NETAJI SUBHAS OPEN UNIVERSITY

STUDY MATERIAL

POST GRADUATE ZOOLOGY

PAPER - 8
GROUP : A(I)

Parasitology &
Public Health

PREFACE

In the curricular structure introduced by this University for students of Post-Graduate degree programme, the opportunity to pursue Post-Graduate course in Subject introduced by this University is equally available to all learners. Instead of being guided by any presumption about ability level, it would perhaps stand to reason if receptivity of a learner is judged in the course of the learning process. That would be entirely in keeping with the objectives of open education which does not believe in artificial differentiation.

Keeping this in view, study materials of the Post-Graduate level in different subjects are being prepared on the basis of a well laid-out syllabus. The course structure combines the best elements in the approved syllabi of Central and State Universities in respective subjects. It has been so designed as to be upgradable with the addition of new information as well as results of fresh thinking and analyses.

The accepted methodology of distance education has been followed in the preparation of these study materials. Co-operation in every form of experienced scholars is indispensable for a work of this kind. We, therefore, owe an enormous debt of gratitude to everyone whose tireless efforts went into the writing, editing and devising of a proper lay-out of the materials. Practically speaking, their role amounts to an involvement in invisible teaching. For, whoever makes use of these study materials would virtually derive the benefit of learning under their collective care without each being seen by the other.

The more a learner would seriously pursue these study materials the easier it will be for him or her to reach out to larger horizons of a subject. Care has also been taken to make the language lucid and presentation attractive so that they may be rated as quality self-learning materials. If anything remains still obscure or difficult to follow, arrangements are there to come to terms with them through the counselling sessions regularly available at the network of study centres set up by the University.

Needless to add, a great deal of these efforts is still experimental—in fact, pioneering in certain areas. Naturally, there is every possibility of some lapse or deficiency here and there. However, these do admit of rectification and further improvement in due course. On the whole, therefore, these study materials are expected to evoke wider appreciation the more they receive serious attention of all concerned.

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POST GRADUATE ZOOLOGY
[M. Sc]

PAPER : PGZO - 8
GROUP : A(I)

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Group A (I)

Unit 1	❑ Introduction : public health and parasites	7-7
Unit 2	❑ Vectors and their importance in transmission of parasite	8-9
Unit 3	❑ Biology and importance of a few parasites	10-44
Unit 4	❑ Epidemiology : classification, epidemiology of malaria , kala azar, filariasis	45-54
Unit 5	❑ Zoonosis and its significance	55-62

Unit 1 ❐ Introduction : public health and parasites

The word 'parasite' (Gk. *Parasitos*) means 'one who eats at another's table' or 'one who lives at another's expense'. In fact, parasites have invaded every kind of living body, called the *hosts*, that generally provide food and shelter. The major groups of animal parasites are found among the Protista, the helminths and the arthropods. In 1956, Cameron defined a parasite as 'an organism which is dependent for some essential metabolic factor on another organism which is always larger than itself.' In his classical book published in 1976, Smyth also defined parasitism as an intimate association between two organisms in which the dependence of the parasite is metabolic. Many parasites apparently act as commensals, but are pathogenic when their numbers become unusually high.

Man has had great sufferings through the centuries because of parasites. Even today, diseases like, Malaria. African sleeping sickness, Schistosomiasis and other diseases have resulted in death of millions of people. Parasitic diseases plus nutritional deficiencies are still the primary killers of man. The majority of infections occur in the tropical countries. The figures of those infected by the animal parasites are astonishingly high. The general notion that the United States is free from worms, is not at all correct. An estimate states that about 55 million children there carry a burden of worms.

Man cannot completely shed off responsibilities in creating situations that allow parasites to spread. We have deforested huge areas for our habitations, constructed dams and irrigation canals for increasing our agricultural products and in doing so, the entire ecology of the world has changed. High population density and subsequent environmental pollutions are causing sufferings to millions of people, particularly the children. The resurgence of malaria is attributed to a change in the cultivation; tractors have replaced bullocks and buffaloes and the mosquitoes are now infecting more people with the malarial parasites.

Parasitologists and medical practioners have now the role to help achieve a lower death rate, with a concurrent lower birth rate and higher quality of life. More money should be provided for research on tropical infections.

Unit 2 ❐ Vectors and their importance in transmission of parasites

Structure

2.1 Definition

2.2 Types of vectors

2.3 Role of vectors

2.1 Definition

Arthropods and other invertebrates that act as hosts, as well as carriers, for protozoan and other smaller parasites and inject the next host are referred to as vectors. For example, various species of mosquitoes serve as vectors for the protozoan malaria parasites, *Plasmodium* spp. Although arthropods comprise the most common group of vectors, the role is not restricted to them. Lee (1971) pointed out that various groups of worms, including trematodes, cestodes and nematodes, are also known to serve as vectors for various microorganisms. Noble and Noble (1982), however, defined a vectors as an essential intermediate host, usually an arthropod, in which the parasite undergoes a significant change.

2.2 Types of vectors

Vectors in relation to the development of the parasites may be divided into the following types :

A) Propagative type : There is no cyclical change in the life history of the parasite but its multiplication will occur in the arthropod host.

Example : Example of this type of vector is the sandfly, *Phlebotomus argentipes* in the gut of which *Leishmania donovani,* the protozoan parasite causing Kala-azar or visceral leishmaniasis, only propagates by binary fission without undergoing any cyclical change.

B) Cyclopropagative type : Cyclical changes in the life history involving multiplication occurs within the arthropod host.

Example : *Anopheles* spp., the mosquito in which the malarial parasites of man, like *Plasmodium vivax,* multiplies along with cyclical changes.

C) Cyclical type : Cyclical change involving metamorphosis without actual multiplication occurs within the arthropod host, i.e., a single infecting form gives rise to a simple infective stage.

Example : The Culicine mosquitoes, *Culex* spp., in the gut of which the filarial worm, *Wuchereria bancrofti*, undergoes metamorphosis without any multiplication.

D) Paratenic type : In this case the parasite does not undergo development but remains alive and infective in another host, serving to bridge an ecological gap between the intermediate and the definitive hosts.

Example : Eggs of the nematode, *Spirocerca lupi* (Spiruroidea) are taken up by scarabeid beetles in which the larval stage of the parasite encysts. Such beetles with encysted larvae are eaten by paratenic hosts like lizards, chicken or mice. The encysted larvae remain viable all through while awaiting final host (cat or dog) that do not eat beetles. Thus the ecological gap is bridged with the help of the paratenic host which are eaten up by the definitive host.

2.3 Role of vectors

Vectors play very important roles in the epidemiology of parasitic infections. Vectors act as the transport media for parasites to be transmitted from one host to another. It has already been pointed out that vectors are hosts required for the completion of the life cycles of particular parasites. Trypanosomes of man cannot develop in another person unless these undergo some parts of their life cycles and the infective stage in the appropriate vector(s). As such, it is very important to study the biology of vectors like their habits, habitats life cycle patterns, overall behaviour etc. before any effective measures are adopted against any human or animal disease.

The roles of important vectors in the transmission of diseases have been discussed in details in Unit 3 under the heading "Biology and importance of parasites."

Unit 3 ❐ Biology and importance of parasites

Structure

3.1 ***Entamoeba histolytica*** **Schaudinn, 1903**

3.2 **Genus *Giardia***

3.3 **Pathogenic soil amoebae and Primary Amoebic Meningoencephalitis (PAM)**

3.4 **Genus *Leishmania***

3.5 ***Ancylostoma duodenale*** **(Hookworm)**

3.6 **The Fleas : Order Siphonaptera**

3.7 **Genus *Pediculus***

3.8 **Genus *Phlebotomus***

3.9 **Genus *Glossina***

3.10 **Mosquitoes**

3.11 **Probable questions**

3.1 *Entamoeba histolytica* Schaudinn, 1903

Genus *Entamoeba* includes many species that live as parasites in the invertebrate as well as vertebrate hosts. In these amoebae, there is a vesicular nucleus with a centrally or eccentrically located endosome with chromatin granules along the inner surface of the nuclear membrane.

The best known species under the genus *Entamoeba* is *Entamoeba histolytica* of man. The organism was first discovered by Lösch in 1875 in Russia and is the causative agent of amoebic dysentery or amoebiasis. *E. histolytica* has a world-wide distribution but its incidence is variable in different areas. Besides human beings, *E. histolytica* is common in apes and monkeys, and may also be found in pigs, dogs, cats and rats. There is a smaller, common, nonpathogenic form (race/strain), and much larger, virulent form. Although nearly 400 million people are infected globally, only a few fraction of this member have any clinical symptom.

Life Cycle

Entamoeba histolytica has the following four stages in its life cycle :—

(i) Trophozoite stage,
(ii) Precystic stage,
(iii) Cystic stage, and
(iv) Metacystic stage.

(i) Trophozoite stage

The mature mobile trophozoite of *E. histolytica* lives in the lower small intestine but is most common in the colon and rectum. It measures 15-60 μm in diameter (18-30 μm in the average). The trophozoite is typically monopodial which means that it produces a single large pseudopodium at a time in an eruptive manner. The cytoplasm is differentiated into a clear outer ectoplasm and an inner granular endoplasm. It contains food vacuoles that contain the host's erythrocytes, leucocytes, bacteria as well as fragments of epithetial cells. The vesicular nucleus measures 3-5 μm in diameter. It has

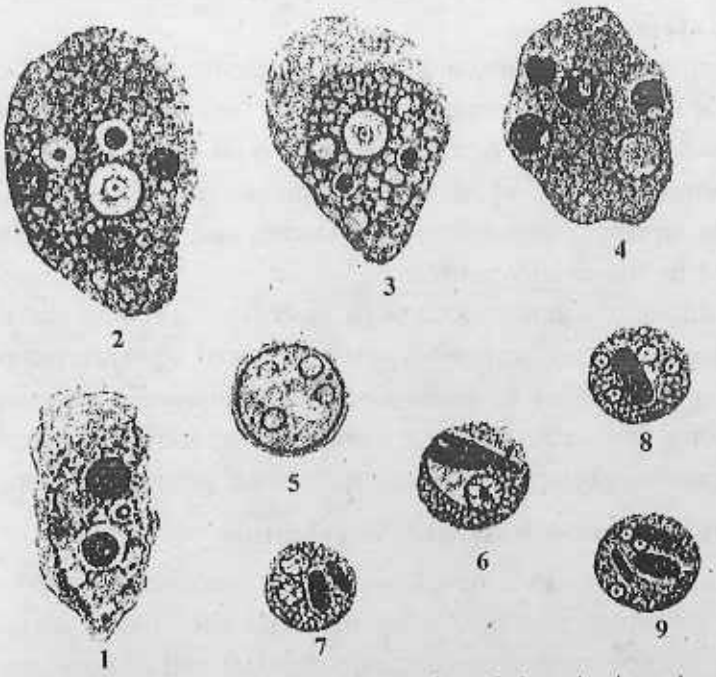


Fig 3.1 : *Entamoeba histolytica*. 1. a living trophozoite ; 2-4, stained trophozoites ; 5, a fresh cyst ; 6-9, stained cysts.

a distinct nuclear membrane containing an endosome which is centrally located. There is a layer of granules situated along the inner wall of the nuclear membrane. Often a ring of halo appears to surround the endosome.

Electron microscopic studies have revealed the presence of smooth endoplasmic reticulum and Golgi complex in the parasite. Ribosomes are abundant in the cytoplasm.

However, mitochondria do not occur in *E. histolytica* which is in agreement with our knowledge that the amoeba is essentially anaerobic.

The trophozoites multiply asexually by binary fission. In some cases these invade the epithelial lining of the large intestine of the host. Parasites' proteolytic enzymes are involved in the process. From the gut tissue, the parasites are carried away by blood circulation to several organs of the body like liver, lungs, brain, etc. Of these, the liver is the most preferred organ where trophozoites feed actively on cells causing severe damage leading to secondary complications.

(ii) Precystic stage

Frequently intestinal trophozoites assume a pre-cystic form, a stage that prepares the parasite to pass on to the next and the infective cystic stage. The body now becomes smaller and spherical and the food inclusions are excluded. Body movement is sluggish since the pseudopods are less frequently formed.

(iii) Cystic stage

Cysts are spherical and surrounded by a refractile cyst wall. Depending upon whether these are of larger or smaller strain, cysts measure 5-20μm (average about 12 μm) in diameter. Each cyst contains four nuclei of vesicular nature with centrally located endosomes. Presence of elongated chromatoid bodies with rounded ends is observed. These represent aggregates of ribosomes and nutrients including glycogen that are utilized as the energy source.

Cysts pass out of the body along with faeces and become the infective stage. Fortyfive million cysts may be passed in the faeces of one infected person per day.

Cysts are highly resistant to dessication and even certain chemicals: These can remain viable for a few weeks to a few months if kept moist. Cysts can not be killed in 50°C temperature and those in faeces on dry land survive for more than 12 days.

Transmission to new host and excystation

Upon ingestion of cysts by a new host through contaminated food or water, these pass along the digestive tract to the ileum, where excystation occurs. Cysts of *E. histolytica* may also be carried mechanically by flies and cockroaches or by people with unclean hands.

Excystation is the process of escape from confinement within the cyst wall. It starts with increased activity of the amoeba with the cyst. With rupture of the cyst wall, the single quadrunucleate amoeba— the *metacystic amoeba*— emerges and immediately undergoes binary fission giving rise to eight small amoebulae. These pass into the large intestine where they feed and grow to repeat the cycle.

Pathogenicity

The disease caused by *E. histolytica* is known as amoebic dysentery or amoebiasis. Symptoms include vomitting, mild fever, diarrhoea, blood and mucus in faeces, tenderness over the sigmoid region of the colon and hepatitis. The parasite may invade the intestinal mucosa in varying degrees and may cause minute sub-mucosal lesions or pitlike ulcers in a massive manner. Several factors like diet, stress, fatigue and cell-mediated immunity may influence the extent of invasion. It has further been reported that host-susceptibility also plays an important role in this regard.

The damage in the intestinal mucosa and invasion of tissues by trophozoites might be due to release of cytotoxic substances. Cytotoxins and enterotoxins may play a role in host diarrhoea. Host cells might be killed by soluble substances from killed amoebae. The initial damage of mucosal cells results from the action of lysomomes released by the amoebae. It has been reported that non-pathogenic enteric bacteria may cooperate with *E. histolytica* in producing pathogenicity through invasion of the tissue.

The parasite is not confined to the intestine alone. Once a lesion is made in the intestinal wall, the amoebae travel through the body by way of blood or lymph and invade any other tissue. Amoebae have been reported from all soft tissues ; however, the most common extra-intestinal locus is the liver, particularly the right lobe. Infection may be mild but a large abscess may also develop. Abscesses may also occur in the skin, the lungs, rarely the brain, the uterus and the vagina. Approximately 85% of human infections are non-symptomatic.

3.2 Genus *Giardia*

Members of the genus *Giardia* belong to the family Hexamitidae under the order Diplomonadia. These are characterized by a blunt anterior and a tapering posterior end.

Giardia intestinalis (G. lamblia) is a universal and common parasite in the upper small intestine of man, monkeys and pigs and is probably the best known example of the family. The flagellate has a trophozoite and a cystic stage in course of its life history.

