Ministry of Higher
Education and Scientific Research
University of Baghdad
College of Science
Department of Biology

Medical Entomology

Master of science / Zoology

الحشرات الطبية

ماجستير / علم الحيوان

Prof. Dr. Hayder Badri Ali
أ.د. حيدر بدري علي

Medical Entomology introduction Lecture 1

Entomology is the science that studies insects and arthropods. In the case of medical entomology, it specifically refers to those insects and arthropods that affect human beings and may produce human disease. This complex science comprises the biomedical study of insects and arthropods and their morphology, biology, and systematics.

In addition, this field analyzes the epidemiology, prevention, and methods of control of the infections and infestations vectorized and caused by these organisms, but also the insect behavior and life history and those aspects related to relationships between vectors and hosts. Today, the medical entomology as a discipline is closely related to different biomedical sciences such as tropical medicine, medical parasitology, medical virology, public health, and epidemiology, among others.

Insects and arthropods can cause direct physical affection to humans (e.g., biting, in this case this includes the so-called external parasites or ectoparasites) as well as being vector of infectious diseases agents (in mechanical and particularly biological vectorizing, e.g., malaria, dengue).

New concepts of medical entomology have been recently proposed, according to which this discipline should comprehensively study the effects of insects and arthropods on human health and possible control of these effects. Then, the tasks of medical entomology are markedly widened to embrace cognitively and practically important problems, which have been neglected.

The study of entomology comprises the phylum *Arthropoda* which comprises the following important classes: *Pentastomida, Arachnida* (scorpions, spiders), *Crustacea* (crabs, crayfish, copepods), *Chilopoda, Diplopoda,* and *Insecta* (insects). Most types of zoological (more than 90 percent of all known species) belongs to this phylum, distinguished by the presence of an exoskeleton.

The most medically important of those classes is the *Insecta*. The class *Insecta* comprises various groups of arthropods, grouped in orders. The most important orders are *Diptera* (e.g., mosquitoes, such *Anopheles, Aedes, Culex*), *Hemiptera* (e.g., bugs, such as triatomines), *Suctoria* (fleas), and *Anoplura* (louse). Other orders included in this class are *Coleoptera*, *Blattaria* (cockroaches), *Lepidoptera* (butterflies), and *Hymenoptera* (ants, wasps and bees).

Genus and species belonging to this class are responsible of vectorize many diseases (vectors), such as malaria, dengue, yellow fever, trypanosomiasis, and viral encephalitis, among others. This represents that those diseases transmitted by these arthropods (so-called arthropod-borne diseases) has a high burden on morbidity and mortality worldwide, particularly in developing and tropical countries. Many epidemiological factors are involved in the figures that those diseases represent year after year, and recently the integration of those factors with ecological ones has emerged in a new science that should support the study of medical entomology, the ecoepidemiology. The tools and approaches offered from this discipline to medical entomology and tropical medicine, as well to public health in affected countries, is related to additional objectives such as prevention, prediction, and forecast of vector-borne diseases.

In the class *Arachnida* is located the Subclass *Acari* and its order *Acarina* (ticks and mites), whose genus and species members are responsible for diseases such as scabies, allergic processes, dermatoses, borreliosis, and ricketsiosis, among others. A summary of the most important pathogens and diseases transmitted by insects is shown in Table below.

Table(1) Insects' Vectors of Medical Importance and Method of Human Exposure

Arthropod Vector	**Disease**	**Disease Agent**	**Method of Human Exposure**
Arachnida			
Mite: *Leptotrombidium sp.* (red mites)	Scrub Typhus (Tsutsugamushi disease)	*Rickettsia tsutsugamushi* (bacteria, intracellular)	Bite of larval mite
Mite: *Liponyssiodes sanguineus* (mouse mite)	Rickettsial pox	*Rickettsia akari* (bacteria)	Bite of mite
Tick: *Dermacentor* sp.	Tularemia	*Francisella tularensis* (Gram negative bacteria)	Bite of tick
Tick: *Dermacentor* sp. and other Ixodid ticks	Rocky Mountain Spotted Fever	*Rickettsia rickettsia* (bacteria)	Bite of tick
Tick: *Ornithodoros sp.*	Endemic Relapsing Fever	*Borrelia sp.* (bacteria, spiral shaped)	Bite of tick

Tick: *Ixodes* sp.	Babesiosis	*Babesia microti* (parasite, protozoan)	Bite of tick
Tick: *Ixodes* sp.	Lyme disease	*Borrelia burgdorferi* (bacteria, spiral shape)	Bite of tick
Tick: *Dermacentor variabilis, Amyblyomma americanum*	Ehrlichiosis, Sennetsu fever	*Ehrlichia canis* *E. sennetsu* *E. chaffeensis* *E. equi* *E. phagocytophilia* (bacteria, intracellular)	Bite of tick
Tick: *Dermacentor* sp.	Colorado Tick Fever	CTF virus, Eyach virus, or strain S6-14-03 (Reoviridae)	Bite of tick
Tick: *Amyblyomma americanum*	**No name for disease yet; only two reported cases**; fever, fatigue, diarrhea, thrombocytopenia, and leukopenia	Heartland Virus; a phlebovirus	Bite of tick
Tick:	Russian Spring-Summer Encephalitis, Louping Ill Encephalitis, Langat Encephalitis, Powassan Encephalitis, Omsk hemorrhagic fever	Russian Spring-Summer Encephalitis, Louping Ill Encephalitis, Langat virus, Powassan virus, Omsk hemorrhagic fever virus (Flaviviridae)	Bite of tick
Tick:	Nairobi Sheep fever, Crimean hemorrhagic fever	Nairobi sheep disease virus, Crimean-Congo hemorrhagic fever virus (Bunyaviridae)	Bite of tick
Tick	Severe Fever with Thrombocytopenia Syndrome (China)	Severe Fever with Thrombocytopenia Syndrome Virus (SFTSV; Phlebovirus)	Bite of tick
Crustacea			
Copepod: *Cyclops* sp.	Diphyllobothriasis, fish tapeworm	*Diphyllobothrium latum* (parasite, cestode, tapeworm)	Arthropod is 1st intermediate host then man swallows infected fish
Copepod: *Cyclops* sp.	Sparganosis	*Diphyllobothrium spirometra* (parasite, cestode, tapeworm)	Man swallows infected *Cyclops.*
Copepod: *Cyclops* sp.	Dracunculosis	*Dracunculus medinensis*	Man swallows infected *Cyclops.*
Crabs, crayfish: various freshwater species	Paragonimiasis	*Paragonimus westermani*	Man eats infected crustacean.

Insecta			
Lice: *Pediculus humanus*	Epidemic typhus	*Rickettsia prowazekii* (bacteria)	"Bite," contaminated by louse feces or crushing louse on skin
Lice: *Pediculus humanus*	Trench fever, bacillary angiomatosis, bacillary peliosis	*Bartonella quintana* (Gram negative bacteria)	"Bite," contaminated by louse feces or crushing louse on skin
Lice: *Pediculus humanus*	Louse-borne relapsing fever or epidemic relapsing fever	*Borrelia recurrentis* (bacteria; spiral shape)	"Bite," contaminated by louse feces or crushing louse on skin
Flea: *Xenopsylla cheopis*, and various other rodent fleas	Plague	*Yersina pestis* (Gram negative rod shaped bacteria)	"Bite" and feces of flea
Flea: *Xenopsylla cheopis*	Murine typhus	*Rickettsia typhi* (bacteria)	"Bite" and feces of flea
Flea: *Xenopsylla cheopis*, and various other rodent fleas	Rat tapeworm infection	*Hymenolepsis diminuta* (parasite; cestode; tapeworm)	Swallowing infected flea
Flea: various species	Dog tapeworm infection, Dipylidiasis	*Diphylidium caninum* (parasite; cestode; tapeworm)	Swallowing infected flea
Bug: *Triatoma* species, *Panstrongylus* sps (Kissing assassin bug, Reduvid bug)	Chaga's disease	*Trypanosoma cruzi* (parasite; protozoan)	Rubbing infected feces on mucous membranes or skin
Beetles: flour beetle	Hymenolepsis	*Hymenolepsis nana* (parasite; tapeworm; cestode)	Swallowing infected beetle
Fly, gnat: *Glossina* sp. (tsetse fly)	African trypanosomiasis, African sleeping sickness	*Trypanosoma brucei rhodesiense and T.b. gambiense*	Bite of infected fly
Fly, gnat: *Simulium* sp. (black fly)	Onchocerciasis, River blindness	*Onchocerca volvulus* (parasite; round worm; nematode)	Bite of infected fly
Fly, gnat: *Chrysops* sp.	Tularemia	*Francisella tularensis* (Gram negative rod shaped bacteria)	Bite of infected fly
Fly, gnat: *Phlebotomus* sp., *Lutzomyia* sp. (sandflies)	Leishmaniasis	*Leishmania* donovani (Visceral, dumdum fever, kala-azar), *L. tropica* (cutaneous; oriental sore, Delphi boil), *L. braziliensis* (mucocutaneous; espundia, american leishmaniasis, (parasite; protozoan)	Bite of infected fly

Fly, gnat: *Phlebotomus* sp. (sandfly in Peru, Ecuador and Columbia)	Bartonellosis, Oroya fever, Carrion's disease	*Bartonella bacilliformis* (Gram negative bacteria)	Bite of infected fly
Fly, gnat: *Chrysops* sp. (mango flies)	Loaiasis, Eye worm	*Loa loa* (parasite; nematode; roundworm)	Bite of infected fly
Fly, gnat: sandfly	Sandfly fever, Rift Valley fever	Sandfly fever Naples virus, Sandfly fever Sicilian virus, Rift valley fever virus(Bunyaviridae)	Bite of infected fly
Mosquito: *Anopheles* sp.	Malaria	*Plasmodium falciparum, P. malariae, P. vivax, P. ovale* (parasite; protozoan)	Bite of infected mosquito
Mosquito: various species	Bancroftian filariasis, filarial Elephantiasis	*Wuchereria bancrofti* (parasite; nematode; roundworm)	Bite of infected mosquito
Mosquito: various species	Malayan filariasis, filarial Elephantiasis	*Brugia malayi* (parasite; nematode; roundworm)	Bite of infected mosquito
Mosquito: various species	Dirofilariasis	*Dirofilaria immitis* (parasite; nematode; roundworm)	Bite of infected mosquito
Mosquito: *Aedes aegypti*	Yellow fever	Yellow fever virus (Flaviviridae)	Bite of infected mosquito
Mosquito: *Aedes* sp.	Dengue fever, Break Bone fever	Dengue fever virus (Flaviviridae)	Bite of infected mosquito
Mosquito: *Culiseta melanura, Coquillettidia pertubans, Aedes vexans*	Eastern Equine encephalitis	Eastern Equine Encephalitis virus (Togaviridae)	Bite of infected mosquito
Mosquito: *Aedes triseriatus*	La Crosse encephalitis	La Crosse Encephalitis virus (Bunyaviridae)	Bite of infected mosquito
Mosquito: *Culex* sp.	St. Louis encephalitis	St. Louis Encephalitis virus (Flaviviridae)	Bite of infected mosquito
Mosquito: *Culex* sp., *Culex tarsalis*	Venezualan equine encephalitis, Western equine encephalitis	Venezualan Equine Encephalitis virus, Western Equine Enchephalitis virus (Togaviridae)	Bite of infected mosquito
Mosquito	Chikungunya forest fever	Chikungunya virus, Mayaro fever, Mucambo fever, O'Nyong-Nyong fever, Pixuna fever, Ross River fever (Togaviridae)	"
Mosquito	fevers and encephalitis	Nile fever, Japanese encephalitis virus, West Nile fever, Zika fever, Wesselsbron fever, Kyasanur forest disease virus (Flaviviridae)	"

Mosquito	fevers and encephalitis	Oropouche virus, Bunyamwera, Bwamba fever, Guama fever, Oropouche fever, California Enchephalitis virus (Bunyaviridae)	"
Mosquito	fevers	Chandipura fever, Piry fever (Rhabdoviridae)	"
Mosquito (*Aedes aegypti and A. albopictus*)	fever, rash, joint pain, and conjunctivitis (red eyes), infection during pregnancy can cause a serious birth defect called microcephaly, as well as other severe fetal brain defects.	Zika virus (Flaviviridae)	"

Until today, most surveillance studies about insects and arthropod remain with the classical taxonomical identification as the first primary tool for the classification of collected samples, but the recent biotechnological revolution in molecular biology has also impacted the entomology leading to a new discipline, the molecular entomology. This discipline explores new promising tools for the control of vector-borne diseases through genetic manipulation of vectorial competence.

