Indira Gandhi National
Open University
School of Sciences

BZYEL-144
INSECT VECTORS AND VECTOR BORNE DISEASES: LABORATORY

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Course Design Committee

Prof. M.S. Nathawat
Former Director, School of Sciences
IGNOU, Maidan Garhi, New Delhi-110068

Prof. S. S. Hasan (Retd.)
School of Sciences, IGNOU
Maidan Garhi, New Delhi-110068

Dr. R.S. Sharma (Retd.)
Head, Centre of Medical Entomology and Vector Control, National Centre for Disease Control, Ministry of Health and Family Welfare, 22, Sham Nath Marg, Delhi-110054

Dr. S.K. Sagar
Associate Professor in Zoology
Swami Shraddhanand College, Alipur Village
University of Delhi, Delhi- 110036

Dr. H.S. Pawar
Scientist D, NIMR
Sector 8, Dwarka, New Delhi-110077

Dr. Ranjana Saxena
Associate Professor in Zoology
Dyal Singh College, Lodhi Road, New Delhi-110003

Prof. Neera Kapoor
School of Sciences, IGNOU
Maidan Garhi, New Delhi-110068

Block Preparation Team

Dr. Nisha Sogan
Consultant, School of Sciences, IGNOU
Maidan Garhi, New Delhi-110068
(Exercises 1 to 9)

School of Sciences
Prof. Neera Kapoor (Exercises 1 to 9)

Course Coordinator	**:**	**Prof. Neera Kapoor**
Course Editor	**:**	**Prof. Sarita Kumar** **Professor in Zoology** **Acharya Narendra Dev College, Kalkaji** **New Delhi-110009**

Production

Mr. Hemant Kumar, SO (P), MPDD, IGNOU

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INSECT VECTORS AND VECTOR BORNE DISEASES: LABORATORY

Insects are the most diverse globally distributed organisms. They are the most successful organisms on this planet due to the combination of peculiar features viz. presence of hard cuticle, high fecundity, adaptability in almost all habitats due to presence of wings, their unique life cycle and varying sizes. One of the most important feature is modification in their mouthparts to ingest the variety of food material.

Exercises 1 and 2 of this course discuss about mouth parts of insects. In Exercise 1 you will study two types of mouth parts i.e., biting and chewing (cockroach, grasshopper) and piercing and sucking (mosquitoes), by prepared slides/photographs. You will be able to relate the structure of mouth parts with the food of insects possessing them. Exercise 2 will apprise you about three types of mouth parts i.e., chewing and lapping type (honeybees), sponging (housefly) and siphoning (butterflies) types. You will appreciate the varied structures and function of these mouth parts.

A vector is a living organism that transmits an infectious agent from an infected animal to a human or other animal. Vectors are arthropods such as mosquitoes, flies, fleas, ticks and lice that can transmit infectious diseases either actively or passively.

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

Diseases transmitted by vectors are called vector borne diseases. Many vector borne diseases are zoonotic diseases, i.e., diseases can be transmitted directly or indirectly between animals and humans.

Exercises 3, 4, and 5 tell about various vectors and vector-borne diseases. Exercises 6, 7, 8, and 9 discuss about medical importance of these vectors.

In Exercise 3, you will observe different mosquito vectors i.e., *Aedes, Anopheles* and *Culex* and differentiate among these vectors through their morphological features i.e., legs, wings sitting posture. In Exercise 4 you will observe ectoparasites i.e., head louse, body louse and pubic louse through slides, and able to differentiate among their morphological features. Exercise 5 speaks about characteristic features and medical importance of four different vectors i.e., flea, bedbug, sand fly and housefly. You will be able to identify and distinguish these vectors from others based on their morphological features. Their medical importance has also been discussed.

Exercise 6 tells about one of the important disease transmitted by *Aedes* i.e., dengue. Various symptoms and diagnosis of the same and preventive and treatment of this disease will be explained through chart/model. Exercise 7 speaks about important diseases transmitted by *Anopheles* and *Culex* i.e., Malaria, Filariasis & JE respectively. The life cycles of parasites/pathogens causing these diseases are explained. Preventive and control measures are explained in detail in the exercise.

In Exercise 8, you will learn about the diseases caused by flea, bedbug, sand fly and housefly i.e., plague, biting nuisance, Leishmaniasis, myiasis respectively. Their preventive and control measures are also dealt with.