Trophozoite

Motile trophozoites of *G. intestinalis* are 7 × 14 μm in the average (length 8-16 μm and width 5-12 μm). The body is somewhat pear-shaped with a broad anterior and a tapering posterior extremity. The dorsal surface of the body is convex; the

ventral surface is concave. This forms the adhesive disc, that acts as an attachment organella. The body is bilaterally symmetrical. There are two vesicular nuclei in the anterior half, two needle-like axostyles and eight flagella in two pairs. Two of these flagella originate near the anterior end of the axostyles, cross each other and follow the antero-lateral margin of the disc, and then become free ; two originating near the

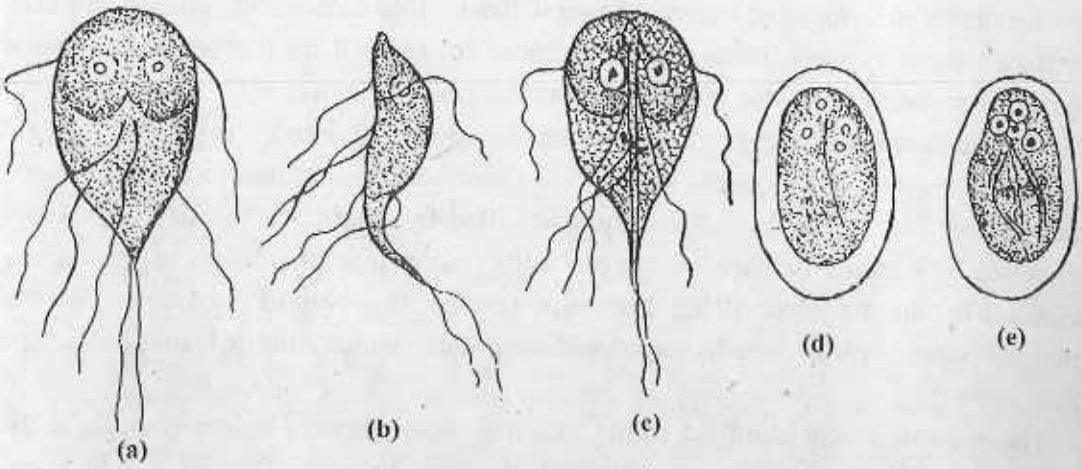


Fig. 3.2 : *Giardia intestinalis (a. front and b. side view of living organisms ; c. stained trophozite ; d. fresh and e. stained mature cysts).*

anterior part of the axostyles leave the body about one-third from the posterior tip; two ventral, which are thicker than others, originate in axostyles at nuclear level and remain free; finally, the two caudal flagella arise from the posterior tips of axostyles. The pellicle is distinct and the cytoplasm is hyaline. There is no cytostome. Electron microscopy has failed to detect any mitochondria in this flagellate. There is a pair of crescent-shaped parabasal bodies in the cytoplasm. When the flagella lash actively, the parasite shows a slight forward movement with a sidewise rocking motion.

Cyst

This is the infective stage, ovoid in shape and refractile in nature. It measures 8-14 μm in length and 6-10 μm in width. Cyst wall is thin. When fully mature, the cytoplasm contracts from the periphery so that there appears a gap in between these two. There are four vesicular nuclei, a comma-shaped parabasal body and deeply staining strands, in pairs. Cysts do not show the presence of mitochondria, endoplasmic reticulum and Golgi bodies.

Transmission

The passage of the cysts of *G. intestinalis* from host to host is effected by the

ingestion of cysts in contaminated food or drinking water, or from infected person who may have cysts on his body or clothes.

Pathogenicity

The disease caused by the parasite is known as *Giardiadis*. It is highly contagious. The manifestations range from asymptomatic cyst passage to severe malabsorption. Diarrhoea, abdominal cramps, fatigue, loss of weight, flatulence, anorexia, malaise, and bacterial overgrowth are also common symptoms.

Host-cell damage may be caused by direct contact with parasites or by the action of toxic substances produced by the flagellate. Adherence of a large number of parasites to the intestinal wall may interfere absorption of fats thereby causing a deficiency of fat-soluble vitamins. Although primarily a parasite in the small intestine, *G. intestinalis* occasionally invades the bile-ducts causing cholecystitis. Diagnosis is confirmed by the finding of cysts and trophozoites in the faeces under the light microscope.

3.3 Pathogenic soil amoebae and Primary Amoebic Meningoencephalitis (PAM)

Two genera of small, free-living amoebae belonging to the families Vahlkampfidae and Acanthamoebidae have drawn the attention of experts during the last few decades. The members of the genus *Naegleria* (fam. Vahlkampfidae) and the genus *Acanthamoeba* (fam. Acanthamoebidae) ordinarily live in the soil, water and sewage but under certain conditions become facultative parasites in man and primates and exhibit high degree of pathogenicity. Another genus, *Hartmanella* (fam. Hartmanellidae) does not enter into the human body, but invades several invertebrate groups.

The genus *Naegleria* was established by Alexeieff. One species, *N. gruberi*, exhibits facultative parasitism. The species is diphasic with an amoeboid and a flagellated stage. The former is 10-36 μm by 8-18 μm. There is a large lobopodium and the cytoplasm is clearly differentiated. The nucleus is spherical, vasicular and has a large endosome. There is a conspicuous contractile vacuole and the food vacuoles containing bacteria. The cysts are uninucleate. The flagellated stage is minute with two flagella. A parabasal body is seen attached with the flagella. Transformation from flagellated to the amoeboid stage takes place by the absorption of the flagella or by shedding of one or more flagella or casting off a part of the cytoplasm to which the flagella are attached. Species of the genus *Acanthamoeba volkonsky* are

also small, only 9-17 μm in diameter. Ectoplasm is not well-developed; the nucleus is vesicular with a large endosome. The mitotic figure is ellipsoidal and develops at

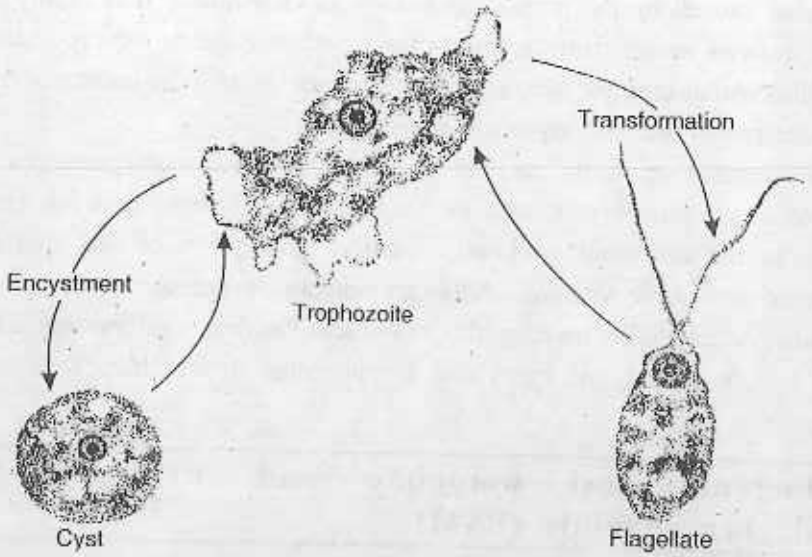


Fig 3.3 : Life Cycle of *Naegleria fawleri*

the end of metaphase. The cysts are spherical, 10-15μm in diameter and have a smooth inner and a much wrinkled outer wall. Common species are *A. castellanii, A. culbertsoni, A. hyalina,* etc.

The disease

The disease caused by the pathogenic soil amoebae is known as Primary Amoebic Meningoencephalitis or, briefly, PAM. It is characterized by high fever, nausea, rigidity of the neck and other symptoms related to the upper respiratory tract. Brain is severely affected where the olfactory lobes and the cerebral cortex are severely damaged. The disease is fatal since the infected person dies within two to three days in acute cases or after a more chronic course. The portal of entry of the amoebae is the nasal mucosa from where the amoebae reach the meninges and brain through the cribiform plate and the olfactory nerves.

Distribution

Cases of human Primary Amoebic Meningoencephalitis caused by these opportunistic amoebae have been reported throughout the world particularly the United States of America, southern Australia, England, Czech Republic and other countries. Victims were children and young adults, swimming in warm ponds, streams, swimming pools

including those filled with chlorinated water. In fact, every type of water system has been implicated as a source of pathogenic soil amoebae including the brackish and oceanic sediments.

3.4 Genus *Leishmania*

One of the most important parasitic protozoans are the members of the genus *Leishmania* (Order Kinetoplastida ; family Trypanosomatidae) causing a severe disease of human beings known as leishmaniasis. Three species, viz., *L. donovani, L. tropica* and *L. braziliensis* infect man but are morphologically indistinguishable. The genus is characterized by two different stages in the life cycle, each occurring in two distinct hosts. In the vertebrate host, the body is rounded or oval and called amastigote in which the flagellum never fully emerges out. In the invertebrate host the body assumes a promastigote form with a free flagellum.

Leishmania donovani is the causative organism of visceral leishmaniasis, also called the Dum Dum fever or Kala-azar, a disease that very often is fatal to human beings. The parasite is distributed in northeast India, Bangladesh, Sudan, the Mediterranean extending through southern Russia to China, northeast Brazil, Argentina, Paraguay, Mexico and some other countries.

The amastigote stage, also called the Leishman-Donovan body (L.D. body) measures 2 to 5 μm in diameter and in rounded or oval in shape. The cytoplasm is vacuolated and there is a vesicular nucleus, kinetosome and kintoplast. There is, no free flagellum. The parasite is lodged into the cells of the reticuloendothelial system, e.g., macrophages, monocytes and certain other cells of spleen, liver, lymph nodes and bone marrow in

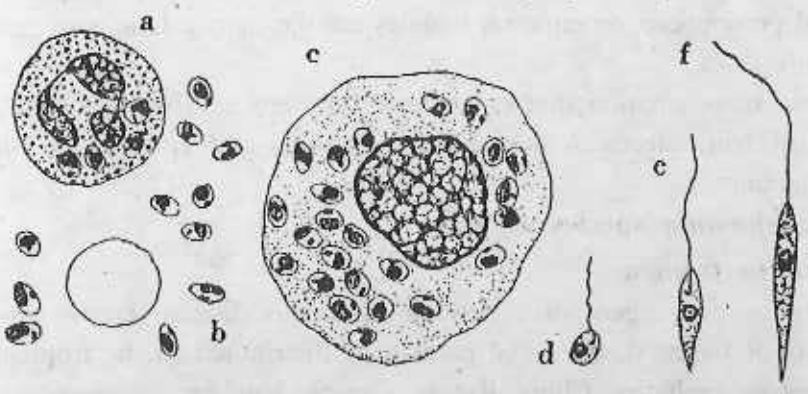


Fig. 3.4 : *Leishmania donovani, a, an infected polymopho-nuclear leucocyte ; b, organisms scattered in the blood plasma ; c. an infected monocyte ; d-f. flagellate forms which develop in blood-agar cultures.*

the mammalian host. Upto 100 parasites may be present in a cell and their reproduction is by binary fission.

When the parasitized host cells rupture, the amastigotes are released and are again engulfed by phagocytic cells. Sandflies, *Phlebotomas spp. (P. argentipes* in the Indian subcontinent), while biting an infected person, pick up both amastigote and parasitized cells. In the midgut of the insect, amastigotes, transform into large numbers of promastigotes by binary longitudinal fission within 3 days. Promastigotes are characterized by having an elongated body, a large vesicular nucleus and a free flagellum arising from the kinetosome near the anterior end of the body. Promastigotes arrive the pahrynx and mouth cavity by the fifth day. From here the flagellates easily migrate to the proboscis and are introduced again into the mamalian host when the sandfly bites again. The promastigotes are then engulfed by phagocytic cells and establish as intracellular parasites in the host body.

The disease

As already stated, *L. donovani* is the causative organism of Kala-azar in human beings. The disease is fatal. Another name, visceral leishmaniasis, has been attributed since several internal organs, especially the spleen and liver are involved.

The first response to the bite is a small skin sore. The parasites establish in the viscera, however, the incubation period is long. Initially, the patient complains of headache and weakness. Reticuloendothelial cells throughout the body are affected. There is a chronic course of the disease, characterized by irregular fever, increasing enlargement of the spleen and liver, anaemia and leucopenia. In untreated cases, death may occur in 2 months to 2 years. Post-Kala-azar dermal leishmaniasis may appear after about 2 years of acute Kala-azar in the viscera. Depigmented area of the skin and pronounced oedematous nodules are the manifestations of post-kala azar dermal leishmaniasis.

Pathogenic manifestation due to leishmaniasis are exhibited in dogs. In severe cases, loss of hair, ulcers in the lips and eye-lids and enlargement of liver are common symptoms.

Other *Leishmania* species of man

- ***Leishmania tropica***

It is the causative agent of a serious cutaneous disease known as cutaneous leishmaniasis or Oriental sore. The parasite is distributed in the tropical and sub-tropical countries including China, Russia, Greece, Southern Europe, Africa and the New World. The vectors are different species of phlebotomine insects like *Phlebotomus sergenti, P. papatasi, P. major;* etc. The life history of the flagellate is similar to that of *L. donovani.* It infects dogs and cats in addition to human hosts. *L. tropica* is an intra-cellular parasite of the endothelial cells around cutaneous sores.

Three types of cutaneous leishmaniasis have been reported. These are :

1) moist (rural), caused by *L. tropica major* : a lesion develops at the site of the bite, develops rapidly and subsides gradually;

2) dry (urban), affected by *L. tropica minor* : in which lesions grow slowly and ulcerate; and

3) relapsing type, where lesions enlarge slowly over years, healing at the centre and advancing peripherally.

Cutaneous eruptions most commonly occur on the hands, feet, legs and face.

- ***Leishmania braziliensis***

This is the third human-infecting species of *Leishmania* causing a severe disease known as mucocutaneous leishmaniasis or espundia and is distributed in most parts of the tropical and sub-tropical regions of the new world—Brazil, Paraguay, Argentina, Venezuala, Panama and some other countries. The infections have also been reported from Kenya, Sudan, India and China.

The life history of *L. braziliensis* is similar to that of the two other human species of *Leishmania*. However, some species of *Phlebotomus* and of *Lutzomyia* like *L. flaviscutellata, L. intermedius etc.* serve as primary vectors. Besides human beings, several other domestic and wild mammals are naturally infected. The bite of the infected sand fly forms a small, red papulae on the skin that forms an ulcer within 1 to 4 weeks but disappears by 1 ½ years. Secondary lesions appear involving the mucous membranes of mouth, nose and pharynx and results in complete destruction of these tissues. The ulcers are resistant to treatment. Uta, a more or less benign form is present in the arid areas of Peru, in which skin lesions heal spontaneously. Espundia may last for years and death results from secondary infection.

3.5 *Ancylostoma duodenale* (Hookworm)

Ancylostoma duodenale, the common hookworm of man, belongs to the super family Ancylostomatoidea. These are blood feeders occurring in the small intestine of various mammals, reptiles and amphibians.