The gene transfer technology is hoped to make the pathogens vectors incapable of supporting the development of the parasite or viruses which will ultimately lead to eradication of the etiological agents and the diseases. One particular area that is under study is the development of transgenic mosquitoes with the objective to avoid the transmission of diseases such as malaria. The first significant advance in this way is the current availability of the genome sequencing of *Anopheles gambie*.

Other new discipline in relation to entomology has been the forensic science, which has taken advantage from the fact that necrophagous insects are important in the

decomposition of cadavers. The close association between insects and corpses and the use of insects in medicocriminal investigations is the subject of this new discipline, called **Forensic Entomology**. Using medical techniques, time since death can only be accurately measured for the first two or three days after death. In contrast, by calculating the age of immature insect stages feeding on a corpse and analyzing the necrophagous species present, postmortem intervals from the first day to several weeks can be estimated. Other uses of entomological data include the toxicological examination of necrophagous larvae from a corpse to identify and estimate drugs and toxicants ingested by the person when alive and the proof of possible postmortem manipulations.

In the class Crustacea (e.g., crabs), some members could be involved as intermediary hosts in the transmission of some diseases, such as paragonimiasis, a disease caused by a trematode called *Paragonimus*.

Medical Entomology Lecture 2

Arthropods of medical importance

Arthropods are small invertebrate animals with jointed legs. Instead of having an internal skeleton made of bone, they have an external shell-like skeleton made of a tough, rigid material called chitin. Their body parts and appendage segments are joined by flexible membranes, which allow the various parts to move.

The majority of arthropods are not harmful to humans. However, a number of species are considered medically important because they can cause annoyance, physical discomfort, or disease in humans. These arthropods can be put into four main categories:

- **Harmful** cause nuisance, discomfort, and/or blood-loss by their bites (mosquitos, bugs, fleas); or cause nuisance by their mere presence (gnats).
- **Ectoparasites** live and feed permanently on the exterior of the host without transmitting germs (head lice, pubic lice, scabies mites).
- **Mechanical transporters** transmit disease passively, by picking up infections from faeces, and then contaminating human food so that disease is contracted orally (flies, cockroaches).
- **Vectors** actively transmit parasitic disease-causing organisms. The pathogen develops and multiplies in the vector, and is transmitted to humans via the arthropod's bite or excreta (mosquitos, tsetse-flies, body lice, fleas).

Insects can be easily distinguished from arachnids in the following ways:

INSECTS	ARACHNIDS
3 distinct body regions (head, thorax, and abdomen)	2 distinct body regions (cephalothorax, and abdomen)
3 pairs of legs	4 pairs of legs (except larval mites, which have 3 pairs)
often have wings	never have wings
1 pair of antennae	no antennae
segmented abdomen	abdomen usually not segmented

The change in form during an insect's development is called metamorphosis. Insects which undergo complete metamorphosis (example: flies) have four stages of development: egg, larva, pupa, and adult. Insects which undergo incomplete metamorphosis (example: bugs) have three stages of development: egg, nymph, and adult. The nymph looks very much like the adult, but is smaller, its size being roughly proportional to its age.

Vector-borne Exposure

Vector-borne exposure occurs when an insect acquires a pathogen from one animal and transmits it to another. Diseases can be transmitted by vectors either mechanically or biologically. Mechanical transmission means that the disease agent does not replicate or develop in/on the vector; it is simply transported by the vector from one animal to another (flies). Biological transmission occurs when the vector uptakes the agent, usually through a blood meal from an infected animal, replicates and/or develops it, and then regurgitates the pathogen onto or injects it into a susceptible animal. Fleas, ticks, and mosquitoes are common biological vectors of disease.

Mechanical disease transmission:

Disease agents are carried from one host to another by arthropods simply mechanically carried by the body parts (example wings, hairs, feces, vomitus, etc). In this type of

disease transmission no change takes place in the number, form or developmental stages of the organism, but simply deposited in the body, food or drink of the host.

Biological disease transmission:

The agent will exhibit changes in form and or number of developmental stages in the arthropod before entry to the host. This includes hereditary (transovarian) and transital transmissions: Propagative, cyclodevelopmental and cyclopropagative.

• Propagative:

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

• Cyclo-developmental:

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

• Cyclo-propagative:

This type of disease transmission is a combination of both propagative and cyclo-developmental; whereby the disease pathogen undertakes a change both in number and developmental form (stage). Example Malaria.

• Trans ovarian/ Trans-stadial transmission:

It is a type of disease transmission, whereas the causative agent is transmitted to the immature stage (usually to the egg) from the adult insects and / or other arthropods which carry disease pathogens.

When the infected egg completes its developmental stage; it becomes infective or can transmit the disease to man and other animals. Ticks and sand flies are very good examples of arthropods that exhibit hereditary disease transmission.

A vector is a living organism that transmits an infectious agent from an infected animal to a human or another animal. Vectors are frequently arthropods, such as mosquitoes, ticks, flies, fleas and lice.

Vectors can transmit infectious diseases either actively or passively:

- Biological vectors, such as mosquitoes and ticks may carry pathogens that can multiply within their bodies and be delivered to new hosts, usually by biting.
- Mechanical vectors, such as flies can pick up infectious agents on the outside of their bodies and transmit them through physical contact.

Diseases transmitted by vectors are called vector-borne diseases. Many vector-borne diseases are zoonotic diseases, i.e. diseases that can be transmitted directly or indirectly between animals and humans. These include for example Lyme disease, tick-borne encephalitis, West Nile virus, Leishmaniosis and Crimean-Congo haemorrhagic fever.

Many vector-borne diseases are considered as emerging infectious diseases:

- a disease that appears in a population for the first time, or
- that may have existed previously but is rapidly increasing in incidence or geographic range.

Some vectors are able to move considerable distances. This may affect the transmission ranges of vector-borne zoonotic diseases.

Vectors can be introduced to new geographic areas for example by:

- travel of humans and international trade;
- animal movement, for instance of livestock;
- migratory birds;
- changing agricultural practices;
- or the wind.

Medical Entomology **Lecture 3**

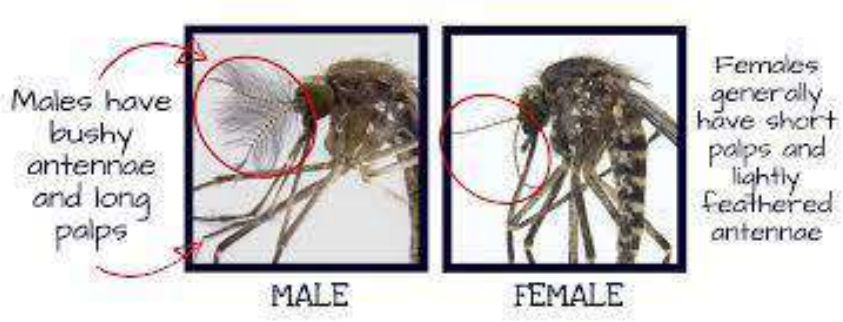
Mosquito-borne diseases

There are over 3000 species of mosquitoes in the world which are distributed from the tropics to the altitude of 4300 meters. They are also found 1160 meters below the sea level in the gold mines in south India. They are virtually distributed everywhere except in Iceland and poles.

Identification characters

Order: Diptera
Suborder: Nematocera (Long antenna)
Family: Culicidae (Mosquitoes)

Males of all species have rudimentary maxillae and mandibles so that they cannot suck blood but can suck fluids and nectar from flowers. They also possess very bushy whorl plumose antennae and tip of abdomen with characteristic male genitalia. On the other hand females have short hairs on the antennae (pilose antennae) and needle-like maxillae and mandibles for piercing the skin of host for sucking blood. Other characteristics are given below according to the species.

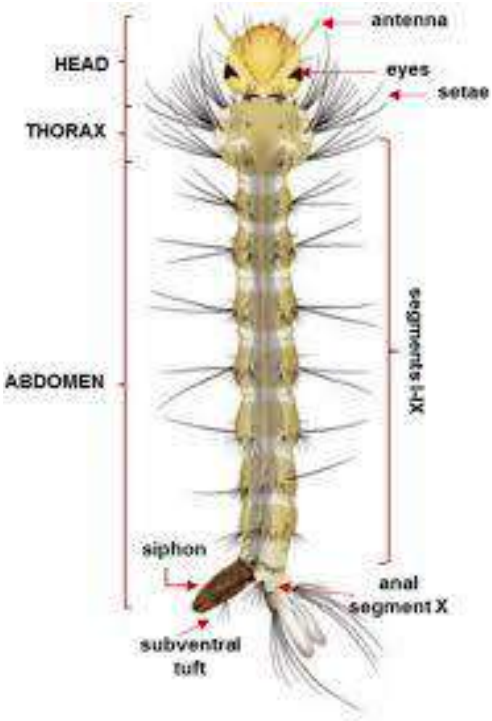


Life Cycle

Eggs are laid on the surface of water and have some device to keep them afloat for oxygenation. Blood meal is essential for the development of ovaries and maturation of ova and hence female sucks blood. Incubation period in all species is about 2 days.