Like all other IGNOU laboratory courses this is an intensive residential exercise requiring one week to complete it. Everyday there will be two laboratory sessions of 4 hours each. So there will be a total of 14 sessions. The first session will be introductory and the remaining 2nd to 13th session will be based on the exercise given in to course. Sessions 1 to 13 will have guided exercises under the supervision of the academic counsellor. The last two sessions i.e., 13 and 14 will be unguided sessions that is the term end examination. In each session you will perform exercises sessions for 3 hours and for the remaining 1 hour you will complete your practical note book. A schedule for laboratory exercises will be given to you in the first session.

You are aware that there is a time constraint as you will have limited access to laboratory work, therefore, you are required not to miss any of the laboratory sessions.

You will be assessed for your performance each day (Guided Experiments) and on the last day you will have the term end examination (Unguided Experiments). This examination will be compulsory for you to pass.

Study Guide

1. Before you enter your laboratory for performing laboratory exercises you should read the theory components of Insect Vectors and Vector Borne Diseases course.
2. You should also go through the laboratory manual and underline the important steps given in it.
3. Do not forget to carry laboratory manual and a practical record book for making and recording your observation.

Objectives

After completing this course, you should be able to:

- describe different kinds of mouth parts; biting and chewing; piercing and sucking, siphoning, sponging chewing and lapping,
- draw well labelled diagrams of these mouth parts and explain their structures and functions,
- relate the structure of mouth parts with the food of insects possessing them,
- discuss about three important mosquito vectors i.e., *Aedes*, *Culex* and *Anopheles,*
- explain the morphological features of three species of mosquitoes and differentiate among them,
- discuss the diseases vectored by *Anopheles* and *Culex,*
- describe the lifecycle of pathogens/parasites causing these diseases,
- list the prevention and control measures of these diseases,
- explain the three species of lice morphologically; i.e. *Pediculus humanus capitis, Pediculus humanus corporis* and *Pthirus pubis* and discuss the morphological differences among these three species,
- discuss about medical importance of *Xenopsylla cheopis, Cimex lectularius, Phelobotomus argentipes* and *Musca domestica,* and
- discuss about the symptoms, diagnosis preventive measures and treatment of dengue and dengue haemorrhagic fever.

EXERCISE 1

STUDY OF DIFFERENT KINDS OF MOUTH PARTS IN INSECTS–PART I

Structure

1.1 Introduction
Objectives
1.2 Materials Required
1.3 Observations
1.4 Terminal Questions

1.1 INTRODUCTION

Insects are the most diverse organisms widely distributed throughout the world. They have unique combinations of features which provide them survival advantage and unparalleled success. One of these features is modification in their mouthparts to ingest the variety of food material.

The mouthparts of insects are **ectognathous** in nature, *i.e.,* they are projected externally from the head. The type and structure of mouthparts in insects vary among different groups depending upon their food and feeding habits. Primarily, these can be categorized into two types *viz*., **mandibulate** (feeding mainly on solid food) and **haustellate** (feeding mainly on liquid food). In this exercise, you will study about two kinds of mouth parts; biting and chewing type; and piercing and sucking type.

Objectives

After the completion of this exercise, you will be able to:

- describe two kinds of mouth parts; biting and chewing; and piercing and sucking,
- draw well labelled diagrams of these mouth parts,
- explain the structure and functions of these mouth parts, and
- relate the structure of mouth parts with the food of insects possessing them.

1.2 MATERIALS REQUIRED

i) Prepared slides/photographs of mouthparts of insects,

ii) Compound Microscope.

1.3 OBSERVATIONS

I. Biting and Chewing Type of Mouth parts

Examine the biting and chewing types of mouth parts carefully. These are primitive type of mouth parts and are used for pinching off, **chewing**, and **swallowing** the pieces of plant and animal tissue. These mouth parts are found in insects; such as **cockroaches** and **grasshoppers**.

The biting and chewing type of mouth parts consists of five major parts – Labium, labrum, maxilla, mandibles and hypopharynx (Fig. 1.1).

- **Labrum or Upper lip:** It is a flap-like and a bilobed structure which forms the roof of mouth cavity. It is attached to the *clypeus*, a broad sclerite in front of the head, by means of an articular membrane. The labrum is slightly movable in upward and downward direction. It holds the food in position, helps to pull the food into the mouth and prepares the way for mandibles to act on it.
- **Labrum-Epipharynx:** The inner surface of the labrum is referred to as labrum-epipharynx. It is membranous and contains taste buds. Thus, it is an organ of taste.
- **Mandibles:** The mouth part contains a pair of mandibles, which are called as the first pair of jaws (primary jaws). Each mandibles has two articulation points through which they articulate with the cranium. Mandibles are unjointed, triangular-shaped and heavily sclerotized structure bearing teeth on the inner border. The distal teeth are sharply pointed and are called incisor or cutting teeth; while proximal teeth are called molar or grinding teeth. Teeth work transversely to bite and grind the food into small fragments.
- **Maxillae:** These are also paired structures and are called **secondary jaws** or **accessory jaws**. Structure of maxilla is more complicated than mandibles. It consists of three parts.