Geographical Distribution

The two most important hookworms of man are *Ancylostoma duodenale*, the oriental species and *Necater americanus*, the American hookworm. Modern travel has provided ample opportunities for both to become worldwide in distribution. *A. duodanale* is found chiefly in Europe, Africa and the Oriental region. It is the dominant

hookworm species in the Mediterranean area, India, China and Japan. It has also been reported among Paraguayan Indians as well as in the Caribbean. It has been

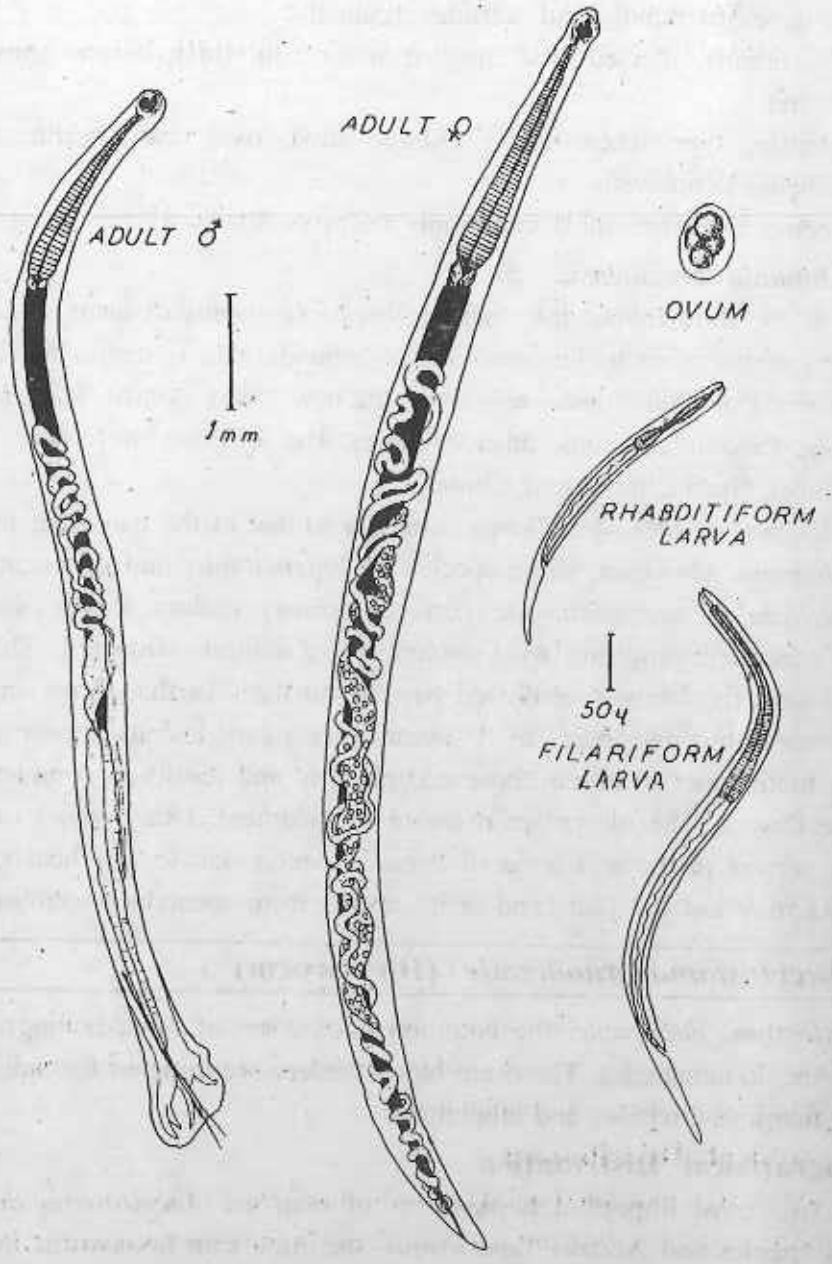


Fig. 3.5 : *The hookworm Ancylostoma duodenale*

known to occur in coal mines in Belgium and Great Britain and was responsible for

a type of anaemia among the miners. Construction workers in Switzerland, Germany and Italy were also affected.

Structure

A. Male :

1) 8 to 11 mm × 0.4 to 0.5 mm in size.

2) Posterior end of the body is flared and forms a bursa supported by fleshy rays with a characteristic pattern.

3) A pair of long spicules passes from the genital canal to the outside through cloaca.

4) A *gubernaculum*, sclerotized as are the spicules, is also used during copulation to guide the spicules.

B. Female :

1) Averages 10 to 13 mm × 0.6 mm in size.

2) Posterior end of body tapers to a blind point.

3) Vulva located at a point about two-thirds the length of the body from the anterior end.

4) Eggs ovoidal, thin-shelled and measure 56 to 60 µm × 34 to 40 µm.

5) Eggs found in the faecal examination are already in the early stages of segmentation.

C. Common features :

1) Both males and females have a buccal capsule containing teeth or cutting plates.

2) Male bursa is commonly conspicuous.

3) The name "hookworm" is said to have derived from the position of the anterior end, which is bent backward (dorsally).

4) It is also purported to derive from the hook-like appearance of the bursal rays.

5) Alimentary system is a simple tube—mouth leads to a buccal capsule, thence to a muscular esophagus that empties into the intestine. Intestinal cells are rich in mitochondria, Golgi complexes, ribosomes, glycogen, protein bodies, lipid granules and endoplasmic reticulum. Food consists of host blood and tissues.

6) Female reproductive system consists of a long tubule that forms the vagina opening through vulva. Distal end terms the ovaries, then the oviduct, and the remainder, the uterus.

7) Males have a simple testis which is the distal end of a long coiled tube that continues as the vas deferens and opens in the cloaca. Transfer of sperm to the female worm is aided by a pair of spicules.

Life cycle

1) Starts with a fertilized egg that, by the time reaches the soil, is well on its way to becoming a larva.

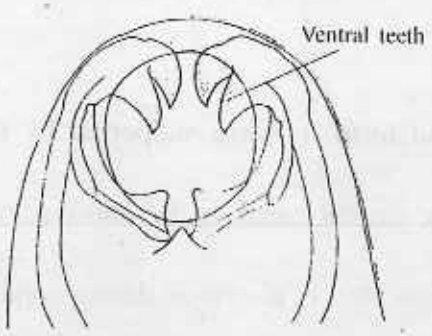


Fig 3.6 : *Ancylostoma duodenale,* buccal capsule

2) The daily output of eggs from a single female worm is probably 10,000 to about 30,000.

3) Within 24 hours in moist, warm soil, rhabditiform larvae hatch from the eggs. Free O_2 is essential for hatching and for further development.

4) Larvae grow rapidly, molt twice and in about a week, become non-feeding, slender and filariform. *This third larval stage is infective to man.*

5) Young worms crawl to a high point of dirt, vegetation or bit of rock, so long as it is moist, and wait for a new host to come along.

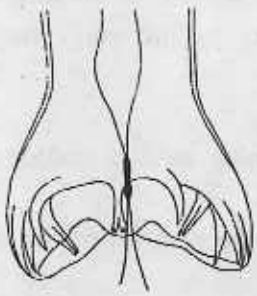


Fig 3.7 : A. *duodenale, dorsal view of bursa*

6) If a filariform larva comes into contact with the skin of a new host, it burrows into the skin and, if it is deep enough, enters a blood or lymph vessel. When migrating larvae reach intestinal mucosa, they molt and become adults.

7) A patient suffering from severe hookworm disease may discharge with his faeces 6 million eggs per day. A single hookworm may produce upto 80 million eggs in its lifetime of 1 to 9 years.

Fig 3.8 : *A. duodenale, caudal end of female*

8) A study in India showed that *A. duodenale* larvae do not always develop directly to adulthood on invasion of man. There might be seasonal occurrance of dormant parasitic stages to overcome unfavourable seasonal conditions.

Human hookworm disease

Hookworm disease has been, and remains, among the most prevalent and important

of the parasitic diseases of humans. Unlike malaria, amoebiasis or schistosomiasis, hookworm disease may not be clinically spectacular, yet it can affect the entire populations by gradually sapping its victims of thin strength vitality and health. Daily loss of blood due to this disease has been estimated as the equivalent of the total volume of blood of 1,500,000 persons. The victims become lethargic and nonproductive resulting in economic losses beyond computation. The hookworm disease has neither been controlled nor eradicated. It remains a major public health problem in many parts of the world, especially in developing countries.

The pathogenesis of human hookworm disease is divided into the following three steps :

(A) Invasion phase : Commences when the infective larvae penetrate the skin. The damage is inflicted to the superficial skin layer, but the larvae while penetrating the blood vessels, stimulate a cellular reaction that may isolate and kill them. This, combined with the stimulatory effects of pyogenic bacteria introduced into the skin with the invading larvae, results in a urticarial reaction commonly known as *ground itch.*

(B) Migration phase : This phase occurs when larvae escape from capillary beds in the lung, enter into the alveoli and progress up the bronchi to the throat. This migration causes haemorhages that could be serious if a large number of worms are present. Otherwise dry cough and sore throat are the common symptoms.

(C) Intestinal phase : Most serious phase in hookworm infection. On reaching intestine, young worms become attached to the mucosa by their buccal capsule and teeth and commence to suck blood. This results in iron-deficiency anaemia, and is accompanied by intermittent abdominal pain, loss of appetite and a craving for soil (geophagy). In heavy infections, severe protein deficiency, dry skin and hair, oedema, distended abdomen, delayed puberty, cardiac failure, mental dullness and even death may occur.

Larva migrans

Hookworms of animals, for which humans are incompatible hosts, often attempt to penetrate skin of man. These normally fail to pass through the stratum germinativum of the skin and migrate for some time at that level causing a skin eruption known as *cutaneous larva migrans,* or creeping eruption. For example, larvae of the cat hookworm, *Ancylostoma brasiliensis,* may wander into the skin of man and causes creeping eruptions. This is characterized by visible tracks with red, painful and swollen advancing ends, often associated intense itching.

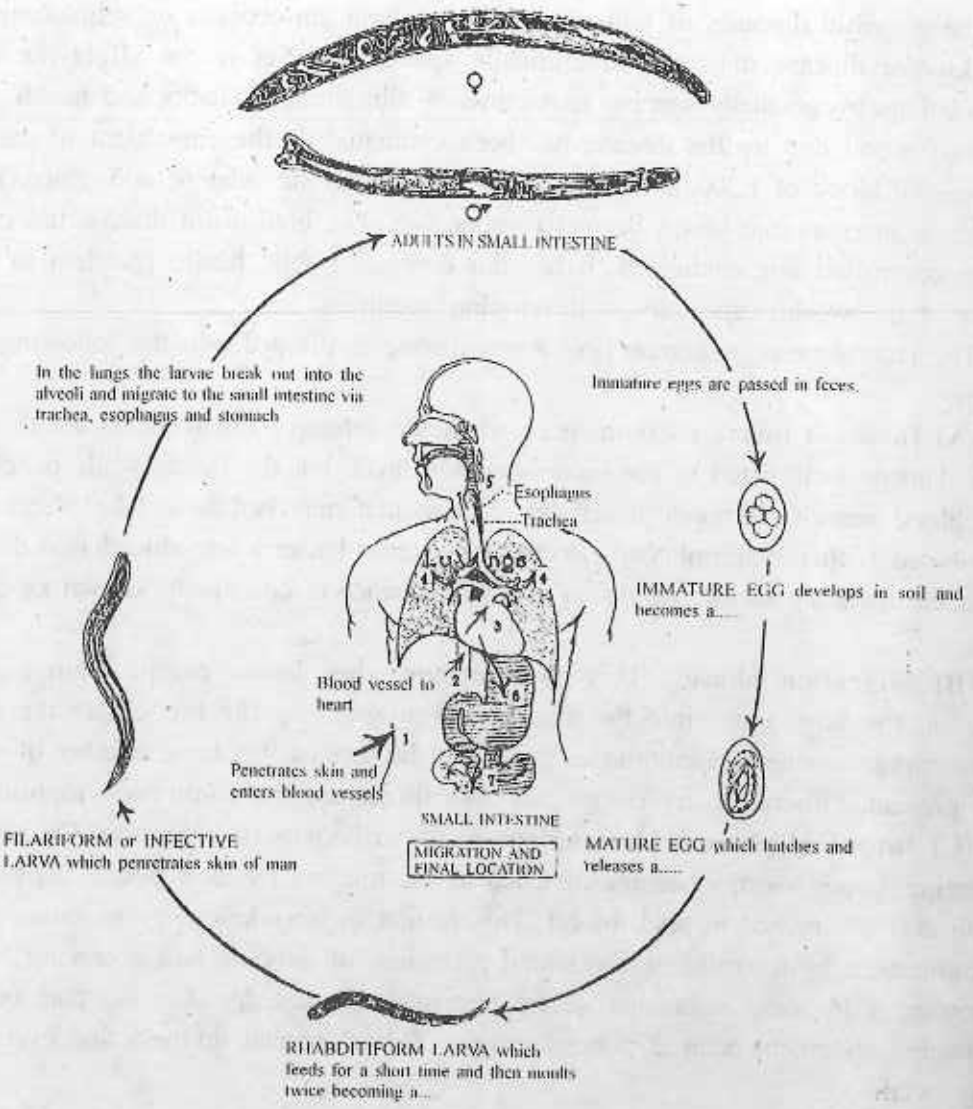


Fig 3.9 : Life cycle of hookworms

3.6 The Fleas : *Order Siphonaptera*

The Siphonaptera includes the fleas. Over 2000 species of these blood-sucking ectoparasites are known. These predominantly parasitize mammals although about 100 species are parasitic in birds.

The origin and evolution of fleas remain highly speculative. Most agree, however, that the fleas of mammals have evolved from the fleas of birds. It is quite possible

that the bird fleas, found in nests, have become adapted to tree-climbing mammals, which in turn, have passed them on to the terrestrial mammals.

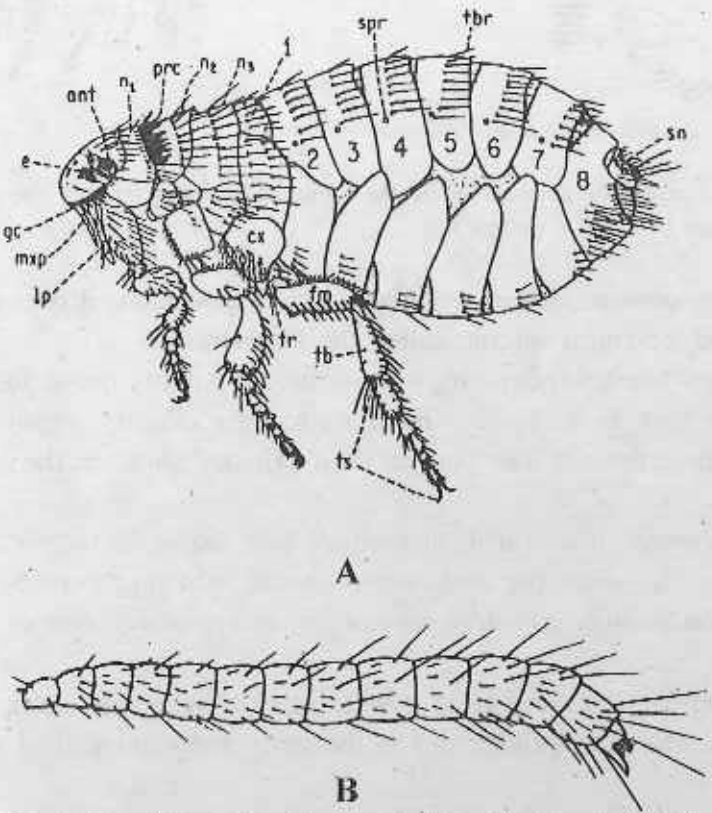
Interest in fleas among parasitologists stems from three avenues of investigation—that concerned with the blood-sucking habits of these pests, that concerned with fleas as vectors for pathologic microorganisms and that concerned with the fleas as intermediate hosts of helminth parasites.

Structure and life cycle

1) Body laterally compressed.

2) Coxa, the first segment of each leg, is large and aids in the jumping ability for which fleas are justly famous.

3) The slippery body, the backward directed spines, and the strong, active legs tipped with claws enable fleas to jump from one host to another and to move easily among hairs and feathers.