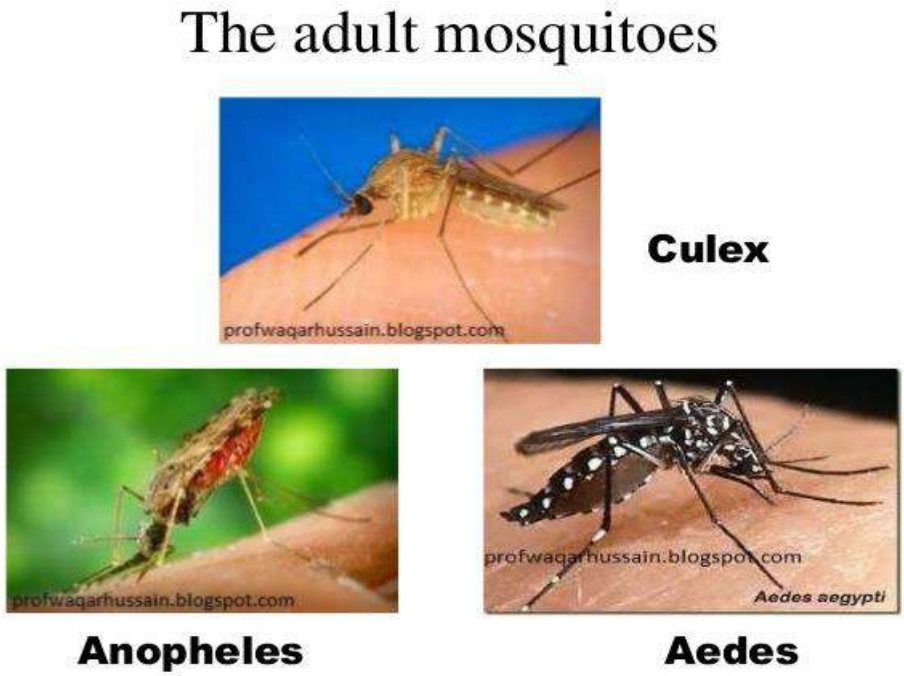
Larva has head, thorax and a long abdomen. Thorax is the bulkiest part of the body. There are paired eyes, antennae and feeding brush that drives a current of water along

with food particles towards the mouth. Abdomen is 10-segmented, 8-9 segments are fused to form a complex spiracular apparatus or respiratory apparatus. Anal gills are located on the tenth segment. Respiratory siphon is located on the 9th segment and internally divided by a septum into two chambers. Thorax and abdomen have long hairs on the lateral sides. There are 4 larval instars and larval period ranges between 6 and 8 days.



Pupa is comma shaped, having cephalothorax and abdomen. Cephalothorax has a pair of respiratory tubes called respiratory trumpets and a pair of eyes. Abdomen is 8 segmented and has caudal paddles and hairs at the tip. Pupa does not feed but moves about actively. Pupal period is two days. During adult emergence, the cephalothorax of

pupa breaks on the outer surface and imago comes out, sits on the pupal case for sometime to dry up its wings and then flies away. Total life cycle takes 10-12 days.



Culex pipiens. It is dull whitish mosquito having unspotted wings and makes humming sound when flying. There are overlapping scales and six transverse whitish bands on the abdomen. Scutellum in dorsal view looks trilobed and each lobe has a bunch of long hairs. Thorax has no markings on the dorsal side. Maxillary palps of female are short, 3-5 segmented, while in male they are long and equal to or longer than proboscis. While resting it sits parallel to the ground. There are about 240 species in India out of which 4-5 are vectors of diseases. It breeds in cesspools, drains, disused wells and stagnated water. Polluted water is preferred for breeding. (other *Cx. quinquefasciatus* Say, 1823)

Eggs are long cigar-shaped, whitish in colour and deposited on the surface of water in a raft of 50-100 eggs, which help the eggs to float. Egg incubation period is 2 days**.** **Larva** is aquatic, with head, thorax and 10-segmented abdomen and bunches of long hairs on the thorax and abdomen. Respiratory siphon on the 9th abdominal segment is long and narrow and is thrust out of water for air breathing, while the body hangs at an angle of about 45 degrees.

Head bears a pair of eyes, antennae, maxillary palps and feeding brush. There are long bunches of hairs and anal gills on the tip of abdomen but the gills are inadequate respiratory organs. Larva is also called *wriggler*. There are 4 larval instars with a total larval period of 6-8 days. **Pupa** is coma-shaped, with long and narrow respiratory trumpets on the cephalothorax. Abdomen is curved with caudal paddles on the last segment for swimming. It does not feed but swims actively. Pupa is also called *tumbler*. Pupal period is two days and pupa comes to the surface before adult emergence.

Aedes egypti: This is called zebra mosquito as it has black and white bands on the abdomen and legs. It belongs to the same subfamily as *Culex* and hence has structural similarities with it. Thorax is black with a pair of sickle like white markings on the dorsal side. Scutellum is trilobed with three bunches of long hairs on the posterior margin. Maxillary palps of female are small but those of male equal to proboscis or longer.

The species breeds in tree holes, broken containers, flower pot, puddles, coolers and other small water collections. **Eggs** are laid singly on water surface. They are blackish with small pits on the surface which help them to float on water. They hatch in two days. Eggs can also be laid in moist soil where they can remain dormant for months. **Larva** is also black in colour and has a short and barrel shaped spiracle. It is a bottom feeder and has structural similarities with *Culex* larvae.

Pupa is deep coma shaped, black with white markings and having three abdominal segments attached to cephalothorax. Respiratory trumpet is funnel-shaped, narrow at base and gradually broadening at the apex. Pupal period is only two days.

***Anopheles* spp.:** There are 44 species out of which six species are known vectors of malaria in India.

Adults are dull whitish in colour having wings with blackish spots and dark veins. They make no noise while flying. There may be scattered scales on the abdomen. Thorax without any markings on the dorsal side and scutellum not lobed and has uniformly distributed hairs on its posterior margin. Maxillary palps in both sexes are

equal to proboscis but in male they are clubbed at the tip. Adult in resting position makes an angle of 45 degrees against the surface.

Eggs are laid singly on the surface of water. They possess a pair of floats which prevent them from drowning. **Larva** rests parallel to the water surface and has palmate hairs on the sides of abdomen for that. Respiratory siphons are absent and there are a pair of respiratory openings instead. Larval period is about a week.

Pupa is deep coma shaped in which 5 abdominal segments are attached to cephalothorax. Abdomen is 8 segmented. Respiratory trumpet wine-glass shaped, with a stalk and parallel-sided body. Adults emerge in 2-3 days.

MOSQUITO CONTROL

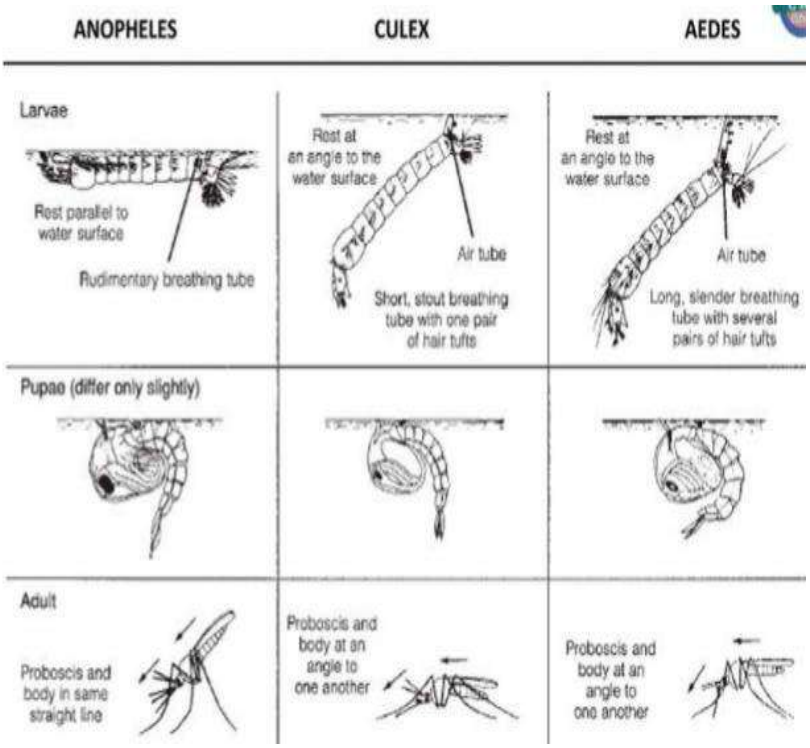
Mosquito control efforts have not been successful because of the ability of mosquitoes to develop resistance against insecticides very quickly and their capacity to inhabit a variety of environmental conditions. The following measures are generally adopted to reduce mosquito populations.

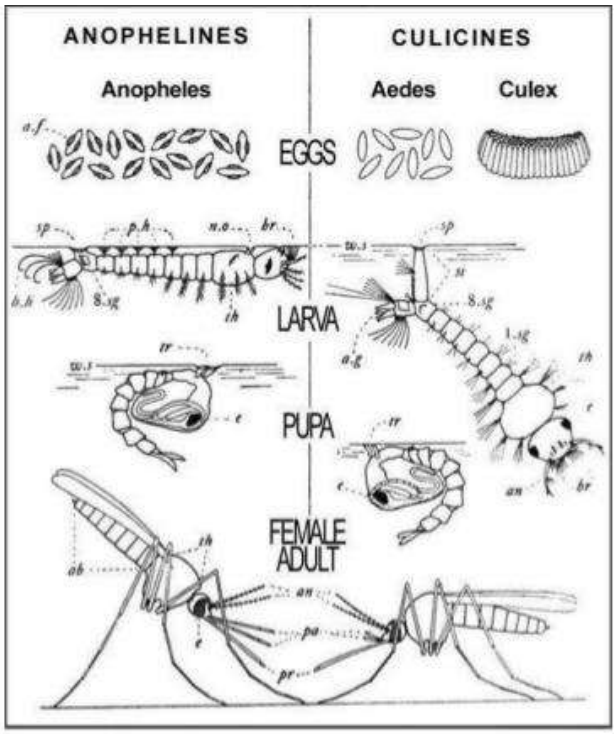
	Genus *Anopheles*	**Genus *Aedes***	**Genus *Culex***
Habitat	• *Anopheles* mosquito larvae are found in a wide variety of habitats. Many species of *Anopheles* prefer open-water pools with little vegetation, but others have adapted to different habitats.	***Aedes aegypti*** and ***Aedes albopictus*** are container breeding mosquitoes. They lay eggs in artificial containers that contain water. The females lay the eggs just above the water level. When the water level rises, it moistens the eggs, and they then begin to develop. *Aedes aegypti* strongly prefer artificial containers. *Aedes albopictus* will use both artificial and natural containers.	*Culex* mosquitoes breed in • stagnant water: places such as rainwater barrels, drainage systems, septic tanks, and containers (tires, buckets and rain barrels). • open habitats: surface water habitats that become stagnant and enriched with organic matter (swamps, marshes, bogs, rice fields, pastures).
Egg lay	*Anopheles* species lay individual eggs, supported by floats, on the water surface or on moist soil immediately	Other *Aedes* mosquitoes breed in floodplains after rain events, in irrigation ditches, in woodland	They prefer to lay eggs in rainwater barrels, storm drains, septic tanks. • Eggs are laid in rafts that

	adjacent to fluctuating water bodies.	pools, brackish swamps and salt marshes.	float on the water surface 14
	Malaria is a disease caused by parasites that are transmitted to humans by the *Anopheles* mosquito. Malaria causes more deaths per year than any other mosquito-transmitted disease. • The female *Anopheles* requires a blood meal to produce her eggs. • When female mosquitoes bite an infected person the parasite is transmitted to the mosquito. The parasite enters the mosquito gut and eventually moves to her salivary glands. The mosquito injects the parasite along with her saliva at a subsequent feeding. • Not all *Anopheles* mosquitoes transmit malaria.	*Aedes aegypti* and *Aedes albopictus* are species that potentially transmit pathogens to humans that can cause the following diseases: • Yellow fever • Dengue fever • Zika virus • Chikungunya • Lymphatic filariasis	Some species of the genus *Culex* carry viruses or other pathogens. A number of viruses are transmitted by the mosquito to animals and livestock. There are also some viruses that can be transmitted to humans. Diseases include a number of encephalitis viruses that are found around the world, as well as West Nile virus. Some species of *Culex* can also transmit filarial worms- a type of nematode. Adult female mosquitoes acquire the worm larvae. The larvae mature and migrate to the proboscis of the mosquito; they enter the bite puncture or the intact skin of a person bitten by the mosquito. Filariasis causes swelling in the lymph glands in humans.