  (a) Protopodite: This is the basal part and consists of two segments; *cardo* and *stipes.* Cardo joins the maxilla to head at proximal end. The second segment, stipes,bears next two parts – endopodite and exopodite.

  (b) Endopodite: It comprises an inner part, *lacinia* and outer part, *galea.* The galea bears taste buds and helps in grasping, and mastication of food.

  (c) Exopodite: It is tactile in nature and consists of 5-segmented *maxillary palp* attached to stipes by a lateral sclerite, *palpifer.*

  Maxillae direct the food into the mouth and hold the food in place when the mandibles are in action. They act as auxiliary jaws and assist in mastication of food.

- **Hypopharynx:** It is a tongue-like organ, located centrally in the preoral cavity arising from its floor. The duct of a salivary gland opens at its base.

- **Labium or lower lip:** It is partially-fused second pair of maxillae and forms the floor of the mouth cavity. It comprises three median sclerites *viz.*,

  (a) submentum (large basal sclerite),

  (b) mentum (middle sclerite) and

  (c) prementum (apical sclerite).

  The lateral side of the prementum has two small lateral sclerites, called *palpiger*, which bear three-segmented labial palpi. Distally, prementum bears *ligula* which is made of two pairs of lobes, a pair of *paraglossae* and a pair of *glossae,* respectively equivalent with galea and lacinia. These help in pushing the food into the pharynx.

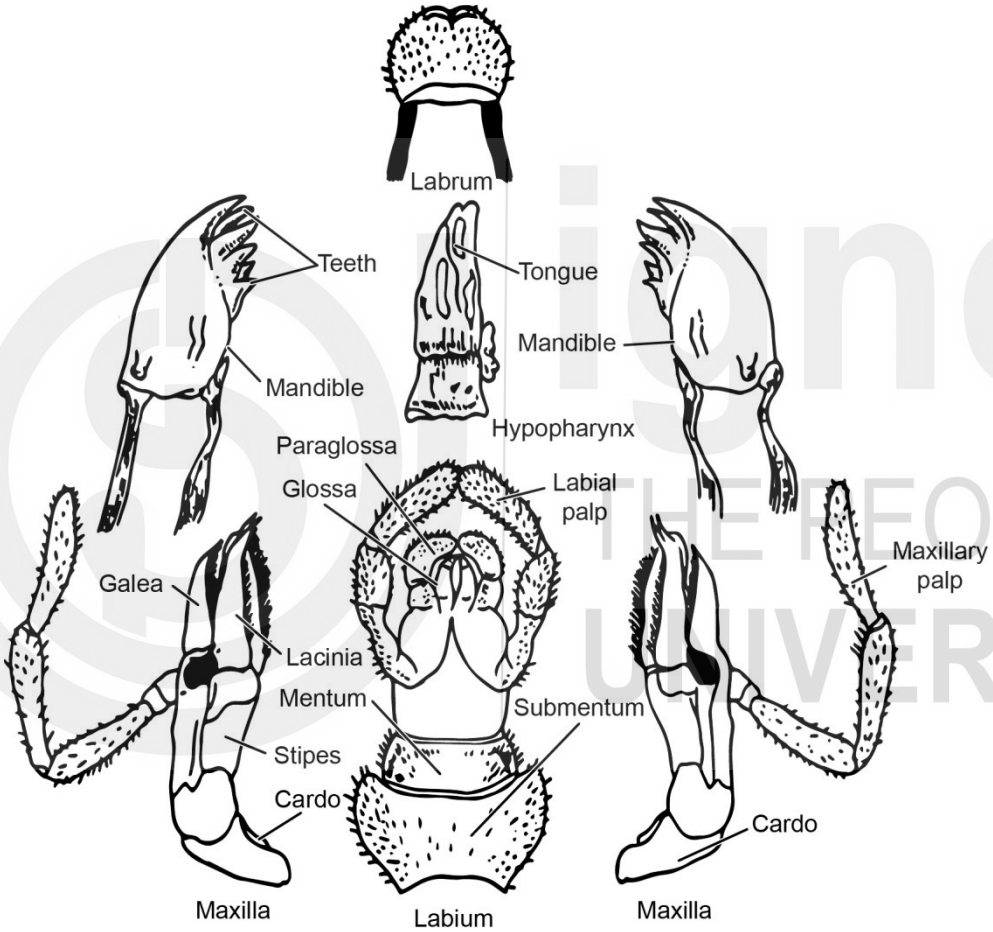


Fig. 1.1: Mouth parts of *Periplaneta Americana* (American cockroach).