A

B

Fig 3.10 : *A.* An adult cat flea, *Ctenocephalides felis* (bouche) ; *B.* Larva.

4) Antennae of males are nearly always longer than those of females.

5) Male body has an upward tilt posteriorly, whereas the female body is evenly rounded posteriourly.

6) Fleas are truly encased in a suit of armour, and each segment of thorax, prothorax, mesothorax and metathorax may be regarded as a membranous ring of adjoining plates.

7) Notum of prothorax is armed with a row of heavy, pigmented spines called the *pronotal Ctenidium* or *pronotal comb.*

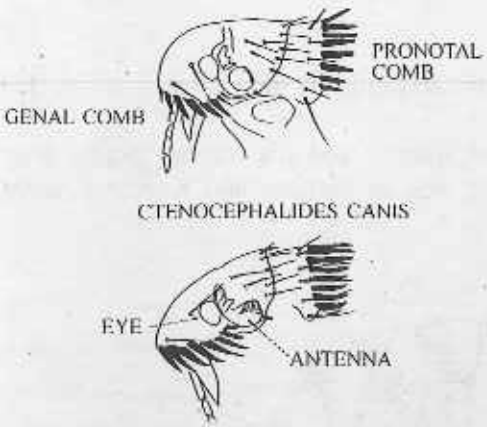


Fig 3.11 : Head of *Ctenocephalides canis*, the dog flea, and of *C. felis*, the cat flea.

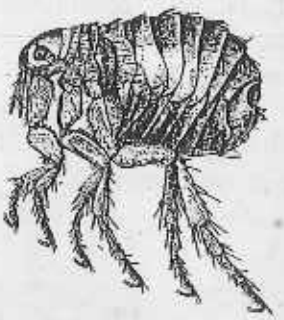


Fig 3.12 : *Pulex irritans*, the human flea, adult female, greatly enlarged.

8) Abdomen consists of ten segments; each segment has a dorsal sclerite called the *tergum* and a ventral sclerite called the sternum.

9) The plates overlap, permitting considerable flexibility inside the abdomen.

10) Tergum nine in the male is modified to form clasping apparatus used during copulation with a female. The clasper is of primary value in the identification of males.

11) Ninth segment in both male and female fleas has on its tergum a dorsal sensory plate called the *pygidium* (or *sensitium*) covered with pits, bristles and hairs.

12) The structure suggests a tiny pin-cushion, and possibly functions in the detection of air currents.

13) The spermatheca consists of a wide *head* or *reservoir* and a terminal, long, sausage-shaped *tail* or *appendix*. this is the most important genital structure of the female flea.

14) Alimentary canal is the internal organ system of particular importance in disease transmission :

(a) mouth leads to a thick-walled pharynx equipped with pumping muscles, thence to a narrow gullet or oesophagus, which enters into a pear-shaped proventriculus or gizzard.

(b) Gizzard is provided with a series of spines internally that projects backwards in front of the entrance to the stomach.

(c) Spines help to crush blood cells of the host.

(d) Between gizzard and stomach is a valve that prevents the food in the stomach from being vomitted during the process of digestion.

(e) At the posterior end of stomach are situated four tubular glands that function as kidneys.

(f) Intestine is short and equipped distally with six small, oval rectal glands.

(g) A pair of salivary glands lies on each side of the stomach.

Feeding behaviors

During the process of biting and feeding, the piercing mouth parts enter the host skin and the flea thrusts its head downward, elevating the abdomen and hind legs. At the end of the meal, the mouth parts are withdrawn with a sudden jerk. When a flea bites, the salivary pump pours out a stream of saliva that reaches the host blood vessels through a grove on the inner surface of the laciniae. At the same time, pharyngeal pump works to draw up the host blood, mixed with saliva, and forces it into the oesophagus and stomach, where it is digested.

Life history and habits

1) During copulation, the male takes up a position underneath the female and holds her firmly with his antennae from below. Tergum nine in the male is modified to form a clasping apparatus used during copulation with the female.

2) During their life cycles, fleas pass through a complete metamorphosis from egg to larva to pupa to adult.

3) Eggs are large, smooth, oval and translucent. The human flea, *Pulex irritans,* may lay over 400 eggs during her life time.

4) In 2 to ten days eggs hatch into eyeless, legless but active larvae. The body segments bear numerous bristles.

5) Under favourable conditions, larvae may reach their third stage in about two weeks; these feed on various organic debris found in the host's nests, crevices in floors, and under rugs.

6) Larvae molt twice before reaching the third stage. Each larvae then spins a cocoon within which it pupates. Larval stage may last for 24 weeks. Pupae may live for 4 week up to a year. The entire life history may be as short as 18 days or it may last for many months.

7) The fully formed adult flea may be quiescent for an indefinite period before it begins an active existence.

Important species

A) Genus *Ctenocephalides* : This genus includes approximately 10 species commonly found on carnivores. The most familiar of these are *Ctenocephalides canis*, the dog flea and *C. felis*, the cat-flea. These species are not host specific because both species bite both dogs and cats as well as humans.

In addition to causing dermal irritations while feeding, *C. canis* is a suitable host for the dog tapeworm, *Dipylidium caninum*.

B) Genus *Xenopsylla* : Over 35 species of *Xenopsylla* are known. *X. cheopis*, the asiatic rat flea is the most commonly encountered species. A major vector for *Yersinia pestis*, both male and female fleas take in the bacillus from infected rats while feeding.

The bacillus after being taken, continue to multiply inside the flea. The bacteria are limited to the stomach, intestine and rectum an never in the salivary glands. Consequently infection is brought about in humans by the rubbing of contaminated flea faeces into fresh bite sites. Transmission is also possible during bite through the mouth parts but never through the salivary gland.

Flea-borne diseases

I. Plague

The disease commonly referred to as plague (the "black death") is caused by the bacillus, *Yersinia pestis*. With the introduction of the bacterium into the skin, the lymph glands become inflammed, the condition known as *bubonic plague*. When established in the blood, the condition is known as *septicemic plague* and when lungs are involved it is called the *pneumonic plague*. Bubonic plague is fatal in about 25 to 50% of untreated cases, and the other two are usually fatal.

After a 2-4 days of incubation period, there is a chill followed by high temperature upto 40°C. Lymph glands swell and become haemorrhagic. Mental anxiety, followed by delirium and coma cause death within 5 days. The rapid and serious effects of plague are due to toxins released by the bacterium. Rats and mice appear to be more sensitive than rabbits, dogs and primates. Plague among rodents is known as *sylvatic plague*.

II. Murine Typhus

Fleas serve as vectors for murine typhus organism, *Rickettsia typhi*. The organism is transmitted via contaminated flea faeces which are rubbed into bitten wound. Fleas contact the rickettsiae while feeding on either infected human or infected rats and mice. The organisms become intracellular parasites within midgut cells of fleas where they multiply.

In man, murine typhus is a mild disease that lasts for about 14 days. There is chill, severe headache, body ache and a rash. It is more severe among the elderly persons.

III. Myxomatosis

Myxomatosis, a commonly fatal disease caused by the myxoma virus, is a threat for rabbit raisers in England. This virus is transmitted by several arthropods including mosquitoes, flees and mites. Among these, the flea *Spilopsyllaes cuniculi* is a common vector in Great Britain. The virus was intentionally introduced into Australia to control the rabbit population, but this venture failed. More recently *S. cuniculi* has been introduced into Australia together with more virulent strains of the virus. This combination holds greater promise for rabbit control.

IV. Tapeworm Infection

Dipylidium caninum, the common tapeworm of cats and dogs occurring in the faeces of the host will be taken up by the larvae of *Pulex irritans*, *Ctenocephalides canis* and *C. felis*. Within the body of the adult flea, cysticercus stage of the tapeworm develop. Dog swallow such fleas while licking its body and the infection is established. Man, especially children, accidentally acquire infections by ingesting the infected flea.

V. Round worm Infection

Dipetalonema reconditum, a filarial parasite of dog, develops in *C. felis* and *C. canis*. The infected flea is swallowed by the dog thus acquiring the infection.

3.7 Genus *Pediculus*

The genus *Pediculus* belongs to the family Pediculidae of the Order Anoplura or the sucking lice whose mouth parts are modified for sucking rather than biting as in the order Mallophaga. All members of the anoplurans are ectoparasites of mammals and feed on the host's blood sucked through the mouth parts.

The family includes two medically important species— the body louse or *Pediculus*

humanus and the crab louse or *Phthirus pubis*. *Pediculus humanus* occurs in two forms. The head louse, *P. humanus capitis* and the body louse, *P. humanus humanus*. *P. humanus* is a major vector for three important human diseases, viz., relapsing fever, louse-borne typhus and trench fever.

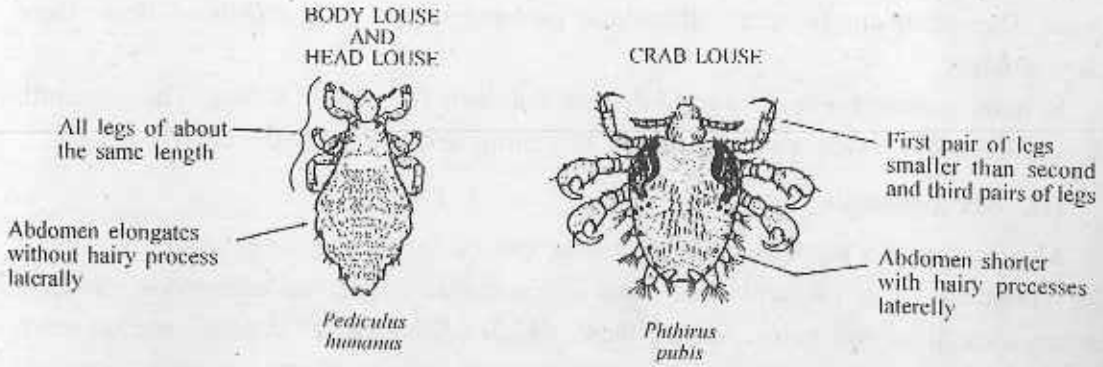


Fig. 3.13 : Lice commonly found on man.

Structure

The two subspecies of *P. humanus* look much alike. They overlap in appearances and movements. However, body lice are seldom found on head, while head lice attach themselves to hairs ; body lice also find their place in clothings. The two subspecies can interbreed and give birth to fertile off-spring possessing characters intermediate between the two parents. According to some authorities, the two subspecies are merely races or forms of the same species.

In general, *P. humanus* is grayish in colour. Males are 2-3 mm long and the females are 3-4mm long. These have characteristic piercing mouth parts, their thorax is small and fused and the antennae are usually composed of five segments which are always visible. Eyes are small and the third pair of legs is the largest, often broad and flattened. Each tarsus has only one claw. There is a single pair of spiracles that opens on the dorsal side of the mesothorax. Only seven of the nine abdominal segments are visible externally. The piercing mouth parts are retracted into the head when not in use.

Life cycle

The life cycle of *P. humanus* follows the general rule as in the anoplurans and mallophagas and is *hemimetabolous* in nature. Here the newly hatched larvae are similar to the imago and their feeding habits are also similar. The eggs are whitish in colour and less than 1 mm or slightly larger according to the races. A single female lays between 80 and 100 eggs (this number is between 200 and 300 in the

other form). The minute eggs attach firmly with the hair or clothing by a cement-like excretory product. Eggs hatch in 5 to 20 days and the emerging forms are known as nymphs which are just like miniature adults. However, their antennae have three segments, instead of five as in the adults.

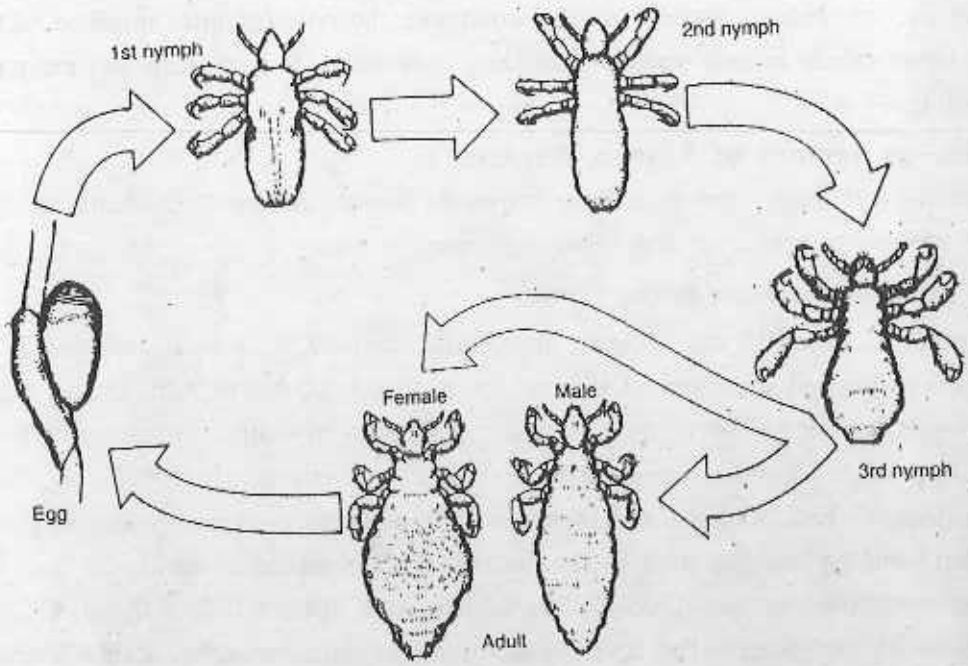


Fig. 3.14 : Life cycle of head lice, *Pediculus humanus capitis*

Development is rapid, and the adults are formed after two nymphal instars. Under suitable temperature (between 23°C to 38°C), life cycle is completed in three weeks. The young forms require immediate feeding upon hatching, otherwise these die within 24 hours. Females have a larger life span of 33 to 40 days than the males.

Method of copulation

Copulation of male and female *P. humanus* is completed on their host. During the process, males crawl underneath the females from behind. When the tips of their abdomen unites, the female rises to a vertical position thereby lifting the male above. Finally, the female and the male return to a horizontal position in which condition they remain for 30 minutes or more.

Effects of biting of lice on their hosts

When the lice bites, the saliva injected into the wound prevents the host blood from coagulating as it is sucked through the parasite's mouth parts. The reaction of

the host cells to the louse saliva causes symptoms of irritation. The inflammatory reaction of the host skin results in a thickening of the epidermis and an increase in tissue lymphocytes, monocytes, mast cells and fibroblasts. Human skin subjected to louse bites for a long period may become deeply pigmented resulting in a condition known as "vagabond's disease". In this condition, the host becomes immune to louse bites. Other effects include scratching of skin, restlessness, loss of sleep and interruption in feeding.

Lice as vectors of human diseases

Pediculus humanus transmits three important human diseases : epidemic or louse-borne typhus, trench fever and relapsing fever.

1. Epidemic of louse-borne typhus

Typhus is caused by the obligate intracellular bacteria, *Rickettsia prowazekii*. This is a much dreaded disease and is now limited to Asia, North Africa, and Central and South America. The disease is associated with crowding, stress, poverty and mass migration. Mortality rates during epidemics may be nearly 100%.

Incidentally, both Ricketts and Prowazek, the pioneers in typhus research, became infected with typhus and died in the course of their research work.