Diseases transmitted by mosquito's species.

Vector	Disease caused	Type of pathogen
Aedes	Chikungunya Dengue Lymphatic filariasis Rift Valley fever Yellow Fever Zika	Virus Virus Parasite Virus Virus Virus
Anopheles	Lymphatic filariasis Malaria	Parasite Parasite
Culex	Japanese encephalitis Lymphatic filariasis West Nile fever	Virus Parasite Virus





Difference between major mosquitos – species (*Anopheles, Culex* and *Aedes*)

Medical Entomology **Lecture 4**

2) Black flies (Simuliidae)

Black flies belong to the family Simuliidae and have a worldwide distribution.
There are more than 2000 species in 25 genera. However, only three genera, *Simulium*, *Prosimulium* and *Austrosimulium*, contain species that commonly bite people.
Medically, *Simulium* is by far the most important genus as it contains many vectors. In Africa, species in the *S. damnosum* complex and the *S. neavei* group, and in Central and South America, species in the *S. ochraceum, S. metallicum* and *S. exiguum* complexes, transmit the parasitic nematode *Onchocerca volvulus*, which causes human onchocerciasis (river blindness). In Brazil, *S. amazonicum* transmits *Mansonella ozzardi*, a filarial parasite that is usually regarded as non-pathogenic. The Simuliidae are commonly known as black flies, but in some areas, especially Australia, they may be called sand flies, this latter terminology is confusing and best avoided because biting flies in the family Ceratopogonidae are sometimes also called sand flies, while flies in the subfamily Phlebotominae are regarded as the true sand flies.

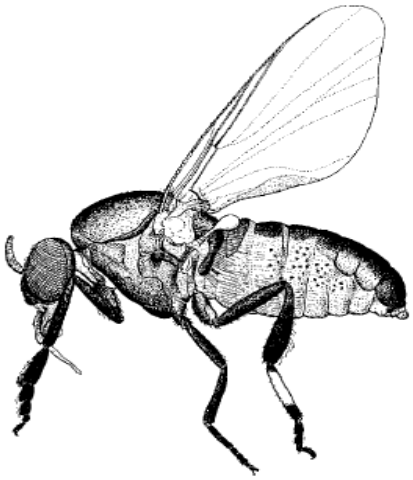


Figure 1 Adult simuliid black fly (*Simulium damnosum*) in lateral view.

3) Psychodidae family: (Phlebotomine Sand Flies and Moth Flies):

The Psychodidae are considered to be the most ancient of dipteran families, with fossils dating back to the late Jurassic or possibly early Triassic period, Of the six subfamilies, the Psychodinae and Phlebotominae are by far the most common .The Phlebotominae are biting flies (Fig. .2) and are known throughout the world for their role in transmitting two protozoan diseases, visceral and cutaneous leishmaniasis. They

also are known vectors of several viral diseases such as sand fly fever, vesicular stomatitis, Changuinola and Chandipura viruses. One bacterial disease of humans, bartonellosis (Carrion's disease)(**Bartonella bacilliformis** species) , is transmitted by several phlebotomines of the high Andes. Two genera encompass almost all known disease vectors: *Phlebotomus* in the Old World and *Lutzomyia* in the Americas. The term "sand fly" has been a source of misunderstanding because the term is also applied commonly to biting midges (Ceratopogonidae) and occasionally to blackflies (Simuliidae).

Figure 2 Sand fly, *Phlebotomus papatasi*, female feeding on a human.

Table 1 Sand Fly-Borne Diseases of Humans

Disease	Causative Agent	Geographic Distribution	Reservoirs	Sand Fly Vectors
Sand fly fever (Old World)	Sand fly fever virus (Naples, Sicilian serotypes)	Tropical and subtropical Europe, Asia, northern Africa	Rodents (Muridae)	*Phlebotomus papatasi, P. perfiliewi, P. perniciosus*
Chandipura virus disease	Chandipura virus	India, West Africa	Hedgehogs	*Phlebotomus papatasi*
Cutaneous leishmaniasis (Old World)	*Leishmania major,b Le. tropicaa Le. killicki, Le. aethiopica,*	Tropical and subtropical Europe, Asia and Africa	Monkeys, rodents (Sciuridae, Muridae), dogs, hyraxes	*Phlebotomus aculeatus, P. alexandri, salehi, P. sergenti P. ansarii, P. duboscqi, P. guggisbergi, P. longipes, P. papatasi, P. pedifer, P. rossi, P.*
Visceral leishmaniasis (Old World)	*Leishmania archibaldi, Le. donovani,b,c Le. infantumb,c*	Tropical and subtropical Europe, Asia and Africa	Canines, rats (Muridae)	*Phlebotomus ariasi, P. alexandri P. longicuspis, P. longiductus, orientalis,, P. argentipes, P. caucasicus, P.*

Horse Flies and Deer Flies (Tabanidae):

The term horse fly is applied to relatively large species of tabanids, typically 10-30 mm in length. They can be a serious nuisance to livestock and human and can mechanically transmit several significant animal pathogens, including those that cause surra, anaplasmosis, and equine infectious anemia. The smaller tabanid species called deer flies typically are 6-11 mm long. In contrast to horse flies, they frequently attack humans. Fortunately, there are just a few human diseases known to be associated with deer flies. Most pest species are members of the genera *Chrysops*, *Hybomitra*, and *Tabanus*.

In most temperate areas, adult tabanids are primarily nuisance pests of humans. In this regard they can pose economically significant problems for local tourism. The painful bites, sometimes exceeding 10 per minute, can entirely prevent recreational outdoor activity. Horse-fly larvae can be local pests by inflicting painful bites to the feet of people working in rice paddies. If handled carelessly, the larvae will bite defensively, but they rarely can penetrate the skin of human fingers. Tabanids transmit some pathogens and parasites biologically, in which cases the disease agent replicates and/or develops within the fly for a period of time prior to transmission

Disease Agent	Vectors	Geographic Occurrence	Transmission
Protozoa			
Besnoitia besnoiti	*Tabanus, Atylotus* spp.	South America, Southern Europe, Africa, Asia,	Mechanical
Trypanosoma evansi	*Tabanus, Haematopota, Chrysops* spp.	South America, North Africa, Asia, India	Mechanical
Trypanosoma vivax	*Tabanus* spp.	South America, Africa	Mechanical
Filarial nematodes			
Loa loa	*Chrysops* spp., esp. *C. dimidiatus*, *C. silaceus*	Central Africa	Biological
Elaeophora schneideri	*Hybomitra, Tabanus* spp.	North America, southern Europe	Biological

Table 2 Selected Disease Agents Transmitted by Tabanids

Medical Entomology **Lecture 5**

Muscid Flies (Muscidae):

The family Muscidae includes significant blood-feeding parasites, vectors of disease agents, and species that annoy humans and domesticated animals. These flies and others in related families are often called synanthropic flies, species that exploit foods and habitats created by agriculture and other human activities. Muscid flies and their relatives can be grouped according to their habitat affinities. There are **filth flies**, such as the **house fly**, whose adults and immatures occur in a variety of filthy organic substrates, including latrines, household garbage, manure, and manure-soiled animal bedding. A subset of filth flies are **dung flies**, such as the horn fly, whose immatures occur exclusively in cattle droppings.

The life cycles of flies are complex, but each species has the same developmental stages in common, consisting of an egg, larval (maggot) stage, pupa, and finally the adult. Growth at each immature stage is dependent on many variables but primarily temperature and suitable substrates for a food supply. Each adult fly has its own special requirements that must be met before mating and egg laying (oviposition) commences. Non-biting Australian flies contain many species that are of medical significance. These flies are responsible for contamination and spoilage of foodstuffs, annoyance, mechanical transmission of disease-causing pathogens, and invasion of living tissues (myiasis). Collectively known as "filth flies", they are distributed throughout the families of Calliphoridae (blow flies), Sarcophagidae (flesh flies) and Muscidae (house flies).

The common housefly is one of the most widely distributed insects and has the ability to transmit disease to people. Because of its close association with people and its ability to transmit disease, it is considered a greater threat to human welfare than any other species of non-biting fly. They can carry more than 1 million bacteria on their bodies and can transfer these to contaminate surfaces and food. The common housefly can transmit the pathogens that cause shigellosis, typhoid fever, *E. coli*, and cholera. The disease-causing agents can either be transmitted by the body hairs or by the tarsi which are transmitted to food or surfaces when the fly lands. Additionally, pathogens can be transmitted when a fly regurgitates onto food in order to liquefy material for digestion. The life cycle of the fly starts with the egg and larval stage. These two stages

develop in animal and vegetable refuse. In favorable conditions, eggs can hatch in as little as 24 hours. Fly larvae (maggots) are a creamy-white color and are about 1/2 inch long. This stage lasts for 4-7 days and the shell hardens and darkens. This marks the beginning of the pupal stage. When the pupal stage is complete, the adult fly exits the puparium, dries, hardens, and flies away to feed, with mating occurring soon after emergence.

Flies and myiasis:

Myiasis is the invasion of organs and tissues of humans or other vertebrate

animals by fly larvae, which at least for some time feed on the living or dead tissues or, in the case of intestinal myiasis, on the host's ingested food.

Types of myiasis

Myiasis may be accidental, obligatory or facultative.

1. ***Accidental myiasis*** usually involves eating food that is contaminated by eggs or larvae of flies that are not parasitic in mammals, such as house flies. Although the larvae may survive for some time in the intestine, no flies are specially adapted to cause intestinal myiasis in humans. (In contrast, obligatory intestinal myiasis occurs in other mammals.) The presence of larvae in the human intestine may nevertheless cause considerable discomfort, abdominal pain and diarrhea, which may be accompanied by discharge of blood and vomiting. Living larvae may be passed in excreta or vomit.