II. Piercing and Sucking Type of Mouthparts

It is usually found in the sucking insects such as mosquitoes, bed bugs and herbivore insects which feed on the plant saps or mammalian blood. This type of mouth part is characterized by the modification of mandibles and maxillae into needle-like stylets to pierce the skin and plant tissue. Let's study the mouth parts of mosquitoes.

The characteristics of mosquito mouth parts are as follows.

- **Labium:** It is modified into an elongated, dorsally grooved, and fleshy tube called **proboscis**. Labial palps are modified into small **labellae**

which are located at the tip of proboscis. These act like feelers and help the mosquitoes to locate the suitable part of the host for feeding**.**

- **Mandibles and Maxillae:** These mouth parts are distally pointed, needle-like stylets which lie within the labial groove.
- **Hypopharynx:** It is also modified into elongated and pointed structure, placed in the labial groove. The hypopharynx also has a mid-dorsal groove for salivary secretion.
- **Labrum:** It is long, needle-like and fused with epipharynx. It covers the labial groove dorsally.

While sucking the blood, stylets in the groove move apart from each other and form a food channel in the labium through which blood is sucked in. When a female mosquito bites a host, the maxillae, mandibles and hypopharynx penetrate the skin of the host. Saliva is injected into the blood vessels through hypopharynx, which prevents the blood from coagulation (Fig. 1.2 a and b). **Both mandibles and maxillae are reduced in male as they feed on plant nectar and juices of decaying fruits. The labial palps are also absent.**

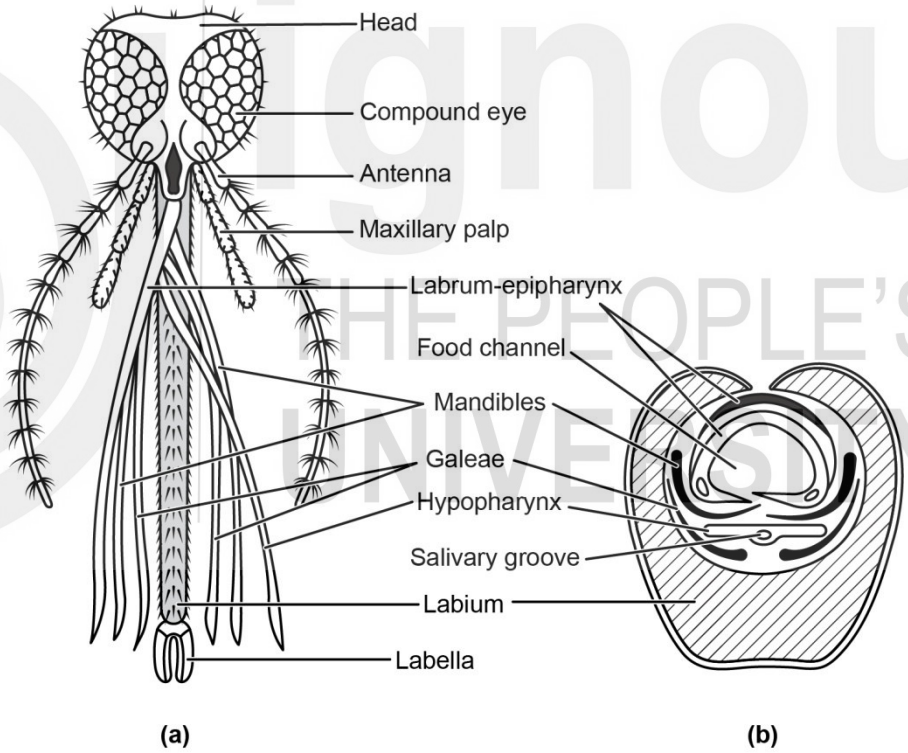


Fig 1.2: a) Head and mouth part; b) T.S of mouth part of female *Culex* mosquito.

1.4 TERMINAL QUESTIONS

1. Name two insects which have biting and chewing type of mouthparts; and two insects which possess piercing and sucking type of mouth parts.
2. Name the following:
   (a) The sclerite to which labium of cockroach is attached.
   (b) Modified labial palps in mosquitoes.
   (c) Second pair of maxillae in cockroaches.

3. Draw well labelled diagrams of mouth parts studied in this exercise. List different parts and write their functions.

4. Fill in the blanks:

   (a) The distal mandibular teeth of cockroaches are ……. while proximal teeth are ……. .