The symptoms of the disease start with a high fever of 39.5°C- 40°C which continues for two weeks. The fever is accompanied with backache, severe headache, bronchopneumonia and also bronchitis. There may be malaise, loss of appetite, vertigo and also the face becomes flushed. Skin rash appears on 5th or 6th day involving several body parts. After two weeks, there is profuse sweating and the fever subsides. Now the patient either starts recovering or there may be further involvement of the central nervous system and death. Those who survive, become asymptomatic and are capable of infecting lice.

2. Trench fever

This is a non-fatal disease caused by the rickettsia, *Bartonella quintana*, transmitted by *Pediculus humanus*. Trench fever is not very common today but was observed during the World Wars I and II. Now-a-days, small endemic foci have been discovered in Egypt, Algeria, Ethiopia, Japan, China, Burundi, Bolivia and Mexico. The rickettsia is introduced into the human body through contaminated louse faeces. It is an extracellular pathogen in man but not pathogenic for lice.

An infected person experiences headache, body pain and malaise in about 10 to

30 days of the entry of the pathogen. Body temperature rises rapidly to about 39.5°C-40°C. This is accompanied dizziness and pain in the eyes. A rash appears on the chest, abdomen and back but disappears within 24 hours. Fever continues for several weeks and thus recovery is very slow. Although non-fatal, trench fever is thus highly debilitating.

3. Relapsing fever

This is the third important human disease transmitted by body lice and is caused by a spirochete. *Borrelia recurrentis.* Mortality rate in low but may reach upto 50% in undernourished people. Lice become infected with the pathogen while feeding but the spirochetes penetrate the lice-gut to reach haemocoel where they multiply. Since these neither penetrate the salivary glands, gonads nor malpighian tubules, transmission is, therefore, only possible when a louse is crushed by the host-scratching which relases the spirochetes. Thus, the pathogens enter the human body through abraded skin. However, the organisms may also penetrate unbroken skin.

After an incubation period of 2 to 10 days, the victim experiences headache, dizziness, muscle pain and a fever that develops rapidly. Body rash is common. After 4 to 5 days of severe illness, body temperature suddenly falls which is accompanied by profuse sweating. The cycle may be repeated several times in untreated cases.

Louse-borne relapsing fever still occurs in small endemic foci in South America, Europe, Asia and Africa.

Control

The basic defense against human lice involves personal cleanliness of body and clothing. Laundering of body garments including dry cleaning of woolens generally control body lice population. Rinsing of hair with a low concentration of the insecticide permethrin yields good results. However, reports are pouring in which show that permethrin resistance has also developed. Extensive combing and picking head lice help reduce their numbers.

3.8 Genus *Phlebotomus*

The largest and most important species of the family Psychodidae (order Diptera) is *Phlebotomus,* to which belong a large number of blood-sucking psychodids, commonly known as *sand-flies.* The flies are seldom more than 4 mm long. Only the females possess piercing-sucking mouth parts and are haematophagous. The males are non parasitic. *Phlebotomus* spp. are nocturnal insects and are limited to the Old World.

Distribution

As already mentioned, all species are native to the Old World, including the Orient and Africa. In general, these flies are limited to the warmer regions of the world.

Species

Phlebotomus papatasi is the common sandfly in the Old World. It is a serious pest in eastern Europe. It is anthropophilic and feeds on blood biting around the ankles and the wrists. The species measures about 2.5 mm in length and is yellowish gray with a dull, red-brown stripe extending longitudinally down the mid-dorsal line of the thorax and with a reddish-brown spot on each lateral surface of the same region. *P. argentipes* is widely distributed in areas of India and Myanmar (Burma), where it primarily feeds on cattle blood, although it attacks humans. *P. sergenti* is widely distributed in the near East and Northern Africa.

In general, species of *Phlebotomus* are small, slender specimens with hairy bodies. Their colouration in dull, usually yellowish. The legs are long and lanky, and when the flies are at rest, their wings are separated.

Life cycle

i) Breeding spots are usually hidden and difficult to find.

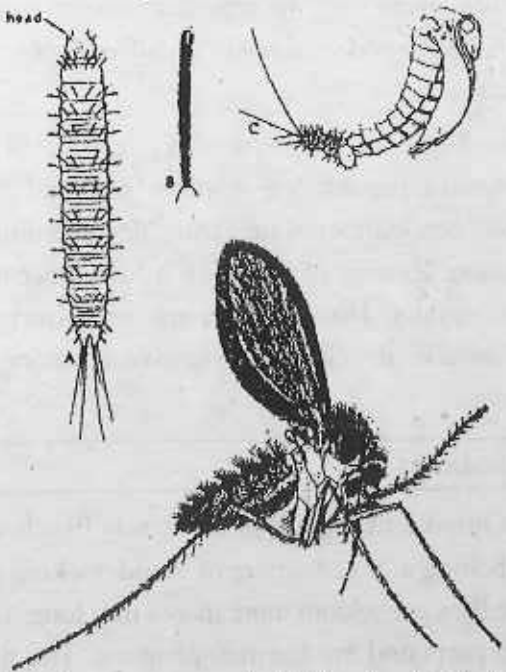


Fig. 3.15 : Larva, pupa, and adult female of *Phlebotomus*

ii) Elongated eggs are oviposited in small batches under stones, in massonry cracks and in similar out-of-the way spots where the temperature is moderate, the environment dark and the humidity high.

iii) Laying habits of the females vary but can be categorized in one of there patterns. The flies feed and refeed several times before ovipositing a batch of eggs.

iv) Eggs of *P. papatasi* incubate for 9-12 days after which minute whitish larvae with long anal spines and chewing mouth parts emerge. Incubation period in other species approximates that of *P. papatasi.*

v) Larvae are free living, feeding on organic debris such as animal excreta. There are four larval instars, the stadia, totalling 4 to 6 weeks. The 4th larval instar metamorphoses into pupa which is not enclosed in a cocoon. This stage lasts for 10 days. Egg-to-egg cycle require 7 to 10 weeks.

Sandflies as vectors

(A) Several species of *Phlebotomus* are suitable vectors for the human-infecting species of *Leishmania. P. argentipes* is the vector for *L. donovani* in India ; *P. chinensia* and *P. sergenti* are the major vectors in China and Africa respectively. As is known, species of *Leishmania* cause a severe disease in man called Leishmaniasis or Kala-azar. Human infections are acquired when flies are crashed and rubbed into the bites; however, infections can also be acquired through bites.

P. papatasi and *P. sergenti* are principal vectors for *L. tropica.* Here also infections can be acquired both mechanically and through bites.

(B) *Sandfly fever,* also known as three-day fever or *papatasi* fever, is a non-lethal disease endemic to the Mediterranean countries, central Asia, South China, parts of India and Sri Lanka and sections of South America. The etiological agent is a virus that is injected into the humans during feeding of the flies and the clinical symptoms appear after 3 to 6 days of incubation. *P. papatasi* and *P. sergenti* serve as suitable vectors.

(C) *Bartonellosis* produces anaemia that is humans is sometimes fatal. It is endemic to Peru, Columbia, Bolivia, Chile and Equador. The causative bacterium, *Bartonella bacilliformis* is found in RBCs in circulating blood and visceral organs. The disease manifestations are fever, accompanied by bone, joint and muscle pains, anaemia and jaundice. Sandflies of the genus *Lutzomyia* are responsible for the spread of the disease.

3.9 Genus *Glossina*

The genus *Glossina* includes tsetse flies which are important not only as the

vectors for certain trypanosomes but also because both the males and females are haematophagous. Their bites result in large wells. Although *Glossina* at one time was widely distributed, it is now concentrated to continental Africa south of the Tropic of Cancer.

Species

Newstead, in the year 1924, provided description of the 20 species of *Glossina*. The most prominent ones are *G. palpalis*, the major vector of Gambian trypanosomiasis, *G. morsitans*, the major vector for Rhodesian trypanosomiasis and *G. swynnertoni*, another vector of Rhodesian trypanosomiasis. Although these flies feed on an array of vertebrate hosts, they definitely demonstrate preference for some. For example, *G. palpalis* favours crocodiles, monitor lizards and other reptiles, *G. morsitans* prefers pigs and warthogs.

Life cycle

(i) The life cycle of *Glossina* spp. follows the basic pattern of the cyclorrhaphan flies, but a few striking differences exist.

(ii) The female gives birth to fully developed living larvae.

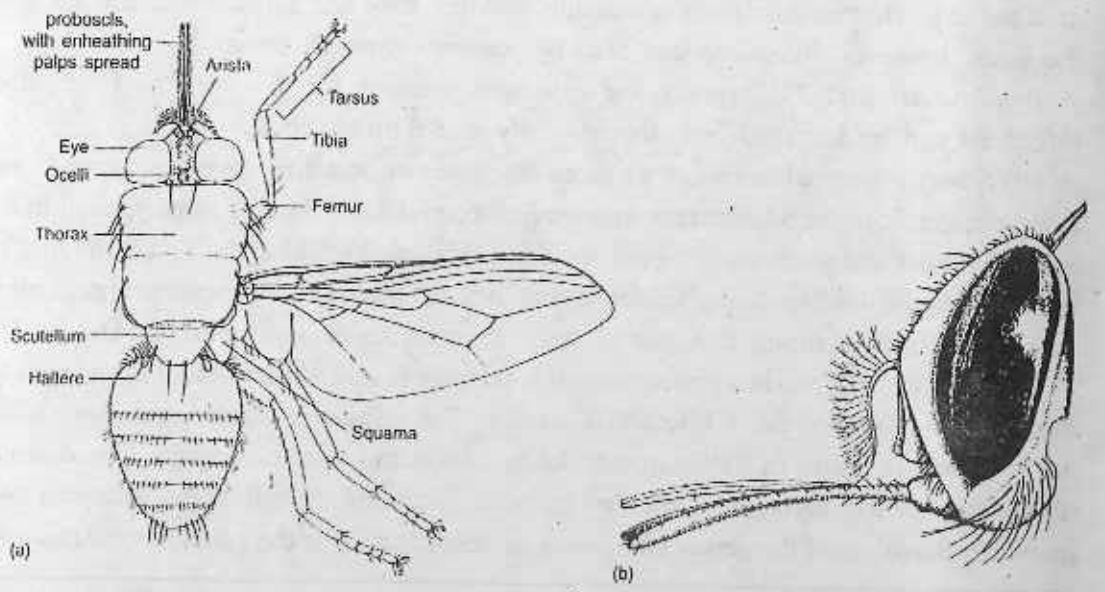


Fig. 3.16 : A tsetse fly with general anatomical features labelled. (a) Dorsal view of *Glossina* showing general anatomical features. (b) Lateral view of head showing proboscis and palps.

(iii) Actually, the larviposited form is the 4th larval instar, for the *in vitro* development involves not only embryonic development, but also three larval stages.

(iv) The *in vitro* larvae feed on the secretions of specialized glands, commonly referred to as *milk glands.*

(v) The 4th stage larvae are deposited at intervals of 10-12 days singly, a total of 8 to 10 larvae being deposited by a single female during her life span.

(vi) Larvipositing females require a blood meal between extrusion of the larvae, and development of the larvae is not completed until blood is ingested by the mother.

(vii) The extruded larvae are off-white to pale yellow and are not capable of the usual worm-like movement.

(viii) Larvae are deposited at the base of shrubs and other vegetation, where the soil is damp and loose.

(ix) Larvae burrow into the soil and undergo pupation. This usually occurs within 1 hour after birth.

(x) The pupa within the puparium is ovoid and brownish-black and bears two characteristic lobes.

(xi) Usual larval period lasts from 3 to 4 weeks.

(xii) Soil moisture and temperature are important influencing factors.

(xiii) The form escaping from the puparium is the adult. It is brownish and bears the distinguishing characters.

Glossina as vector

Apart from the economic losses in domestic animals, trypanosome infections merit interest since two subspecies of *Trypanosoma brucei*, viz., *T. b. gambiense* in west equatorial Africa and *T.B. rhodesiense* in east equatovial Africa are infective to man and both cause *African sleeping sickness.* These haemoflagellaters are transmitted via the bite of *Glossina.* After uptake of infected blood, there is at first a multiplication of the parasites in the gut of *Glossina* followed by their migration into the salivary glands; there, at first they multiply further in the epimastigote stage, and finally change back into an infective trypomastigote form which will be transmitted to the vertebrate host when it is bitten by the insect.

T. b. gambiense infection in man is demonstrable in the blood after about one week. There is periodic alternation of parasitic multiplication with subsequent destruction by specific host antibodies, in which the parasite changes its antigenic character each time at the next multiplication phase in order again to evade the action of the

antibodies. In this way a succession of fever periods is formed. Passing into the lymphatic system results in swelling, particularly of the cervical lymph nodes, as a typical symptom. Finally, the central nervous system is also affected. After periods of excitation, toxic damage induces somnolence and the victim is soon no longer able to take food by himself, unless the course of infection is interrupted by the nowadays very effective chemotherapy.

Nagana, a disease of economic animals in Africa, is caused by *T. vivax* and *T. congolense* which differ morphologically from *T. brucei*. These too are transmitted by *Glossina*. However, they have not become adapted to the salivary glands of the tsetse flies which carry them. *T. congolense* first infects the middle gut and then passes into the piercing proboscis; *T. vivax* infects only the proboscis.

It has been observed that only about 1-5% of the tsetse flies are infectious. If the natural alternation between *Glossina* and the vertebrate host is interrupted for a long time by repeated passage through the blood of the vertebrate host alone, the capacity to develop in the arthropods can be completely lost.

3.10 Mosquitoes

The mosquitoes belong to the family Culicidae of the order Diptera and represent the largest group of dipteran pests. There are at least 3000 species which are found in every part of the world. It is now known that almost all female mosquitoes feed on a variety of hosts, if available.

Many mosquitoes not only cause great torment through their bites, but also serve an efficient vectors for such dreaded diseases as malaria, yellow fever, dengue and encephalitis as well as some forms of filariasis. Thus it is not surprising that on the basis of weight alone, the literature on mosquitoes is staggering.

With a few exceptions, most mosquitoes are 2.5-6 mm long. The venation of the single pair of wings is characteristic. The veins and posterior margins of each wing is covered with a large number of scales. These have slender bodies and long legs. Mouth parts of adult females form a blood-sucking proboscis. Antennae of the male are bushier and thus are more prominent than those of the female.

Life Cycle

I. Eggs : Most mosquitoes oviposit in water. Eggs are quite resistant to desiccation and remain viable in the unhatched state until they are covered with water.