2. ***obligatory myiasis*** it is essential for the fly maggots (larvae) to live on a live host for at least a part of their life. For example, larvae of *Cordylobia anthropophaga*, *Cochliomyia hominivorax*, *Chrysomya bezziana*, *Dermatobia hominis* and Wohlfahrtia magnifica are all obligatory parasites of humans and other vertebrates.

In contrast, in **3. *facultative myiasis*** larvae are normally free-living, often attacking carcasses, but under certain conditions may infect living hosts.

Several types of fly, including species of *Calliphora, Lucilia (= Phaenicia), Phormia and Sarcophaga*, which normally breed in meat or carrion, may sometimes cause facultative cutaneous myiasis in people by infecting festering sores and wounds.

Occasionally facultative urogenital myiasis occurs in humans, usually involving larvae of *Musca* or *Fannia* species. Ovipositing flies attracted to unhygienic discharges lay their eggs near genital orifices, and on hatching the minute larvae enter the genital orifice and pass up the urogenital tract. Considerable pain may be caused by larvae obstructing these passages, and mucus, blood and eventually larvae may be discharged during urination.

Different terms are used to describe myiasis which affects different parts of the body – for example, *cutaneous*, *dermal* or *subdermal* myiasis; *urogenital* myiasis; *ophthalmic* or *ocular* myiasis; *nasopharyngeal* myiasis; and *intestinal*, *gastrointestinal* or *enteric* myiasis. When larvae burrow just under the surface layers of the skin this is sometimes called *creeping eruption* or creeping myiasis; when boil-like lesions are produced the term *furuncular* myiasis may be used; and when wounds become infested this is often referred to as *traumatic* myiasis.

- **True Bugs (Hemiptera):**

The order Hemiptera includes all the insects known as true bugs. Hemipterans are characterized as soft-bodied insects with piercing and sucking mouthparts and usually two pairs of wings. The order traditionally was divided into two major divisions, the Heteroptera and the Homoptera, based on wing morphology. The name Hemiptera (literally, "halfwings") is derived from the members of the Heteroptera ("different wings"), most of which have forewings called hemelytra.

kissing bugs (reduviidae)

The kissing bugs are so named because most of them are nocturnal species that feed on humans, often biting the faces of their sleeping victims. Members of the heteropteran family Reduviidae are commonly called assassin bugs because most species attack and feed on other insects. There are 23 subfamilies in the Reduviidae, including the Triatominae, or kissing bugs.

Public Health Importance: Chagas Disease (American Trypanosomiasis)

Triatomine species that are important vectors of *Trypanosoma cruzi* are listed with their geographic occurrences in Table 8.2. Triatoma infestans is probably most often responsible for transmission of the trypanosome to humans because this species has colonized human dwellings over a wide geographic range in South America. Rhodnius prolixus is the second most important vector because it is widely distributed in sylvatic and domestic habitats in northern.

Bed Bugs (Cimicidae)

The family Cimicidae includes species known by several common names, including bed bugs, bat bugs, and swallow bugs. All species in this family are wingless, obligate hematophagous ectoparasites. Their medical and veterinary importance relates primarily to the loss of blood and discomfort caused by their feeding on vertebrate hosts. The scientific name for the common human bed bug, *Cimex lectularius*,

Public Health Importance

Usinger (1966) listed 27 human pathogens, including viruses, bacteria, protozoa, and helminths, that have beenshown to survive for varying lengths of time in C. lectularius and C. hemipterus. However, there is little or no evidence to incriminate bed bugs as vectors of these or any other disease agents.Recent attempts to explain transmission of Hepatitis Bvirus and, to a lesser extent, HIV in otherwise unexplainedsituations have focused on the possibility of cimicidtransmission. Hepatitis B antigens (and HBV DNA) persist for several weeks in cimicid tissues and feces under laboratory conditions after the bugs have fed on infected blood. Replication of the virus, however, does not occur.

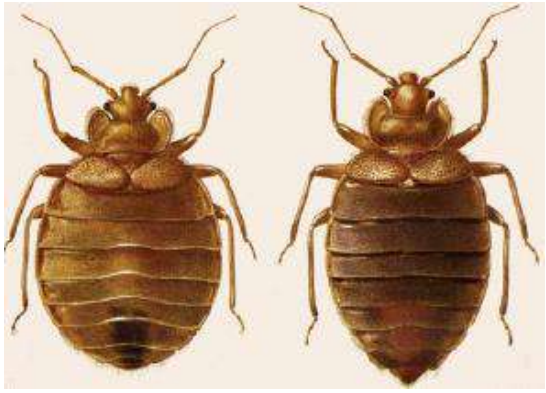


Figure 3 Human bed bug, *Cimex lectularius*; female, left; male, right.

Medical Entomology Lecture 6

Order Siphonaptera (Fleas):

There are about 2500 species and subspecies of fleas in about 220 genera, but only relatively few are important pests of humans. About 94% of species bite mammals, while the remainder is parasitic on birds. Fleas occur almost worldwide, but many have a more restricted distribution; for example the genus Xenopsylla, which contains important plague vectors, is confined to the tropics and warmer parts of some temperate countries.

Medically the most important fleas are *Xenopsylla* species, such as *X. cheopis*, which is a vector of plague (*Yersinia pestis*) and flea-bornemurine typhus (*Rickettsia typhi*). Fleas in the genus *Ctenocephalides* may be intermediate hosts of cestodes (*Dipylidium caninum*, *Hymenolepis diminuta*). Fleas may also be vectors of tularaemia (*Francisella tularensis*), and the chigoe or jigger flea (*Tunga penetrans*) 'burrows' into people's feet.

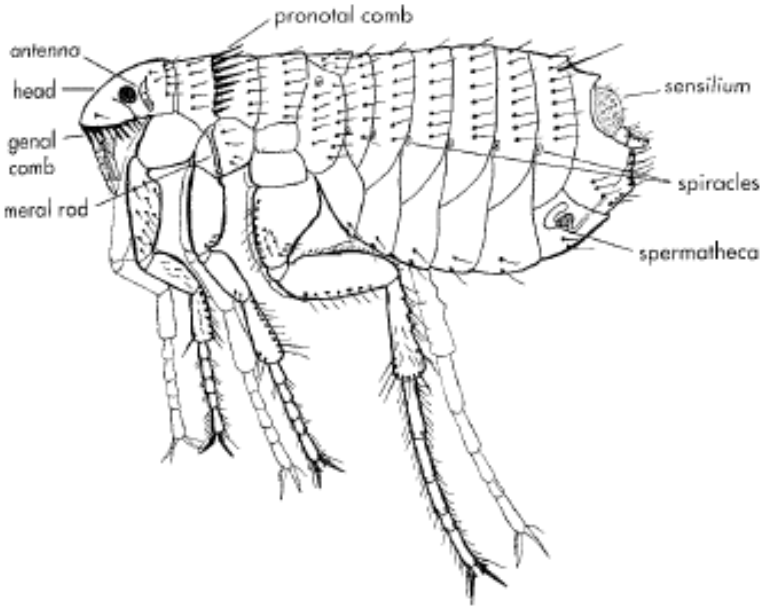


Figure 1 Lateral view of an adult flea, showing position of combs and the meral rod (pleural rod).

Medical importance:

- Flea nuisance:

Although fleas can be important vectors of disease, the most widespread complaint is their upsetting bites, which may result in considerable discomfort and irritation. The most common nuisance flea is the cat flea (*Ctenocephalides felis*), which has a worldwide distribution. Females often lay up to 25 eggs a day for about a month. Of lesser importance as a pest is the dog flea (*Ctenocephalides canis*) and more rarely the human flea (*Pulex irritans*). The cat flea has become the most common flea on dogs.

- Plague

There are three main types of plague, *bubonic, septicemic and pneumonic*, all caused by the bacterium *Yersinia pestis*. Medically the most important is *bubonic plague*, of which there are worldwide about 1000–3000 cases annually in parts of Asia, northwestern and southern Africa, South America and western North America. Bubonic plague is a *zoonosis*, being primarily a disease of wild animals, especially rodents. About 200 rodent species and 14 lagomorphs (e.g. hares and rabbits) have been shown to harbour plague bacilli. The transmission cycle of plague between wild rodents, is termed *sylvatic*, *rural* or *enzootic* plague. Many different species of fleas bite rodents and maintain plague transmission amongst them. When people such as fur trappers and hunters handle these wild animals there is the risk that they will get bitten by rodent fleas and become infected with plague

- Murine typhus

Although murine typhus, also known as endemic typhus or Mexican typhus, occurs almost worldwide, the annual number of human cases has fallen from more than 5000 in 1945 and 1946 to presently just 20–80 cases a year. Murine typhus is caused by the bacterium *Rickettsia typhi*, which is ingested by a flea with its blood-meal. In the gut the rickettsiae multiply, but unlike plague bacilli, they do not block the proventriculus. Transmission occurs when infected faeces are scratched or rubbed into scrapes or come into contact with delicate mucous membranes, and also by the release of *rickettsiae* from crushed fleas.

Faeces remain infective for many months to a year or more; under laboratory conditions they have remained infective for 4.5–9 years! Murine typhus is essentially a disease of rodents, particularly rats such as *Rattus rattus* and *R. norvegicus*. It is spread

among rats and other rodents by *Xenopsylla* species, especially *X. cheopis*, but also by *Nosopsyllus fasciatus* and *Leptopsylla segnis*. A few ectoparasites which are not fleas are vectors, such as the spined rat louse (*Polyplax spinulosa*) and possibly the cosmotropical rat mite (*Ornithonyssus bacoti*).

People become infected mainly by the faeces of *Xenopsylla cheopis*, but occasionally species such as *Nosopsyllus fasciatus*, *Ctenocephalides canis*, *C. felis* and *Pulex irritans* may be involved in transmission. *Leptopsylla segnis* does not bite humans, but it is possible that murine typhus is sometimes spread to people by an aerosol of this flea's infective faeces.

- Cestodes

Dipylidium caninum is the commonest tapeworm of dogs and cats, and it occasionally occurs in children. It can be transmitted by fleas (*C. felis, C. canis* and *P. irritans*) to both pets and humans as follows. Tapeworm proglottids containing eggs excreted by a pet crawl away from the host and dry on exposure to air. Larval fleas feeding on organic debris in host bedding bite into the dried proglottids, releasing the eggs, which they then swallow. Larval worms hatching from the ingested eggs penetrate the gut wall of the larval flea and enter the body cavity (coelom).

Medical Entomology Lecture 7

Order Anoplura (Sucking lice):

Three types of blood-sucking lice occur on humans, the body louse (***Pediculus humanus***), the head louse (***Pediculus capitis***) and the pubic or crab louse (*Pthirus pubis*). Morphologically the body and head lice are virtually indistinguishable. In the laboratory the two can interbreed but there is very little evidence they do this outside the laboratory, and here they are treated as two distinct species, although many regard the head louse as a subspecies of the body louse. All three species of lice have a more or less worldwide distribution, but they are often more common in temperate areas. Body lice are vectors of louse-borne typhus (***Rickettsia prowazekii***), trench fever (***Bartonella quintana)*** and louse-borne relapsing fever (***Borrelia recurrentis***).

