lose of sphincter control
        - Hypertension
        - Toxic myocarditis
        - Cardiac failure
        - Pulmonary oedema

    - Neurotoxin effects as:
        - Fasciculation
        - Spasms

- Respiratory paralysis

Treatment

- Parenteral opiate analgesics such as pethidine and morphine may be required
  - But are alleged to be dangerous in victims of *Centruroides sculpturutus*

- Systemic envenoming should be treated with specific anti-venom given intravenous injection as in snake bite treatment – Anti-venoms are manufactured in many countries as USA, Britain, Germanys, Mexico, Turkey, Algeria, S. Africa, Egypt and Iran

  - But no antivenom is available for treatment of *Buthotus tamulus* stings in India

SPIDER BITES

- Spiders belong to the Family Araneae
- Family contains a large group of spiders in over 30,000 species
- Only 1% of these is non-venomous
- Only 12% of species of spiders are known to cause dangerous envenoming in humans
- The spiders bite with a pair of fangs – the chelicerae, to which the venom glands are connected
- A central venom duct opens near the tip of the fangs

Clinical features:-

- Two main clinical features syndromes are caused by spider bite
  - Necrotic
  - Neurotoxic

Necrotic araneism

- Characterized by skin lesions
- Vary in severity from mild localized erythema and blistering to quite extensive tissue necrosis
- Range of severity attributed to variety of species of spiders
- Members of the genus *Loxosceles* are the most important cause of the syndrome
- *L. laeta* is widely distributed in Central and South America especially in Chile
- *L. reclusa* – the brown recluse spider is distributed in USA
  - Has caused at least 200 bites with 6 deaths

- *L. rusfescens* – occurs in the Mediterranean region N. Africa and Israel
- 80% of patients are bitten indoors usually in their bedrooms while asleep or dressing
- In the US, a number of men were bitten on their genitals when they sat on the outdoor lavatories on which the spider had spun their webs

Clinical presentation:-

- Spider bite is characterized by a burning pain at the site of bite
- Oedema and development of a violaceous plaque follows
- In a few days the plaque becomes a black eschar which sloughs in a few weeks
- In 12% of cases there are systemic effects involving:-
    - Heamoglobinuria
    - Jaundice
    - Fever
    - Respiratory distress
    - Collapse
- Average mortality is 6% in all reported cases, and 30% in those with systemic envenoming

Neurotoxic araneism

- Neurotoxic venoming results from bites by spiders in the *Latrodectus*, containing:-
    - Widow spiders
    - Hourglass spiders
    - Red-black spiders

- These are the most widespread and numerous of all venomous animals dangerous to man
- *L. mactans* – the black widow spider,
    - Occurs in Americus
    - 63 deaths were attributed to this species in the US in 1950 – 1959

- *L. mactans tredecimguttatus* – incorrectly referred to 'tarantula' is widely spread in the Mediterranean countries
    - Live in fields
    - Has been responsible for epidemics of spider bites
    - 946 cases were reported in Italy in 1946 – 1951

- *L. mectans hasselti* – Australian and New Zealand 'red-black spider or 'kitopo'
    - Cause upto 340 reported bites each year in Australia
    - 20 deaths have been attributed to such bites

Clinical presentation of the spider bites

- *L. m. hasselti bites*
    - Local heat
    - Sweating and redness which is rarely extensive
    - Intensive local pain which develops in about 5 minutes
    - Pain in the local lymph nodes after 30 minutes
    - Headache, nausea, vomiting and sweating occurring after one hour
    - Tachycardia and hypertension may follow

- Muscular tremors and spasms occur which may be severe enough to require artificial ventilation

- *L. m. mactans* bites
  - Local dull aching or numbness may develop in 30 – 40 minutes
  - Painful muscular spasms and lympadenopathy spread and increase in intensity during the next few hours
  - The trunk of abdomen and limbs get involved
  - Respiration may be inhibited

Treatment

- **First aid** may be needed for spider bites with rapidly active potent venom such as *A. robustus*.
  - Firm crepe bandaging or splinting of bitten limbs, or tight tourniquet may delay venom spread until patient reaches hospital

- **Specific treatment**
  - Treatment mainly based on use of anti-venoms
  - Specific antivenoms are manufactured in a number of countries including Australia, USA, USSR, Italy, Yugoslavia and South Africa