Anopheles spp. release their eggs singly in loosely arranged clusters, each one armed with a float of air cells that provide buoyancy. In *Culex* spp. eggs are

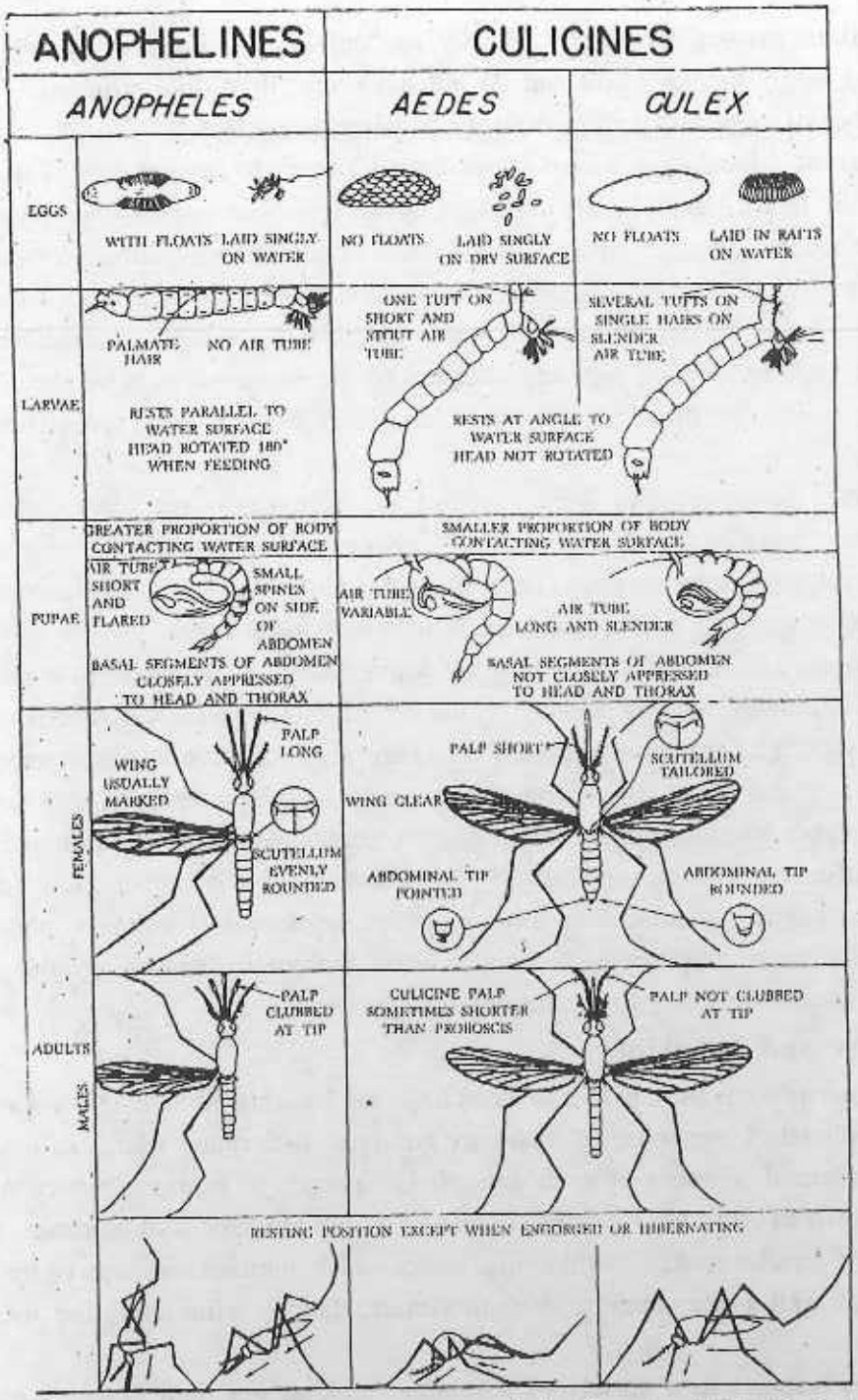


Fig. 3.17 : Anophelines and culicines, comparative charateristics. (From the U.S. Public Health Service.)

deposited in masses arranged vertically as "egg-boats". Eggs of *Aedes* spp. are deposited singly in moist soil and do not have any 'float'-like structure.

Number of eggs laid varies from 40 to several hundred.

II. Larvae : Incubation period varies from 12 hours to several days. The escaping form is the larva. Basically all mosquito larvae resemble one another possessing a breathing siphon (elongate siphon) on the posterior segment; mandibulate mouth parts; and an elongate, distinctly segmented body bearing setae. However, species differences do exist, even to the extent that their positions under the water surface differ. Larvae of *Culex* spp. and *Aedes* spp. are attached to the water surface by their siphons, but their bodies are directed downward; among *Anopheles* spp., larval bodies rest horizontally.

Mosquito larvae are free living, feeding on micro-organisms. During the warm months they undergo four larval stadia of development. The fourth larval instar, after molting, transforms into the pupa. There is a consistent increase in size, the microscopic first instar developing into a 8-15 mm long fourth instar larva.

III. Pupae : This is a non-feeding but active tissue reorganisational stage. A part of breathing tubues, located dorsally on the cephalothorax, replaces the caudal siphon of the larva. Pupae are extremely active and are very sensitive to disturbances. They will flutter up and down when disturbed, hence the common designation, *"tumblers"*.

IV. Imago : Mosquito imago or adults, are similar yet different in minute details. Adults differ not only morphologically but also ecologically and in their behaviour pattern and habits. All adult male mosquitoes are vegetarians, feeding on plant juices, but the females are either nectar feeders or blood suckers. In parasitology, our interests naturally are concerned with the haematophagous species.

Biology and behaviour

Male mosquitoes are capable of detecting and locating females from a range of several centimeters. Antennae of males are equipped with many whorls of long hairs, and the subnasal segment of each antenna is enlarged to house a battery of sense organs known as *Johnstan's organs* stimulated by the movement of antennae. Beating of wings of females makes a whimming noise, which stimules the hairs of the male's antennae as well as the antenna shaft to vibrate, thereby stimulating the Johnston's organs.

Females respond to a variety of stimuli in seeking out their hosts. It has been reported that smell is important in locating host, but heat and moisture together also

serve as attractants. The thermotaxis as achieved by CO_2. *Aedes aegypti* is most attracted to dark colour and usually approaches the shaded parts of a host. It still remains uncertain why certain humans do not appear to attract mosquitoes. For example, the entire Eskimo race is refractile.

Important genera and species

I. Genus *Culex* : *Culex* includes over 480 species. Important generic characters are :

i) Postnotum lacks setae; scutellum trilobed, one lobe bearing bristles.

ii) Body humpshaped when at rest.

iii) Tip of abdomen blunt in females.

iv) Eggs deposited in tight floating masses like rafts on water surface.

A) *Culex pipiens* : This is the common brown house mosquito, found in many temperate climates. It is a nocturnal feeder. This domestic species breeds in any body of stagnant water, no matter how small, around the house and in backyards. Eggs require 18 to 24 hours to hatch, the larval instar lasts 7 days and pupal instar lasts 2 days. There is little host specifically since it feeds on domestic animals, humans and even birds.

B) *C. quinquefaciatus* : ***C. quinquefaciatus*** is a species closely related to *C. pipiens*, and is widespread in warmer climates, including the southern United States.

C) *C. tarsalis* : This is a common species in the semi-arid Western United States. It is large and robust and is distinguished by its dark brown to black body and its abdomen, which is ringed by basal segmental bands of yellowish white scales. It breeds in water in any sunny location and feeds primarily on birds at night. It also feeds on humans and other mammals and transmits western equine encephalitis (WEE).

D) *C. tritaeniorhynchus* : ***C. tritaeniorhynchus*** is the most important vector of the Japanese encephalitis virus in the Orient.

II. Genus *Aedes* : Includes about 800 species, well represented throughout the world. Characterized by :

i) Postnotum lacks setae; scutellum trilobed.

ii) Body humpbacked when at rest.

iii) Eggs deposited singly on water surface or on mud.

A) *A. aegypti* : The most notorious of *Aedes* species, distributed throughout the warm and humid parts of the world. Adults are marked with transverse bands of

silvery white or yellowish white on the abdomen. The legs are banded and the tarsi of the last pair of legs are white. The larval stadia usually last 9-12 days and the pupal stadium usually lasts only 36 hours.

A. aegypti is the principal vector for the yellow fever virus.

Other important species are *A. vexans*, distributed globally; *A. dorsalis* found in the United States, Canada, Europe, North Africa and Taiwan.

III. Genus *Anopheles* : Widely distributed containing about 400 species, with the following important characters :

i) Postnotum lacks setae, scutellum not lobed.

ii) Palpi of both sexes usually as long as proboscis.

iii) Body not humpbacked when at rest.

iv) Eggs laid singly with floats ; larvae rest parallel to water surface.

A) *A. Stephensi* : This is one of the most important vectors of human malaria in India, Pakistan, Bangladesh, Iraq, Iran, Saudi Arabia and several other countries. The adult is a medium sized mosquito, that take shelter in houses, cattleshades, barracks, etc. However, in Calcutta, adults are not easily collected in houses. Adults are most active in biting before midnight. Although *A. stephensi* is an important malaria vectors, it bites cattle predominently.

B) *A. philippinensis* : Found abundantly in West Bengal, Assam and neighbouring areas. Recent studies have revealed that this species is gradually vanishing from the alluvial deltic West Bengal. However, this has not taken place in Assam.

C) *A. quadrimaculatus.* : This is the common species in eastern North America. It can be recognised by its dark wings. In former years the species was the major vector of malaria in North America.

Mosquito as vector

Mosquitoes are not only vicious pests, but also serve as vectors for various pathogenic organisms. The major mosquito-transmitted diseases are discussed below.

A) Malaria : Malaria is one of the most vicious diseases of man. It has played a major role in shaping history and in the decline of civilizations. Human malaria is known to have contributed to the fall of the ancient Greek and Roman empires. Troops of both the civil war and the Spanish-American war were severly incapacitated by this disease.

How widespread is malaria? Certainly, it is not limited to the tropics. In the 1940s there were 350 cases of malaria throughout the world. In 1980, an estimated 300 million people suffered from malaria.

Malaria is usually chronic, debilitating and periodically disabling, although lethal cases are by no means uncommon. *Plasmodium falciparum* is by far the most lethal of the human-malaria causing species. Relative to the malaria causing organisms, various species of *Anopheles* serve as the only suitable vector. However, *Anopheles* spp., *Culex* spp. and *Aedes* spp., primarily the latter two, are the major vectors for swain malaria.

B) Filariasis : Filariasis (Elephantiasis or Bancroft's filariasis is another widely distributed disease of mankind and is caused by *Wuchereria bancrofti* that is transmitted by mosquitoes. Filariasis occurs in the Nile Delta, Central Africa, Turkey, India, Southwest Asia, Phillippines, many pacific islands, Indonesia, Australia, the Caribbean islands and parts of South America. In brief, this parasite is found throughout a broad equatorial belt. Millions of human cases of filariasis are in existence.

Members of the *Culex pipiens* complex represent major vectors of the filarial worms, *W. bancrofti* and Dirofilaria immitis. These mosquitoes can also transmit avian malaria, avian pox and encephalitides caused by arboviruses (arthropod-borne viruses).

C) Yellow fever : This is a viral disease that has plagued the mankind for centuries. During the building of the Panama Canal, Yellow fever caused so much illness among workers that the project almost came to a standstill. It was then that Dr. Walter Reed and his workers won fame by providing Dr. Carlos Finlay's hypothesis that *Aedes aegypti* serves as transmitter of the pathogen.

Mosquitoes become infected with the virus while feeding on yellow fever victims. A single female usually remains infective for the rest of his life-200 to 240 days. Under field conditions, the normal incubation period is 12 hours in the vector body. Jungle animals, especially monkeys of the genus *Cebes* serve as natural reservoirs for the yellow fever virus.

The fever is characterized by headache and fever with temperature exceeding 39°C, accompanied by nausea and vomiting. Jaundice may appear by the 3rd day. Bleeding from gastrointestinal tract and gum may be noted. In severe cases death may occur 3 days or more after the onset of illness.

D) Dengue fever : This is commonly referred to as breakbone fever. This is another fever transmitted by mosquitoes. Investigations have revealed that a number of species of mosquitoes are suitable vectors. Among these are *Aedes aegypti*, *A. albopictus*, etc. The latter species is prevalent in Japan, New Guinea, the Philippines and several other countries.

Dengue is characterized by febrile illness with chills, headache, body aches, vomitting, nausea, etc. Illness usually persists for 7 days, after which complete recovery is the rule.

However, dengue is followed by a haemorrhagic fever, particularly among children, accompanied by a shock syndrome, with a case fatality rate of 50%.

3.11 Probable questions

1. Define vectors. Clasify different types of vectors with descriptions and examples.
2. Discuss the roles of mosquitoe as vector of different types of diseases.

Unit 4 ❐ Epidemiology : classification, epidemiology of malaria, kala azar, filariasis

Structure

4.1 **Definition of epidemiology**

4.2 **Classification**

4.3 **Epidemiology of malaria**

4.4 **The parasites**

4.5 **Epidemiology**

4.6 **Concluding remarks**

4.7 **Epidemiology of leishmaniasis**

4.8 **Epidemiology and disease burden in visceral leishmaniasis**

4.9 **Cutaneous leishmaniasis**

4.10 **American cutaneous leishmaniasis**

4.11 **Epidemiology of filariasis**

4.1 Definition of epidemiology

Epidemiology is the science that deals with all ecological aspects of a disease to explain its transmission, distribution, prevalence and incidence in a population. The distribution of parasites in a particular population is dependent upon a number of factors such as age of the host, sex, socio-economic status, diet and the ecology of the region favouring the completion of the life cycle of the parasite. Vectors, that transit parasites from one host to another, are one of the most important factors in epidemiology. These are mostly the blood-sucking arthropods or snails.

It was observed that certain parasitic infections are prevalent in some ecosystems but not in others. For example, African sleeping sickness of man is restricted to the African continent but not in other parts of the globe. Thus such disease has a natural focus, called the *nidus*, which is the set of ecological condition under which it can be predicted to occur. Another term, *landscape epidemiology* is the consideration of all ecological aspects of a nidus.

4.2 Classification

Epidemiology has been classified into three major categories : epidemic, endemic and pandemic.

(i) epidemic—a sudden outbreak of infectious disease that spreads rapidly through the population. Influenza is considered to be one of the commonest epidemic disease today.

(ii) endemic— a disease that occurs frequently in a particular region or population.

(iii) pandemic—the term applied to an epidemic so widely spread that vast numbers of people in different countries are affected. AIDS is currently considered to be pandemic.

4.3 Epidemiology of malaria

The word "malaria" means bad air (Ital. *mala* = bad ; *area* – air). A connection between swamps and fevers was long recognized and it was a common belief that the disease was contracted by breathing bad air. Another name, *paludism*, meaning marsh disease is still used for malaria. It is one of the most widespread and most devastating disease of mankind and the World Health Organization has recognized malaria as one of the six major tropical disease of the world. It has played a signifiant role in the history of human civilization as large areas of the earth have repeateadly been subjected to the ruinous effects of the disease. According to a report avilable in 1977, there were at least 100 million cases of malaria per annum.

Although malaria, as a disease, has been known since antiquity, there was no progress in the aetiology of the disease until 1847, when Mackel observed black pigment granules in the blood and spleen of a patient who died of malaria. Later investigations by Charles Louis Alfanso Laveran, Marchiafava and Celli and finally Sir Ronald Ross have contributed to several facts about the disease. It is now established that malaria in man is caused by four species of the genus *Plasmodium* and the parasites are transmitted from man to man through the bite of female anopheline mosquitoes.

4.4 The parasites

As already stated, four species of the genus *Plasmodium* are found in man. These are :

(i) *Plasmodium vivax* (simple, benign or tertian malaria)— responsible for about 43% of cases of human malaria.

(ii) *Plasmodium malariae* (malariae or quartan malaria) — causes about 7% of the world's malaria.

(iii) *Plasmodium falciparum* (malignant, tropical, pernicious or aestivo-autumnal malarial)— the most pathogenic one and often causes death. Responsible for about half the human cases of malaria.

(iv) *Plasmodium ovale* (ovale or ovale tertian malaria) — rare ; generally confined to tropical Africa.

The first three malaria species are worldwide in distribution, found mostly in warmer countries, but also in cold areas like Korea, Manchuria and Southern Russia.