- **The body louse (*Pediculus humanus*)**

Adults are small, pale beige or greyish wingless insects, with a soft but rather leathery integument, and are flattened dorsoventrally (Fig. 12.1, Plate 21). Males measure about 2–3mm and females about 3–4mm. The head has a pair of small black eyes and a pair of short five-segmented antennae.

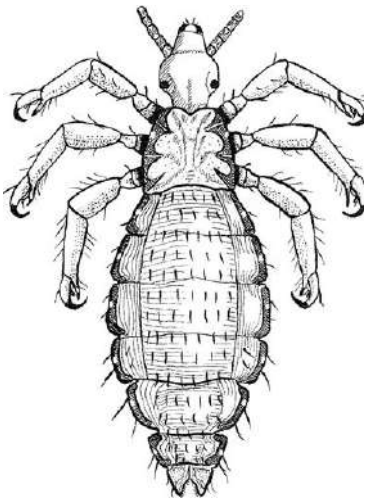


Figure 1 Dorsal view of body louse *(Pediculus humanus*). The head louse *(P. capitis*) looks virtually identical.

Medical importance:

- **Pediculosis**

Presence of body, head or pubic lice on a person is sometimes referred to as pediculosis. The skin of people who habitually harbour large numbers of body lice may become pigmented and tough, a condition known as vagabond's disease, hobo disease or sometimes as morbus errorum.

- **Louse-borne epidemic typhus**

Rickettsiae of louse-borne typhus, *Rickettsia prowazekii*, are ingested with blood-meals taken by both male and female lice, and also by their nymphs. They invade the epithelial cells lining the stomach of the louse and multiply enormously, causing the cells to become greatly distended. About four days after the blood-meal the gut cells rupture and release the rickettsiae back into the lumen of the insect's intestine. Due to these injuries the blood-meal may seep into the haemocoel of the louse, giving the body a reddish colour. Rickettsiae are passed out in the faeces of the louse, and people become infected when these are rubbed or scratched into abrasions, or come into contact with delicate mucous membranes such as the conjunctiva. Humans, therefore, become infected with typhus either by the faeces of the louse or by crushing it, not by its bite.

- **Louse-borne epidemic relapsing fever**

Borrelia recurrentis is ingested with the louse's blood-meal from a person suffering from epidemic relapsing fever, but within about 24 hours all spirochaetes have disappeared from the lumen of the gut. Many have been destroyed, but the survivors have passed through the stomach wall to the haemocoel, where they multiply to reach enormous numbers after 10–12 days. The accepted way that someone can be infected is by the louse being crushed and the released spirochaetes entering the body through abrasions or mucous membranes, or less commonly through intact skin. The habit of crushing lice between the fingernails, or the less desirable habit of killing them by cracking them with the teeth, is clearly dangerous if lice are infected with relapsing fever or typhus. Recently, it has been shown that faeces of infected lice can contain live *B. recurrentis*, and so transmission may also involve the faeces.

- Trench fever

Trench fever is a relatively uncommon and non-fatal disease which was first recognized during World War I (1914–18) among soldiers in the trenches, and then reappeared in eastern Europe during World War II (1939–45). The disease disappeared again, only to reappear later in North America and Europe in the 1980s, occurring mainly in homeless people and those who were HIV-positive. In the 1990s and 2000s it was also reported from many parts of the world, including the USA, Canada, Mexico, Peru, Bolivia, France, Japan, China, Australia, North Africa, Burundi and other sub-Saharan countries.

Trench fever is caused by ***Bartonella quintana***. The bacteria are ingested by the louse during feeding and become attached to the walls of the gut cells, where they multiply. They do not penetrate the cells, as do typhus rickettsiae, and consequently they are not injurious to the louse. After 5–10 days the faeces are infected. Like typhus, the disease is conveyed to humans either by crushing the louse or by its faeces coming into contact with skin abrasions or mucous membranes.

- **The head louse (Pediculus capitis)**

Medical importance:

In many areas of the world head lice are a serious public health problem, and in many countries prevalence has been increasing. In some schools in the USA and the UK almost 50% of pupils have head lice. Often there are higher infestation rates in overcrowded homes and where hygiene is poor. There is little evidence that head lice are natural vectors of the diseases transmitted by body lice – for example, typhus epidemics are always associated with body lice – but they may occasionally be minor vectors in some outbreaks of louse-borne relapsing fever.

- **The pubic louse (*Pthirus pubis*):**

The pubic louse is smaller (1.3–2mm) than Pediculus species and is easily distinguished from them. In the pubic louse the body is nearly as broad as long, making it almost round. Whereas all three pairs of legs are more or less of equal size in the body and head louse, in the pubic louse the middle and hind-legs are much thicker than the front legs and have massive claws (Fig. 2). Presence of a broad squat body and very large claws, together with more sluggish movements, has resulted in the pubic louse being aptly called the crab louse. Medically the most important species of pubic louse is *Pthirus pubis*

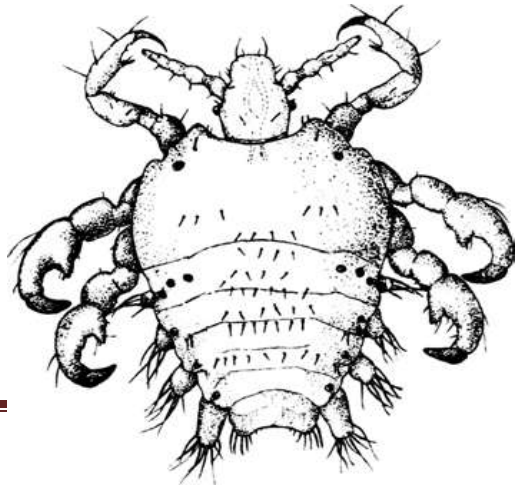


Figure 2 Dorsal view of pubic louse (*Pthirus pubis*), showing very large claws on mid- and hind-legs.

Medical importance

Although in the laboratory pubic lice can transmit louse-borne typhus, there is little evidence that under natural conditions they spread any disease to humans, although it has been suggested that they have been responsible for typhus outbreaks in China. Severe allergic reactions can develop in response to their bites, due to the injection of saliva and the deposition of faeces around the feeding sites.

- **Order Blattaria (Cockroaches) :**

Cockroaches belong to the order Blattaria, and there are about 4000 species of which 20–30 are serious domestic pests. The most important medically are *Blattella germanica* (the German cockroach), *Blatta orientalis* (the oriental cockroach), *Periplaneta americana* (the American cockroach), *P. australasiae* (the Australian cockroach) and *Supella longipalpa* (the brown-banded cockroach). Cockroaches are sometimes called roaches or steambugs. They have an almost worldwide distribution. Cockroaches aid in the mechanical transmission of various pathogenic viruses, bacteria and protozoans.

- **Medical importance**

Allergies:

Only relatively recently has the importance of cockroach allergies been recognized. About half of asthmatics are allergic to cockroaches, they cast-off skins or excreta, while about 10% of non-asthmatic people will exhibit cockroach allergies. Symptoms include sneezing, skin reactions, sore eyes, recurrent ear infections and in extreme cases shortness of breath.

Infectious agents:

Because of their dirty habits of feeding indiscriminately on both excreta and foods, and excreting and regurgitating partially digested meals over food, the presence of cockroaches in houses, hotels and hospitals is, not surprisingly, highly undesirable! Most parasitic infections isolated from cockroaches are also spread directly from person to person without the aid of intermediary insects, so it is usually difficult to prove that cockroaches are responsible for any disease outbreak. Nevertheless, because

of their insanitary habits they have been suspected as aiding the transmission of various pathogens. For example, more than 40 bacterial infections have been isolated from cockroaches, including, *Escherichia coli*, *Klebsiella pneumoniae*, *Mycobacterium leprae*, *Shigella dysentariae* and *Salmonella* species, including *S. typhi* and *S. typhimurium*, *Serratia* species and *Staphylococcus aureus*. And protozoan such as *Entamoeba histolytica*, Eggs of the nematode *Enterobius vermicularis*, which is an extremely common worm in humans, can also be carried by cockroaches.

❖ Argasidae (Soft ticks):

Ticks are not insects, because adults have eight legs, not six as in adult insects. They are closely related to mites and spiders. Ticks are divided into two main families, the **Argasidae (soft ticks)** and the **Ixodidae (hard ticks)**. A third family, Nuttalliellidae, contains just one species which is of no medical importance. Students sometimes find difficulty in distinguishing the very small immature stages of ticks mites, but ticks differ from mites having a toothed hypostome, while adult ticks are also much larger than mites.

Soft ticks (Argasidae) have an almost worldwide distribution. There are 193 species formerly placed in four genera, but some authorities recognize more genera. The medically important soft ticks belong to the genus *Ornithodoros*. Species in this genus are found in many areas of the world including the Americas, Africa, Europe and Asia. The most important species is ***Ornithodoros moubata***, a species in the *O. moubata* species complex, which is a vector of tick-borne (endemic) relapsing fever (***Borrelia duttonii***). A few other species in the *O. moubata* species complex are also of medical importance.

External morphology

Adult argasid ticks are flattened dorsoventrally, 8–13mmlong and usually roundish to oval in outline. The integument is wrinkled and usually covered with fine tubercles (mammillae) or granulations. There is no scutum (dorsal shield) as is found in ixodid (hard) ticks

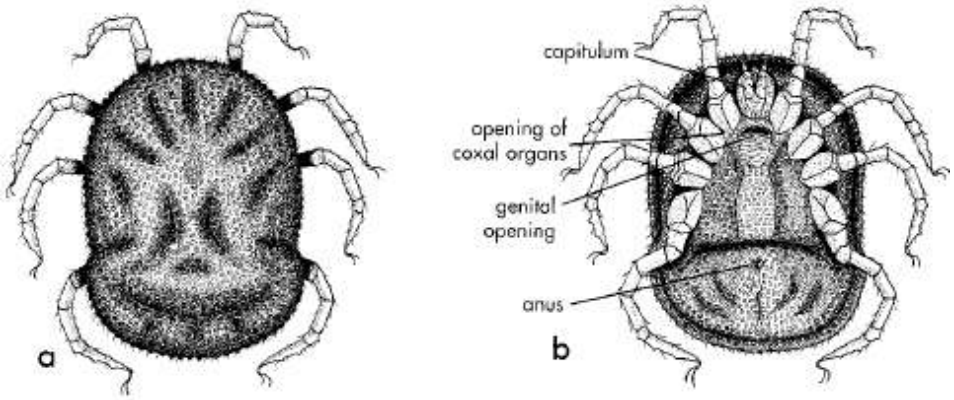


Figure 1 Adults of the soft tick *Ornithodoros moubata*: (a) dorsal view; (b) ventral view.

- **Medical importance:**

- ✓ **Tick-borne relapsing fever:**

Tick-borne relapsing fever is the only important disease transmitted to humans by soft ticks. The infection occurs throughout most of the tropics and subtropics, and in many temperate areas such as North America and Europe, but is absent from Australia and New Zealand. There are 15 or more species of ***Borrelia***, mostly having different geographical distributions, that cause Ornithodoros-transmitted relapsing fevers. The most common is ***B. duttonii***, found in sub-Saharan Africa

and transmitted by ***O. moubata***. In other geographical areas different ticks in the *O. moubata* species complex transmit different species of *Borrelia*.

Spirochaetes ingested with a blood-meal multiply in the mid-gut, penetrate its wall and pass into the haemocoel, where they can be found after 24 hours. In the haemocoel, the spirochaetes multiply enormously and invade nearly all tissues and organs of the tick's body. After three days they infect the **salivary glands, the coxal organs** and **ovaries.**

When either nymphs or adults of O. moubata blood-feed saliva is injected into the bite, and spirochaetes can be introduced by this route, especially by the nymphs. During feeding, excess body fluids are filtered from the haemocoel by the coxal organs and in infected ticks, especially adults, the coxal fluids contain spirochaetes ingested with a previous bloodmeal. These spirochaetes can enter the host through the puncture of the

tick's bite or through intact skin. Humans can therefore become infected with *B. duttonii* by either the bite of *O. moubata* or the coxal fluids, or both.

- ✓ **Q fever:**

Although Q fever is transmitted mainly by ixodid ticks, argasid ticks can also be vectors. See medical important in Hard ticks (Ixodidae).

- ✓ **Viruses**

More than 100 ***arboviruses*** are transmitted by ticks, but only about 30 have

been isolated from soft ticks, and very few infect people. Although soft ticks are not regarded as important vectors of arboviruses to humans, a new Flavivirus causing Alkhurma haemorrhagic fever has been recorded from Saudi Arabia and Egypt. The principal hosts are camels and other domestic animals; human cases are rare and occur mostly in butchers who have become infected through wounds. *Ornithodoros savignyi* appears to be a vector, as do Ixodes species.

- ✓ **Tick-bite allergies and tick paralysis**

Several species of ticks can cause allergies such as itching, skin rashes, fevers, vomiting and diarrhoea, including *Ornithodoros* species such as *O. moubata*, but these symptoms are more commonly associated with ixodid ticks.

Medical Entomology **Lecture 9**

❖ Ixodidae (Hard ticks):

Hard ticks (Ixodidae) have a worldwide distribution, but are more common in temperate regions than soft ticks (Argasidae). There are 702 species of hard ticks belonging to 14 genera. Medically the more important genera are ***Ixodes***, ***Dermacentor***, ***Amblyomma***, ***Haemaphysalis***, ***Rhipicephalus*** and ***Hyalomma***. Hard ticks are vectors of typhuses such as Rocky Mountain spotted fever (***Rickettsia rickettsii***) and Meditteranean spotted fever (***R. conorii***), and Q fever (***Coxiella burnetii***). Many ***arboviruses***, including **tick-borne encephalitis**, **Omsk haemorrhagic fever**, **Kyasanur Forest disease**, **Crimean–Congo haemorrhagic fever** and **Colorado tick fever**, are transmitted by hard ticks. They also transmit tularaemia (***Francisella tularensis***), and cause **tick paralysis**.

External morphology: Adult hard ticks are flattened dorsoventrally, oval in shape and about 2–23mm long, size depending on species and whether they are unfed or fully engorged with blood. Females are usually bigger than males, and because they take larger blood-meals they enlarge much more than males during feeding.

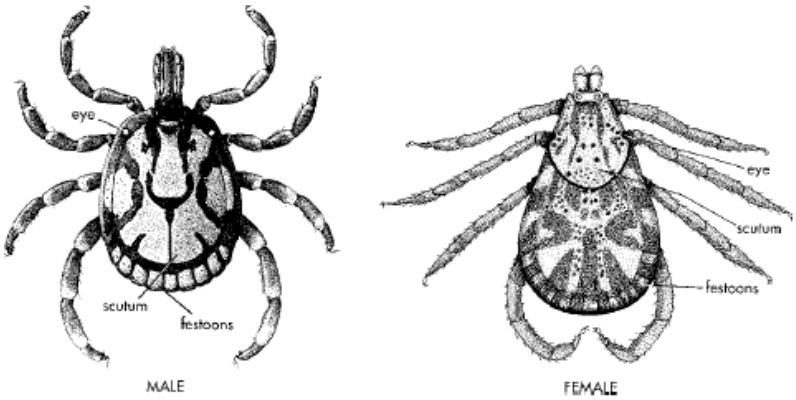


Figure 2 Adults of hard ticks: male *Amblyomma* and female *Dermacentor*, showing sexual differences. A male ixodid has a large scutum while a female has a small scutum.

➢ Medical importance:

✓ Tick paralysis and allergies

Female hard ticks, mainly ***Dermacentor*** and ***Ixodes*** species, can cause tick paralysis. Human cases have been reported from North and South America, Europe, Asia, Australia and South Africa. The condition also affects pets and domesticated animals. Symptoms appear 4–7 days after a tick, usually a female, has commenced feeding.

There is an acute ascending paralysis affecting firstly the legs, resulting in the patient being unable walk or stand, and later the arms cannot be moved and there follows difficulty in speaking, swallowing and breathing. Symptoms are painless and there is rarely any rise in the patient's temperature. Tick paralysis can be confused with paralysis due to poliomyelitis and certain other paralytic infections.

- ✓ ***Arboviruses***

More than 120 *arboviruses* are transmitted by ticks, but the important tickborne viral diseases of humans are spread by hard ticks. All *arboviruses* are transmitted by the tick's bite, and transovarial transmission usually occurs.

- ✓ **Tick-borne encephalitis (TBE) (*Flavivirus*)**

There are three subtypes of TBE, the first of which was described in 1932 as **Russian spring–summer encephalitis** (RSSE), the second in 1937 was known as **central European encephalitis** (CEE), then in the early 1980s the Siberian subtype was recognized. All three subtypes are now known collectively as **tick-borne encephalitis (TBE),** which is widespread in Europe (except the UK, Benelux countries and the Iberian peninsula), Russia, Siberia, Turkey, northern Asia, China and Japan.

- ✓ **Omsk haemorrhagic fever (OHF) (*Flavivirus*)**

The virus causing OHF is antigenically very similar to viruses causing TBE and **Kyasanur Forest disease** (KFD), and clinical symptoms are rather similar to those caused by these other viruses. OHF occurs in Siberia, such as in the Omsk region. The primary vector is *Dermacentor reticulatus* (formerly called *D. pictus*), which feeds on rodents, especially the water vole (*Arvicola terrestris*) and muskrats (*Ondatra zibethida*) which are amplifying hosts, as probably are water voles. Other important vectors are *D. marginatus* and *Ixodes persulcatus*. Infections acquired from animal hosts are transmitted transstadially to nymphs or adults.

- ✓ **Kyasanur Forest disease (KFD) (Flavivirus)**

KFD was first recognized in 1957 when monkeys were dying in Kyasanur Forest in Karnataka State of southern India and people were also becoming ill and dying. The disease is now found in about 5000 km2 in and around Kyasanur Forest and is associated with movements of people into forests, cattle grazing at the forest edge and deforestion for food crops, activities which expose people to ticks. In 2002 about 22% of inhabitants on the Andaman and Nicobar Islands were seropositive for KFD, and in Saudi Arabia a closely related virus (Alkhurma) was also reported.

- ✓ **Crimean–Congo haemorrhagic fever (CCHF) (*Nairovirus*)**

CCHF virus is recorded from many countries in central and eastern Europe, the Balkans, Russia, the Middle East, Pakistan, India, China, Madagascar and in Africa from Mauritania to Ethiopia down to South Africa. After dengue viruses, CCHF virus is one of the most widely distributed *arboviruses*, with human infections known from about 30 countries and virus isolations obtained from ticks in another 10 countries. The disease is typically enzootic in savanna, steppe and semi-desert areas. Transmission is mainly by ***Hyalomma*** species, such as ***H. marginatum marginatum***, but in Africa ***H. marginatum rufipes*** is the vector.

- ✓ **Colorado tick fever (CTF) (Coltivirus)**

CTF occurs in the Rocky Mountain states and South Dakota in the USA and in western Canada. The principal vector is ***Dermacentor andersoni***. Larvae and nymphs feed on small mammals such as rabbits, ground squirrels (*Citellus* species), chipmunks (Tamias species) and woodrats (Neotoma species), which together with ticks are the main reservoir hosts of infection.

- ✓ **Rickettsiae**

Tick-borne typhuses have an almost worldwide distribution and are caused by 22 species of ***Rickettsia***. Ticks are usually regarded as the main reservoirs of infection, although rodents and other mammals may sometimes be reservoir hosts. There is usually transovarial transmission, and often transstadial transmission. The more important tick-borne typhuses are described briefly below.

- ✓ **Rocky Mountain spotted fever (RMSF)**

RMSF, also known as Mexican spotted fever, São Paulo spotted fever, American tick-borne typhus and by several other local names, occurs throughout most of the USA, and less commonly in Canada, Mexico and Central America as well as Colombia and Brazil. The causative agent is ***Rickettsia rickettsii***. The principal vector in western America is ***Dermacentor andersoni***, and in eastern USA ***D. variabilis***, and recently ***Rhipicephalus sanguineus*** has been found to be a vector in Arizona. In Canada the vectors are also ***D. andersoni*** and ***D. variabilis***. In South America Amblyomma cajennense is the main vector, and this species and ***Rhipicephalus sanguineus*** are the important vectors in Central America.

- ✓ **Mediterranean spotted fever**

Also known as boutonneuse fever, Marseilles fever, South African tick typhus, Kenyan tick typhus, Indian tick typhus and Crimean tick typhus. The infective agent is ***Rickettsia conorii***. It occurs in the Mediterranean littoral region, Israel, Portugal, Sicily, eastern Russia, India and North 246 Hard ticks (Ixodidae) Africa.

- ✓ **African tick-bite fever**

Initially confused with typhus caused by Rickettsia conorii, but in 1992 the causative agent was named ***R. africae***. This form of typhus is common throughout most of sub-Saharan Africa, and also occurs in the West Indies. In both regions vectors are ***Amblyomma*** species.

- ✓ **Q fever**

Q fever is a rickettsial zoonotic disease caused by Coxiella burnetii. It was

first diagnosed in livestock handlers in Australia as far back as 1935, but is now known to occur in Europe, Africa, Asia and North America. It is primarily an infection of rodents, other small mammals and domestic livestock. It can be transmitted to people by inhalation of aerosolized ***rickettsia***, by consuming contaminated milk or other dairy products, by contamination with aerosols of tick faeces, which can remain infective for months, and by the bites of ixodid, and to a lesser extent argasid, ticks.