4.5 Epidemiology

It has already been stated that malaria has a worldwide distribution and is definitely restricted to the tropics. In 1937, there were at least 1 million cases of malaria each year in the United States. In the world, 52 of 58 countries of Africa, 11 of 18 countries in South West Asia, the entire Pacific Basin and majority of the countries in southeast and south central Asia reported the prevalance of malaria. In the 1940s, there were 350 million cases of malaria throughout the world. About 3 million people died annually due to malaria. Due to several health programmes sponsored by the WHO of the United Nations, the number of malaria cases came down to 250 million by 1958. However, it still remains a major health problem in many parts of the world. Malaria outbreaks were reported during 1967-1978 in India and Sri Lanka due, perhaps to, relaxation of control and development of resistance to insecticides by the mosquito vectors.

The major clinical manifestations of malaria are the host inflammatory response that causes characteristic chill, fever and anaemia due to large scale destructions of RBCs. Falciparum malaria is most serious and may lead to cerebral malaria, in which there is a rise of body temperature to above 108°F, coma, convulsions and finally death. Generally, a malaria patient experiences malaise, muscle pain, headache, loss of appetite and slight fever. This is followed by a feeling of intense cold, the patient shivers and body temperature rises rapidly to 104°F to 106°F. This is followed by a copious perspiration and the body temperature drops to normal. The fever episode may be continuous or fluctuating, but the patient does not feel well between the paroxysms.

It is believed that fever in malaria is related to maturation of a generation of merozoites, rupture of red blood cells that contain them, and the release of waste products of the parasites into the circulation. These toxic wastes are known as hemozoin. Excessive destruction of RBCs leads to an increase in blood bilirubin, a breakdown product of haemoglobin, and jaundice follows.

4.6 Concluding remarks

Malariologists interpret malaria as being a "man-made" disease. With the clearing of forests for agriculture, construction of dams and irrigation canals, we have altered the ecosystem in such a way that, regions earlier with scanty malaria, have become highly malarious. We shall conclude this chapter with quotations of parasitologists who wrote classical books on Parasitogy. First to quote Cheng [General Parasitology : 1986, AP]" .....some areas where tractors have replaced buffalo in agriculture, there has been a sudden rise in malaria. There is some epidemiologic evidence that this is because the anopheline mosquitoes endemic to such areas originally preferred and fed on buffalo, but with the removal of these herds, they feed on humans and thus became transmitters of *Plasmodium* spp. The second one is from the book written by Roberts and Janory [In Foundations of Parasitology : 2006, McGraw-Hill], "Malaria will be with us for a long time, probably as long as there are people."

4.7 Epidemiology of leishmaniasis

The geographical distribution of human leishmaniasis is restricted to tropical and temperate regions of the world which are also the living areas of the sandflies. The leishmaniases are considered to be endemic in 88 countries of which 16 are developed and 72 are developing countries, 13 of which are least developed (WHO Report on Global Surveillance of Epidemic-prone Infectious Diseases, 2000). The epidemiology of leishmaniasis is diverse with 20 *Leishmania spp.* that are pathogenic for human being, and 30 sandfly species that have been identified as vectors.

Leishmaniasis currently affects some 12 million people worldwide with an estimated number of 1.5 to 2 million new cases occurring annually, 1-1.5 million cases of cutaneous leishmaniasis and 5,00,000 cases of visceral leishmaniasis. It has been estimated that 350 million people are exposed to the risk of infection by different species of *Leishmania* (WHO, 2002). 90% of cases with cutaneous leishmaniasis occur in Afghanistan, Algeria, Iran, Brazil, Peru, Saudi Arabia and Syria, while 90%

of visceral leishmaniasis are found in India, Bangladesh, Brazil, Nepal and Sudan (WHO weekly Epidemiological Record, 2002).

There are sufficient reasons for causing the enormous increase in the number of cases of human leishmaniasis. Man-made environmental changes are important factors increasing human exposure to the sandfly vector. Construction of dams and new irrigation schemes, mining, extraction of timber, development of new housing settlements, intrusion into primary forest areas, deforestation, massive migration from rural to urban areas, fast and unplanned urbanization, are among the main causes for increased exposure to the sandfly bites. Another cause is the movement of susceptable populations into endemic areas, including large scale migration of people for socio-economic reasons such as the development of agro-industrial projects. However, individual risk factors such as malnutrition and immunosuppression owing to HIV co-infection also have important roles in the epidemiology of leishmaniasis.

4.8 Epidemiology and disease burden in visceral leishmaniasis

Visceral leishmaniasis or Kala-azar is the most severe form of leishmaniasis if left untreated. The causative parasite, *Leishmania donovani* invades the reticulo-endothelial system of nearly all visceral organs like liver, spleen, bone-marrow, lymph nodes and intestine. It is characterized by an irregular, undulating fever with often double rise in body temperature, progressive splenomegaly and hepatomegaly, emaciation, leucopenia, lymphadenopathy and hypergammaglobulinemia. It is a visceral infection of the reticulo-endothelial system and predisposes the subject to various other opportunistic infections due to immunocompromised state of the host. Death comes as a result of pneumonia, gastro-intestinal bleeding and perhaps hepatic encephalopathy in untreated cases.

Visceral leishmaniasis is world-wide in distribution. It is endemic in the tropical and sub-tropical regions of Africa, Asia, the Mediterranean, Southern Europe and South and Central America. The distribution of the disease in these regions, however, is not uniform; it is patchy and often associated with areas of draught, famine and densely populated villages with little or no sanitation. In endemic areas, children below the age of 15 are commonly infected. In sporadic and epidemic cases, people of all ages are susceptible : males are at least twice as likely to contact the disease than females, except those who have been conferred immunity due to past infection.

The incidence of Kala-azar in India is among the highest in the world. Here, Kala-azar has been known to occur both epidemiologically and endemically in well-defined in the eastern part of the country, particularly in Bihar, West Bengal, Eastern districts of Uttar Pradesh, Assam, foothills of Sikkim and to a lesser extent in Tamil Nadu and Orissa. Resurgence of Kala-azar in India occurred in epidemic form in late 1960, early 1970 and reached its peak in 1977. Bihar witnessed two major epidemic outbreaks of kala-azar in 1978 and 1992. The disease also spread to West Bengal where indigenous transmission became perceptible in 1980s. The endemic belt in India used to extend from Meghalaya, Assam, Bihar, West Bengal, Uttar Pradesh, coastal Orissa, Andhra Pradesh and Tamil Nadu. Presently, the disease is endemic in Bihar, and West Bengal only with sporadic incidence in Uttar Pradesh.

4.9 Cutaneous leishmaniasis

This is of two types, viz., Old world cutaneous leishmiasis and New world or American cutaneous leishmaniasis, and is caused by several species of *Leishmania* like *L. tropica, L. major, L. braziliensis*, etc. A number of species of *Lutzomyia* and *Phlebotomus* are confirmed vectors.

The Old world cutaneous leislimaniasis is also known as Oriental sore, Bagdad sore, Delhi boil etc. The main symptoms are the appearance of lesions that begin as papulae on the exposed parts of the body like face and extremities. These ultimately develop as wet ulcers and spread to other parts of the body through the lymphatic system. The disease lasts for about 2 to 8 months. In *L. major* infection, the disease may last for more than a year and leaves a permanent scar.

The cutaneous leishmanisis is prevalent from the Mediterranean basin to Pakistan, the central and northern parts of India, Latin America, Morocco, Algeria, Tunisia, Libya, Sudan, Lower region of Egypt, Ethiopia, West Africa, Nigeria, Mexico and the southern parts of the erstwhile Soviet Union.

Dogs, cats and rats act as reservoir hosts.

4.10 American cutaneous leishmaniasis

The disease occurs in different parts of America in wild mammals and man. Two types of *Leishmania*, distinct from *L. tropica*, are responsible. These are the *L. mexicana* complex and the *L. braziliensis* complex.

Species of the *L. mexicana* complex are predominent in Mexico, Guatemala and

Hondurus while those of the *L. braziliensis* are found in Brazil, Panama, Costa Rica, and some other countries. Parasites are transmitted by *Lutzomyia spp.*

L. braziliensis causes classical "espundia" (mucocutaneous form) in Brazilian rain forests. Skin lesions are chronic and death may occur due to septicaemia or bronchial pneumonia.

4.11 Epidemiology of filariasis

Filariasis is a chronic infection caused by tissue-inhabiting species of filarid worms. About 10 species under the family Filaridae are parasitic to human beings each producing a specific syndrome. Adults of these worms live in the tissues or body cavities of vertebrate hosts. Their females produce embryonated eggs which, before or at the time of oviposition, contain embryos that become delicate, thread-like, known as the microfilariae. During their circulation in the peripheral blood or other cutaneous tissues, these microfilariae are ingested by blood-sucking arthropods, where they develop into the infective stage. These now re-enter the vertebrate host at the time of sucking of blood by the arthropod host and complete their life cycle.

The most important species of filarial nematodes which are relatively common as parasites of man and animals are :

1. ***Brugia malayi,*** known as Malayan filaria ;
2. ***Wuchereria bancrofti,*** known as Bancrofti's filaria ;
3. ***Acanthocheilonema perstans,*** known as persitent filaria ;
4. ***Mansonella ozzardi ;*** and
5. ***Dirofilaria*** species.

1. Malayan Filariasis : This is caused by *Brugia malayi.* The adult worms are delicate and white, thread-like bodies coiled up in pairs in dilated lymphatics.

The onset and development of the disease vary greatly from person to person. In many instances, there are few clinical symptoms inspite of the fact that the microfilariae have been detected in the blood. Several French investigators, who studied the disease in African and French soldiers, observed early lesions in these infected persons. The most common symptoms are the enlargement of the lymph glands, eosinophilia and pulmonitis. Adenolymphangitis, often accompanied by swelling of a limb, fever and abscess appear at regular intervals. Elephantiasis is the most characteristic sequal of the infection. Elephantiasis found in *filariasis malayi* is mainly confined to the legs below knees ; it is a debilitating disease and may cause considerable health problems.

Scrotal elephantiasis is not known but hydrocoele and chyluria as well as cerebral and ocular filariasis have been reported.

The distribution of *B. malayi* extends from India to China, Japan, Malayasia, Indonesia and Kenya. In Malayasia, where the incidence of filariasis malayi is very high, children become infected very early in their life. The infection rate rises with age reaching a peak of over 56% when they attain the age of 4 to 10 years. In 1978, a report was published which showed that there was 24% infection with mean age of 34 years, with males showing slightly higher percentage (29%) than females (19%). Similar situations were also reported from India, Rhodesia and America. The following mosquito species are known to be the natural vectors of *B. malayi* :

a) Mansonine mosquitoes, *Mansonia annulata, M. annulifera, M. bomex, M. dives, M. indiana, M. ifformis* ;

b) Aedine mosquitoes, *Aedes togoi* ;

c) Anopheline mosquitoes, *Anopheles albotaeniatus, A. barbirostris, A. sinensis, A. sumbrosus.*

Mansonia and *Anopheles* are the major vectors in India, while in Japan, *Aedes togoi* appears to be the only vector. The role of the vectors varies geographically as well as environmentally.

2. Bancroftian Filariasis : Bancroftian filariasis is caused by Bancroft's filarial worms, *Wuchereria bancrofti.* The adult worms are creamy-white, long and slender, with a smooth cuticle and bluntly rounded ends. The microfilariae of *W. bancrofti* are bluntly rounded anteriorly and pointed posteriorly.

Adults remain tightly coiled into nodular masses and live in major lymphatic ducts. Females are ovoviviparous producing thousands of larvae. The microfilariae are released into the surrounding lymph and most of these are later swept into blood via thoracic ducts. There is a marked "periodicity" of microfilariae in the peripheral blood and maximum numbers are found usually between 10 p.m. to 2 a.m.

The incubation period is mostly symptomless with occasional transient lymphatic inflammation with mild fever and malaise.

The acute inflammatory stage begins with the females reaching maturity and releasing microfilariae. This results in acute lymphatic inflammation usually in the lower half of the body with fever, chills and toxaemia. The area of the lymphatic is swollen and painful and overlying skin becomes red and palpable.

The chronic or obstructive phase is marked by enlargement of involved organ(s). Chyluria or lymph in the urine is a common symptom; Urine becomes milky in colour and is often mixed with blood. The adult worms become more and more confined by tissue proliferation, die and are finally absorbed and calcified. Elephantiasis is the most significant entity of bancroftian filariasis due to repeated attacks of acute lymphatic inflammation. The organs most affected are the scrotum, legs and arms. Vulva and breasts in women are also affected.

Bancroftian filariasis is most widespred of the filarial infections of human beings extending throughout Central Africa, The Nile delta, Turkey, India and South-East Asia, The East Indies, The Phillippines, Australia and parts of South America. Several investigators reported that in India, there was a high incidence of the disease in the states of Bihar and Assam.

More than 75 species of mosquitoes of the genera *Culex, Aedes, Anopheles* and *Mansonia* are the known vectors of *W. bancrofti.* The most important species are *Culex pipiens* var. *quinquefasciatus, C. pipiens* var. *palleus, Aedes aegypti, A. polynesiensis, Anopheles dartingi, A. gambiae, A. punctulatus A. faranti* etc.

The vector mosquitoes are predominantly anthropophilic, i.e., these have the preference for human blood and breed near human habitations.

3. Dirofilariasis : Members of the genus *Dirofilaria* are all natural parasites of dogs or more rarely in monkeys. The parasites have also been found in man, where they cause dirofilariasis. Important species of *Dirofilaria* include *D. immitis, D. megathaesi, D. spectans, D. repens,* etc. The parasites have been recovered from lungs, heart, subcutaneous or conjunctival tissues of man.

The microfilariae of *D. immitis* exhibit certain degree of periodicity, their numbers in the peripheral circulation reaching peak between 11-00 p.m. to 3-00 p.m. Several species of mosquitoes of the genera *Aedes, Anopheles* and *Culex* act as vectors of the parasite.

Human infections with *D. immitis* have been reported from various parts of the world over the past few decades. The parasites were mostly recovered from the lungs or the pleural cavity; abdominal cavity was also another site. Dirofilariasis has been recorded in Russia, India and Africa. A single case of *D. immitis* infection in the breasts of a woman was reported in Japan. The most common symptoms include cough and chest pain; cardiac and pulmonary lesions are common in dirofilariasis. Other species of *Dirofilaria* have been sporadically reported from different geographical areas.

4. Ozzard's filariasis

Mansonella ozzardi causes this type of filariasis in which the infected person does not show any apparent clinical symptom. Reports indicate hydrocoele and enlargement of lymph glands.

In the late nineteenth century, *M. ozzardi* was recognised as an apparently non-pathogenic New World species. The nematode is now established to cause pathogenicity in man. In a survey report of 1983, 25% of human population were found suffering from Ozzard's filariasis. *Culicoides furens* is the vector for *M. ozzardi* in northern South America.

Unit 5 ❐ Zoonosis and its significance

Structure

5.0 Introduction

5.1 Parasitic zoonosis

5.2 Classification of zoonosis

5.3 Environment and zoonoses

5.4 Socio-economic importance of parasitic zoonoses

5.5 Factors influencing prevalence of zoonoses

5.6 Impact of parasitic zoonoses on the host

5.7 Probable questions

5.0 Introduction

Zoonotic diseases represent an important threat to the health and well being of the world's population. In spite of substantial recent progress in disease control and the extension of health care, these diseases continue to register high rates of incidents in urban, periurban and rural areas of developing countries in the world. There are ample reasons to believe that close realtionship between man and animals exists in several diseases which are intercommunicable between man and animals. Consequently they have a potentially great impact on national economy.