Table 1 *Some infections transmitted to humans by hard ticks*

Disease	Infective agent	Principal tick vectors	Main reservoir hosts excluding ticks
Tick-borne encephalitis	*Flavivirus*	*Ixodes ricinus, I. persulcatus*	Rodents, insectivores
Omsk haemorrhagic fever	*Flavivirus*	*Dermacentor reticulatus*	Muskrats, water voles
Kyasanur Forest disease	*Flavivirus*	*Haemaphysalis spinigera, H. turturis*	Monkeys, shrews, rodents
Crimean–Congo haemorrhagic fever	*Nairovirus*	*Hyalomma marginatum* species complex	Hares, cattle, goats
Colorado tick fever	*Coltivirus*	*Dermacentor andersoni*	Many rodent species, rabbits
Rocky Mountain spotted fever	*Rickettsia rickettsii*	*Dermacentor, Amblyomma* and *Rhipicephalus* species	Many rodent species
Mediterranean spotted fever	*Rickettsia conorii*	*Rhipicephalus sanguineus*	Rodents, dogs
African tick-bite fever	*Rickettsia africae*	*Amblyomma* species	Rodents, possibly cattle
Q fever	*Coxiella burnetii*	Many ixodid species	Sheep, goats, cattle, possibly rodents
Human ehrlichiosis	*Ehrlichia chaffeensis*	*Amblyomma* and *Ixodes* species	Deer, rodents
Lyme disease	*Borrelia burgdorferi*	*Ixodes ricinus, I. scapularis, I. pacificus*	Birds, rodents
Tularaemia	*Francisella tularensis*	Many ixodid species	Rabbits, hares, deer, beavers
Tick paralysis	Tick toxins	Mainly *Ixodes* and *Dermacentor* species	Not applicable, as not caused by any pathogen

Table 2 | *Summary of principal features distinguishing soft and hard ticks*

Argasid ticks (soft ticks)	Ixodid ticks (hard ticks)
Morphology	
Scutum (shield) absent	Scutum (shield) on larvae, nymphs and adults. Females with small, and males with large scutums
Mouthparts (capitulum) not visible dorsally in nymphs and adults, but seen in larvae	Mouthparts (capitulum) visible dorsally in larvae, nymphs and adults
Palps leg-like; chelicerae have smooth sheaths	Palps club-shaped; chelicerae have denticulate sheaths
Coxal organs present	Coxal organs absent
Life cycle	
Eggs laid in several small batches of 15–100 eggs	Eggs laid in one large batch of many thousands of eggs
4–5 nymphal stages (8-legged)	Only one nymphal stage (8-legged)
Adults blood-feed rapidly, on hosts for only 20–35 minutes, but feed on several separate occasions	Adults feed slowly, on hosts for 1–4 weeks, but females feed only once
Multi-host ticks, usually about 6 hosts	Usually 2- or 3-host ticks
Ticks found mainly in or around homes of host, disperse little	Ticks attach to host for long time, hence can disperse considerable distances
Diseases	
Vectors of tick-borne relapsing fever	Vectors of tick-borne typhuses, Lyme disease and many viruses. Cause tick paralysis

Medical Entomology **Lecture 10**

❖ Order: Sarcoptidae (Scabies mites):

Adult mites, like ticks, have eight legs and therefore are not insects. They can be distinguished from ticks by the absence of teeth on the hypostome of the mouthparts and in having setae (bristles) on the body as well as the legs. But the principal medically important species (scabies mite, scrub typhus mite, house-dust mite and follicle mite) can most readily be recognized by their characteristic shapes. Sarcoptes scabiei, the scabies or itch mite, occurs on people worldwide.

Morphologically they are indistinguishable from S. scabiei infesting wild and domesticated animals, including dogs, horses and pigs. Mites on such animals are considered to be the same species as those infecting people but physiologically adapted for life on non-human hosts. In animals they cause the condition known as mange. Mites living on animals very rarely infect humans, but if they do the infection can persist for several weeks. Scabies mites are not vectors of any disease but cause conditions known as scabies, acariasis, and crusted or Norwegian scabies.

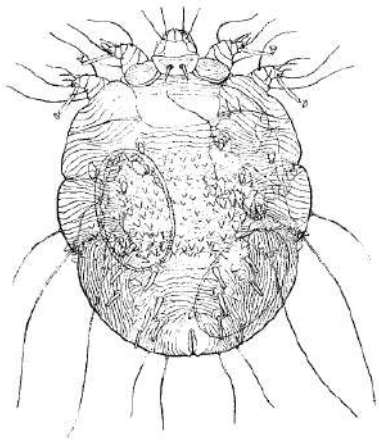


Figure 1 Dorsal view of an adult female scabies mite (Sarcoptes scabiei).

The scabies rash: The scabies rash is a popular eruption that occurs mainly on areas of the body not infected with burrowing mites, such as the buttocks and around the waist and shoulders, but the rash can also occur on other parts of the body such as the arms, calves and ankles. It does not appear on the head, centre of the chest or back, nor on the palms of the hands or soles of the feet. The rash is in response to an allergic

reaction produced by the mites. Frequently patients are unaware they have mites until a rash appears. When a person is infected for the first time with mites the rash does not usually appear until 4–6 weeks, although in exceptional cases the rash may occur within 2 weeks. However, in those who have previously been infected a rash may develop within 2–4 days after reinfection. Severe pruritus soon develops and causes vigorous and constant itching and scratching, especially at night and after hot baths. Scratching frequently causes secondary bacterial infections, which may be quite severe, resulting in boils, pustules, ecthyma, eczema and impetigo contagiosa. Such complications may hinder the detection of mites, and consequently correct diagnosis of scabies may not be made. The seriousness of the symptoms is not always directly related to the number of mites, and severe reactions may be found on people harbouring few mites. The rash may persist for 2–3 weeks after all scabies mites have been destroyed.

- **Order: Trombiculidae (Scrub typhus mites)**

There are more than 2000 species of trombiculid mites in many genera, but only about 20 species commonly attack people. The family Trombiculidae has a more or less worldwide distribution, but the medically most important species, such as *Leptotrombidium deliense*, *L. akamushi* and *L. fletcheri*, which are vectors of **scrub typhus** (**Orientia tsutsugamushi**), are found in Asia, the Pacific regions and the northeast coast of Australia. Other trombiculid mites in many parts of the world cause itching and a form of dermatitis known as scrub itch, autumnal itch or trombidiosis. In northern Europe larvae of *Neotrombicula autumnalis* (harvest mites) and in North America and parts of Central and South America larvae of

Eutrombicula alfreddugesi (red bugs) commonly attack people and cause considerable discomfort. Some authors place both these species in the genus *Trombicula*.

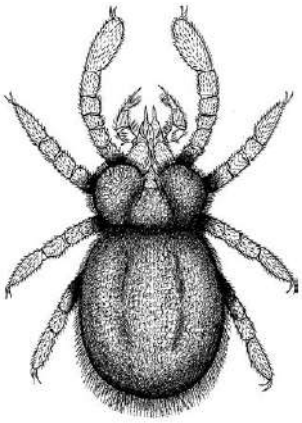


Figure 2 Dorsal view of an adult **scrub typhus mite (*Leptotrombidium* species).**

- **Medical importance:**

✓ **Nuisance:**

Several species of trombiculid mites attack people in temperate and tropical regions. In northern Europe the main pest is the harvest mite (*Neotrombicula autumnalis*), while in the USA it is the red bug (*Eutrombicula alfreddugesi*). Although these mites do not transmit infections they can nevertheless cause intense itching and irritation, commonly referred to as 'harvest-bug itch', 'autumnal itch' or 'scrub itch'. Larval mites commonly attack the legs. If they are forcibly removed, their mouthparts frequently remain embedded in the skin, and this may promote further irritation. People usually become infested with these mites after walking through long grass or scrub vegetation, especially in the autumn or summer.

✓ **Scrub typhus:**

The causative organism of scrub typhus is the rickettsia *Orientia tsutsugamushi*, and the disease is known as scrub typhus, mite-borne typhus, Japanese river fever, chigger-borne rickettsiosis or **tsutsugamushi disease**. The disease is restricted to the Asia–Pacific area, extending from the Primorye region of Siberia through Pakistan and India to Myanmar, Indonesia, Malaysia, Thailand, Southeast Asia, China, Taiwan, the Philippines, Japan, Papua NewG uinea, New Zealand, northeastern Australia and neighbouring southwest Pacific islands. Although scrub typhus is mostly reported from low-lying areas, it can occur at 1000m in many areas, and has been reported up to about 2000m in Taiwan and 3200m in the Himalayas. During World War II (1939–45) the incidence of scrub typhus in troops in the Asia–Pacific area was second only to that of malaria. Although more than 40 mite species in 13 genera are known or suspected as being vectors, only about seven species, including *Leptotrombium deliense*, *L. fletcheri*, *L. akamushi* and *L. pallidum*, are important.

People become infected by the bites of larval trombiculid mites when they visit or work in areas having so-called mite islands, that is patches of vegetation harbouring large numbers of host-seeking larvae. The disease is often associated with 'fringe habitats', in other words habitats separating two major vegetation zones such as forests

and plantations, because such areas are often heavily populated with rodent hosts. Consequently the risk of scrub typhus transmission is often associated with areas having different types of vegetation.

- **Miscellaneous mites:**

In addition to scabies mites and scrub typhus mites there are many other species of mites that can be of medical importance. The most important two, the follicle mites and the house-dust mites, are described below, followed by very brief mentions of a few other mites.

- **Demodicidae: follicle mites (Demodex species):**

Two species of Demodex commonly infect humans, namely *Demodex folliculorum* and *D. brevis*. The former is the more elongate species (0.2–0.4mm long) and primarily inhabits hair follicles and eyelash hair follicles, whereas D. brevis is squatter (0.15–0.2mm) and lives in the sebaceous glands of hairs and eyelashes. A single follicle may contain 25 *D. folliculorum*, but sebaceous glands contain many fewer *D. brevis*. Both species have a striated body and four pairs of very short

stubby legs; they are remarkably non-mite-like. These mites occur only on humans.

Demodex mites feed on subcutaneous tissues, especially sebum, and are particularly common on the forehead, nose, eyelids and cheeks adjacent to the nose. Eggs hatch to produce six-legged larvae which moult to give rise to protonymphs, thennymphs, andfinally adults. All the developmental stages, which extend over 13–15 days, occur within the hair follicles or sebaceous glands. Transfer of mites is believed to occur between mothers and infants during the close contact of nursing. Incidence of infection increases with age, and it seems that 90–100% of older people have these mites.

Pyroglyphidae: house-dust mites (Dermatophagoides and Euroglyphus species):

About 20 species of mites are found in house dust. The most common are *Dermatophagoides pteronyssinus*, known as the European house-dust mite, which occurs in North America as well as Europe, and *D. farinae*, the American house-dust mite, which occurs in the USA and central and southern Europe. However, both species are found more or less worldwide. Another house-dust mite, *Euroglyphus maynei*, also has an almost worldwide distribution. *Dermatophagoides* and *Euroglyphus* mites are very small (0.3mm) and live among bedclothes, mattresses, carpets and general house dust. Female mites lay about 1–3 eggs a day. These hatch after 6–12 days and a six-legged larva emerges, which feeds and passes through two nymphal stages (i.e. protonymph and tritonymph) before becoming an adult. The complete life cycle takes about 3–4 weeks. Beds are the most important, and sometimes only, breeding site. House-dust mites have also been found breeding in clothes such as suits hanging in bedroom wardrobes (closets).