The etymological meaning of the word "Zoonosis" is a disease of animals but according to Nelson (1960) it is a disease of man contracted from animals. In this sense, the term was adapted by WHO and FAO (Rome) Expert committee of Zoonoses in their report in 1951 and defined zoonoses as "Those diseases which are naturally transmitted between vertebrate animals and man." Subsequently it was observed that this definition excludes those viral agents which have been isolated from animals and man and have not so far been incriminated (not said to be criminal) with any disease but can be recovered from both man and animals as well as latent and apparent infections by parasites and microorganisms. As such in their second report in 1959 the Joint WHO-FAO Expert group on Zoonoses modified the definition as "those diseases and infections (the agents of) which are naturally transmitted between (other) vertebrate animals and man." Zoonoses now include only those infections where

there is either proof or circumstantial evidence that there has been a transmission between man and animals.

5.1 Parasitic zoonosis

Zoonotic diseases caused by parasites are referred to as parasitic zoonoses. They consist predominantly of protozoan and helminthic origin. Opinions differ as to whether infections with ectoparasites should be considered as Zoonoses or not. The Expert Committee on Zoonoses of the WHO (1979) reported that if ectoparasites burrow into or otherwise enter the body of the host, they should be considered as Zoonoses.

5.2 Classification of zoonosis

As per classification adopted by the joint WHO-FAO expert Committee (1967), Zoonoses have been grouped into three categories :

A) Based upon reservoir host

(1) Anthropozoonoses : The infections that are transmitted to man from lower vertebrates are termed as anthropozoonoses. Further divided into two categories :

a) Forms which are found essentially in man and not in other species. e.g., *Wuchereria bancrofti, Onchocerca volvulus* (nematode).

b) Forms which are present in other animals and are similar to those present in man e.g., *Ascaris lumbricoides, Ancylostoma duodenale.*

(2) Zooanthroponoses : The infections are transmitted to lower vertebrate animals from man. These lower vertebrate animals act as intermediate hosts, transport hosts, or vectors. e.g., *Schistosoma mansoni, Hymenalepis nana.*

* Intermediate host : Pig for *Taenia solium*

* Transport host : Housefly, *Culex vishnoi* for encephalitis.

(3) Amphixenoses : Infections shared by both man and lower vertebrate animals and may be transmitted in either direction, as in *salmonellosis.*

Salmonella typhi found in the intestine of prawn.

B) Based upon the type of life cycle

(1) Direct zoonoses : The parasites are transmitted from an infective vertebrate host to a susceptible host either by direct contact or through a mechanical vector. The agent itself undergoes little or no propagative change and no developmental change occur during transmission.

e.g., Amoebiasis, Balantidiasis (only ciliate representative in human intestine) Toxoplasmosis, Trichinelliasis and Scabies. *Balantidium* found in man, monkey and pig.

(2) Cyclozoonoses : Zoonoses that involve more than one vertebrate host but no invertebrate host for the completion of development cycle of the parasite.

e.g. *Taenia solium* for Taeniasis by man and pig. Echinococcosis in man and dog.

(3) Metazoonoses : Parasites are transmitted biologically by invertebrate vectors where the agent either multiplies or develops or undergoes both the processes and there is always an extrinsic prepatent period before transmission in such cases. e.g., Schistosomiasis, Leishmaniasis, etc.

(4) Saprozoonoses : These have both vertebrate host and a non-animal developmental site or reservoir like organic matter including food, soil and plants.

e.g., Larva migrans, Myiasis.

C) Based upon etiological agents :

(1) Bacterial zoonoses : Zoonoses caused by bacterial agents.

e.g., Plague, Salmonellosis.

(2) Viral zoonoses : Zoonoses caused by Viruses.

e.g., Rabies, Influenza, Yellow fever.

(3) Rickettsial zoonoses : Zoonoses caused by rickettsia. e.g., Tick typhus.

(4) Protozoa zoonoses : Zoonoses caused by Protozoa. e.g., Toxoplasmosis.

(5) Helminthic zoonoses : Zoonoses caused by helminths. e.g., Taeniasis, Schistosomiasis.

(6) Fungal zoonoses : Zoonoses caused by fungal agents. e.g., Histoplasmosis, Cryptococcosis.

(7) Ectoparasitic zoonoses : Zoonoses caused by ectoparasites. e.g., Scabies, Myiasis.

5.3 Environment and zoonoses

The distribution of the parsites on the surface of the earth is dependent upon the presence of suitable hosts and on the habits and the environmental conditions that may be transferred of parasites from host to host possible. Helminths that have to live for sometime outside the body of the definitive hosts, while the larvae develop, to the infective stage either in eggs (as in *Trichuris*), as free living organisms (as the hookworms) or in an intermediate host, are more limited since they or their intermediate

hosts may be affected by such environmental conditions as temperature, humidity, nature of the soil, etc.

The general climate of an area may be of much less importance than the micro-climate existing in the immediate locality where the parasites live in burrowes, under the soil surface, in mines etc. [*Ancylostoma duodenale*] for Miner's disease where intermediate hosts are involved, suitable ones must be present and climatic conditions must be satisfactory for the development of the larvae in them. Under favourable conditions habits which facilitates the transfer of parasites from water, food, soil, intermediate host, reservoir host and in the occurrance and frequency of parasitic infection, for example, Guinea worms *Dracunculus medinensis*, thrives where cyclops are swallowed with drinking water.

5.4 Socio—Economic importance of parasitic zoonoses

Zoonoses besides being responsible for morbidity and mortality in man cause considerable loss of livestock, dairy product and protein food through affections of animal populations, e.g., *Madcow disease*. Zoonoses with reservoir of infection in domestic animals impose a particularly heavy burden of ill health on a large number of people who live in rural areas and earn their livelyhood through animal farming and other forms of agriculture. Animal species such as cattle, buffaloes, horses and camels that still provide approximately 90% of the world's total draught power are the worst affected with Zoonoses. Other serious losses of high quality protein occur through the rejection of meat which is commonly infected with parasites of Zoonotic importance.

As such Zoonoses are important occupational hazards faced by agricultural, industrial, laboratory workers and animal handlers. There is significantly higher risk rate for workers in the course of their occupation than for the rest of the population like the cutaneous larva migrants in tea plantation (e.g., *Ancylostoma*) and other orchard workers, leptospirosis in rice field workers, trypanosomiasis in hunters, tick borne disease in wood cutters, etc. The trapping of wild life for human consumption or in parts of Africa raises the question of danger that may be created by known or newly recognised zoonotic parasites (WHO, 1979).

Hazards to urban population, from parasitic zoonoses result not only from such cases and from the infections that are acquired from meat, fish and dairy products but also directly from the large population of feral animals and livestock that are found in many of the cities of the world. Toxoplasmosis, larva migrants and hydatidosis are the examples of such cases which man acquires from his pets and companion animals.

5.5 Factors influencing prevalence of zoonoses

1) Ecological factors : It is an ecological fact of life that man lives in association with animals that have been domesticated for a very long time. Man had settled to a domestic life long before he took to agriculture and with the agricultural revolution, farm animals were also domesticated, horses, cattle, sheeps, goats and poultry being among them. Until recent times farm animals were kept in crowded insanitary conditions which favoured not only the spread of diseases but were also harmful to man. Either the circumstances did not exist for man to encounter or were neither recorded nor recognized.

The role of environment in zoonoses was best recognised when the Russian Parasitologist Powlovwsky (1966) gave the concept of "natural nidality of disease". According to this concept, zoonoses are associated with specific reservoirs and often with specific vectors. The habitats of these vectors and reservoirs are often associated with specific types of countries which fulfil the requirements of these two components. When the two types of environmental requirements overlap, the disease agents circulate between the two or more or less restricted localities, such a locality is called a *'nidus'* meaning nest. When man enters into the nidus or disturbs it by his activities like cultivation, deforestation, and intensive hunting, he is likely to acquire a disease and the disease becomes a zoonoses. Harnessing the power of rivers, construction of roads and piplines through virgin or thinly populated areas, clearing or irrigating and cultivating new lands are continuously changing the ecosystems in which potential human pathogens form a part of the biotic community. Outbreaks of water-related Zoonoses such as Schistosomiasis, Tryponosomiasis, Paragonimiasis, Fascioliasis, and Dracunculosis, illustrate the significance of human activities in water resource development like the construction of dams and irrigation schemes.

2) Human behaviour and food habits : Human behaviour is often related to man's risk of acquiring parasitic zoonoses. Hydatidosis is a good example of such behavioural influences. The pastoral Tarkana people of North Western Kenya are one of the most heavily infected with hydatidosis in the world, because through religious customs human dead bodies are exposed to hyaenas and dogs and thus human infections help to perpectuate the transmission cycle and the Tarkana thus act as reservoir of echinococcal infection. Another example of human behaviour related to hydatidosis of Muslim Arabs in eastern Mediterranean where there is a lower risk of

infection among them than among the Christian Arabs of Lebanon. It is reported that the risk of hydatid infection in Beirut (capital of Lebanon) is roughly 21 times more among persons keeping dogs than in those who don't keep dogs.

Some of the food habits of man has also increased the risk of parasitic infection. The transmission of such Zoonotic parasites to man depends on the consumption of raw or partially cooked food or recontaminated food after proper cooking. The different tastes of people in many specialities and consumption of undercooked or raw food is the source of *Taenia solium* infection in man.

3) Animal population : One of the important factors in the epidemiology of parasitic zoonoses are the synantropic animals which live in and around human beings. In the recent years, however, there has been a gradual change in animal husbandary throughout the world. The introduction of large scale intensive units in animal production has greatly increased the density of animal population per unit area. The domestic animal patterns in different countries are considerably variable. For example, in India, buffaloes account for 11.3% of the total livestock population but this species certainly different from other countries, and with the intensive milk supply programme, its number is bound to increase considerably during the coming years. As such, zoonotic infections of buffaloes will play more important role in India than in other countries. At the same time the equine population in India is decreasing considerably while the poultry industry has expanded to more than double its previous size during the past few years compared with other countries. Our swine population is considerably low which has started to increase only recently with the further development of the swine industry. As such the zoonotic infections of equines and swine are less important than those of the poultry.

The import of different livestock and their products from outside India has resulted in the entry of different exotic zoonotic infections. *Salmonella choleraeschis* was not reported in India from pigs till the last few years and a lot of poultry salmonellosis, particularly due to *Salmonella gallinarum* group has been associated with imported origin. Animals like dogs, cats, cage birds and even tortoise can also carry infection which can be potentially danger to man especially children. In many families a variety of pets are kept and people think that the association with pets provide an emotional outlet for children. At many schools also there are pet corners which is regarded as part of a child's education to handle and communicate with animals. Parents and the teachers, however should be aware of the fact that there are risks from animals,

what these risks are and how to minimize them ? For example, dog is the definitive host of the tapeworm, *Echinococcus granulosus.* Children playing with infected dogs get the infections from eggs released in the faeces of such dogs. The wild life reserves, national park as well as sanctuaries in various countries provide congenial conditions for the perpetuation of the parasites. The transport of exotic animals to the zoological gardens may also lead to importation of exotic parasites and parasitic zoonoses. The unrestricted importation of aquatic plants by aquarium supplies could lead to the introduction of molluscan vectors of helminths.

4) Pollution : Pollution of water and environment has a great influence on the existence and survival of parasites as the polluted water is the main reservoir of a number of parasitic zoonoses. Eggs of *Diphyllobothrium latum* are found in polluted water, their intermediate host lives in the polluted water, and thus transmits these infections to human beings. The eggs and larvae of different helminths and protozoan cysts are found in the soil. Where this soil or inadequately treated sewage sludge is used for manuring crops, infections through these crops goes to man.

5.6 Impact of parasitic zoonoses on the host

Zoonoses are responsible for widespread mortality and morbidity in human beings. Infections cause much damage to mankind by deteriotating human health, shortening human life and resulting loss of precious mandays. The effects of parasitic zoonoses upon hosts depend on the species, intensity of infection and their localization of the parasite. Utilization of the host's food to a detrimental point by parasites is the first type of damage they cause. *Diphyllobothrium latum* in man causes macrocytic anaemia similar to pernicious anaemia because of utilization of vit. B12 by this tape worm. Anaemia is also a principal consequence due to *Ancylostoma duodenale* infection and this is related to blood loss from the intestine associated with the feeding habits of the parasite. Not all but some parasites may cause injury to host either by the adults, larvae or eggs. Some parasites injure the host tissue while they enter the host; others inflict tissue damage after they have successfully entered like *Entamoeba histolytica,* the causative agent of amoebic dysentery that produces large ulcerations in the intestine, cercecaria of schistosomes cause inflammation and damage to the surrounding tissue while penetrating the host skin, a condition known as "Swimmer's itch", *Trichinella spiralis,* while encysted in the muscles, causes necrosis of the muscle tissue.

Many parasites secrete or excrete toxins in the host skin which cause irritation and damage to the body. Tick paralysis is the example of such damage. The toxin is elaborated in the tick ovaries and is secreted by the salivary glands. The toxins block the somatic motor fibres and cause motor paralysis. In certain parasitic infection abnormal growth of the host tissue results in a condition known as hyperplasia. Eggs of *Schistosoma haematobium* with their projections irritate the epithelium of the urinary bladder, causing hyperplasia. Hydatid cyst of the dog tapeworm *Echinococcus granulosus* when present in the visceral organs of man causes mechanical interference which results in the pressure atrophy of the organ.

Effect of zoonoses on the animal host also is of considerable importance. In India, cattle alone account for more than 50% of the energy used for crop production and 30% of energy used for all purposes. Diseases in these animals result in the fall in utility of these animals. The diseases not only induce depressed growth of milk and meat quality but also the quantity and quality of wool animals like sheep.

5.7 Probable questions

1. Define and classify zoonoses with examples.

মানুষের জ্ঞান ও ভাবকে বইয়ের মধ্যে সঞ্চিত করিবার যে একটা প্রচুর সুবিধা আছে, সে কথা কেহই অস্বীকার করিতে পারে না। কিন্তু সেই সুবিধার দ্বারা মনের স্বাভাবিক শক্তিকে একেবারে আচ্ছন্ন করিয়া ফেলিলে মুক্তিকে বাধা করিয়া তোলা হয়।

- রবীন্দ্রনাথ ঠাকুর

"Any system of education which ignores Indian conditions, requirements, history and sociology is too unscientific to commend itself to any rational support".

- **Subhas Chandra Bose**

ভারতের একটা mission আছে, একটা গৌরবময় ভবিষ্যৎ আছে, সেই ভবিষ্যৎ ভারতের উত্তরাধিকারী আমরাই। নূতন ভারতের মুক্তির ইতিহাস আমরাই রচনা করছি এবং করব। এই বিশ্বাস আছে বলেই আমরা সব দুঃখ কষ্ট সহ্য করতে পারি, অন্ধকারময় বর্তমানকে অগ্রাহ্য করতে পারি, বাস্তবের নিষ্ঠুর সত্যগুলি আদর্শের কঠিন আঘাতে ধূলিসাৎ করতে পারি।

- সুভাষচন্দ্র বসু

মূল্য : ১৫০ টাকা

১ উডবার্ন পার্ক, কলকাতা ৭০০ ০২০ থেকে নেতাজি সুভাষ মুক্ত বিশ্ববিদ্যালয় কর্তৃক প্রকাশিত এবং ক্লাসিক প্রিন্ট এ্যান্ড প্রসেস্ ২০বি, শাঁখারীটোলা স্ট্রিট, কলকাতা ৭০০ ০১৪ থেকে মুদ্রিত, মুদ্রণকাল : ২২৪৬-২১১১