   (b) While feeding on human blood, saliva secreted from ……. of mosquito prevents coagulation.

5. Differentiate between:

   (a) Palpifer and palpiger.

   (b) Mouth parts of male and female mosquito.

EXERCISE 2

STUDY OF DIFFERENT KINDS OF MOUTH PARTS IN INSECTS– PART II

Structure

2.1 Introduction
Objectives
2.2 Materials Required
2.3 Observation
2.4 Terminal Questions

2.1 INTRODUCTION

You have learnt in previous exercise that insects mouthparts' are modified in various groups to ingest different types of food using different methods. You studied various parts and functions of two kinds of mouth parts; biting and chewing and piercing and sucking types; in different insects.

In this exercise, you will study three more kinds of mouth parts found in common insects; such as bees, butterflies, moths and housefly etc. These insects feed on different kinds of food material based on which their mouth parts are modified to get adequate nourishment for a successful living. These mouth parts include, chewing and lapping, siphoning and sponging types.

Objectives

After the completion of this exercise, you will be able to:

- describe mouth parts found in bees, butterflies/moths and housefly,
- explain the structure and functions of these mouth parts,
- draw well labelled diagrams of these mouth parts and explain each part, and
- relate the modification in the structures of mouth parts with the food ingested by insects.

2.2 MATERIALS REQUIRED

i) Prepared slides/photographs of mouthparts of insects,

ii) Compound Microscope.

2.3 OBSERVATIONS

I. Chewing and Lapping Mouth Parts

Examine the mouth parts carefully. You will observe a few similarities and variations from the mouth parts you studied in the previous experiment. These type of mouth parts are possessed by honeybees which feed on nectar and pollen (Fig. 2.1). These mouth parts are characterised by the following features:

- **Labrum:** The labrum is similar as found in biting and chewing mouth parts. It lies beneath the *clypeus* with fleshy *epipharynx* below it.
- **Mandibles:** A pair of blunt mandibles are located on the either side head. They are modified to grasp, cutting, crushing and shaping wax for comb building, biting flower parts to release pollen, grasping enemies for defense and other manipulative functions.
- **Maxillae:** Each maxilla includes an elongated blade-like *galea.* It is attached to a basal piece composed of two parts- stipes and cardo. The lacinia is absent and maxillary palps are reduced.
- **Labium:** The labial structures are modified to form the lapping tongue, called *proboscis*. It comprises two elongated labial palpi and elongated flexible hairy glossae, while paraglossae are highly reduced. The glossae are united to form retractile tongue called *ligula*. The ligula terminates into a small circular spoon-shaped lobe called *honeyspoon* or *labellum,* which has a ventro-median groove to take nectar (Fig. 2.2).

  The labium is attached to the *prementum,* which is jointed basally to *mentum* and *submentum*.

During feeding, the galea and labial palps are brought together over the ligula. They form a temporary tube containing food channel enclosed within ligula. This tube is inserted deep into the corolla. The maxilla remains stationary but tongue moves backwards and forwards to collect the pollen and suck the nectar. This is assisted by the sucking force of the pharynx.

II. Sponging Mouth Parts

These type of mouth parts are present in houseflies and are modified to feed on the liquid food. Mouth parts, attached to *clypeus,* consist of labrum-epipharynx, maxillae, labium and hypopharynx.

- **Mandibles:** The mandibles are absent in sponging mouth parts.
- **Maxillae:** These are reduced to single-piece maxillary palps.
- **Labium:** It is highly modified and forms a long, fleshy and retractile *proboscis*, which is divided into three parts.

  (a) ***Rostrum*:** It is conical in shape and proximally articulates with head. Maxillary palps are present on the rostrum.

(b) ***Haustellum*:** It is the middle part of the proboscis containing a mid-dorsal oral groove which serves as food passage.Blade-like *hypopharynx* containing salivary channel is located deep inside the oral groove. The *labrum-epipharynx* covers the oral groove dorsally and forms the food channel along with hypopharynx.

(c) ***Labellum*:** Distal part of the proboscis consists of a pair of oval-shaped fleshy labella having fine channels called *pseudotracheae*. Pseudotracheae converge into the mouth present between the two lobes of labella, which leads into the food canal (Fig 2.3).

The labella act like a sponge to suck the liquids.They are protracted and expanded only during feeding, otherwise they remain retracted. When flies feed on easily soluble solid materials such as sugar lumps, dried blood, cheese and cooked meats, the labella are everted. The fly then moistens small food particles with either saliva or the regurgitated contents of its crop so that food can be sucked up. Regurgitation of the crop by fly helps in the spread of a variety of pathogens.

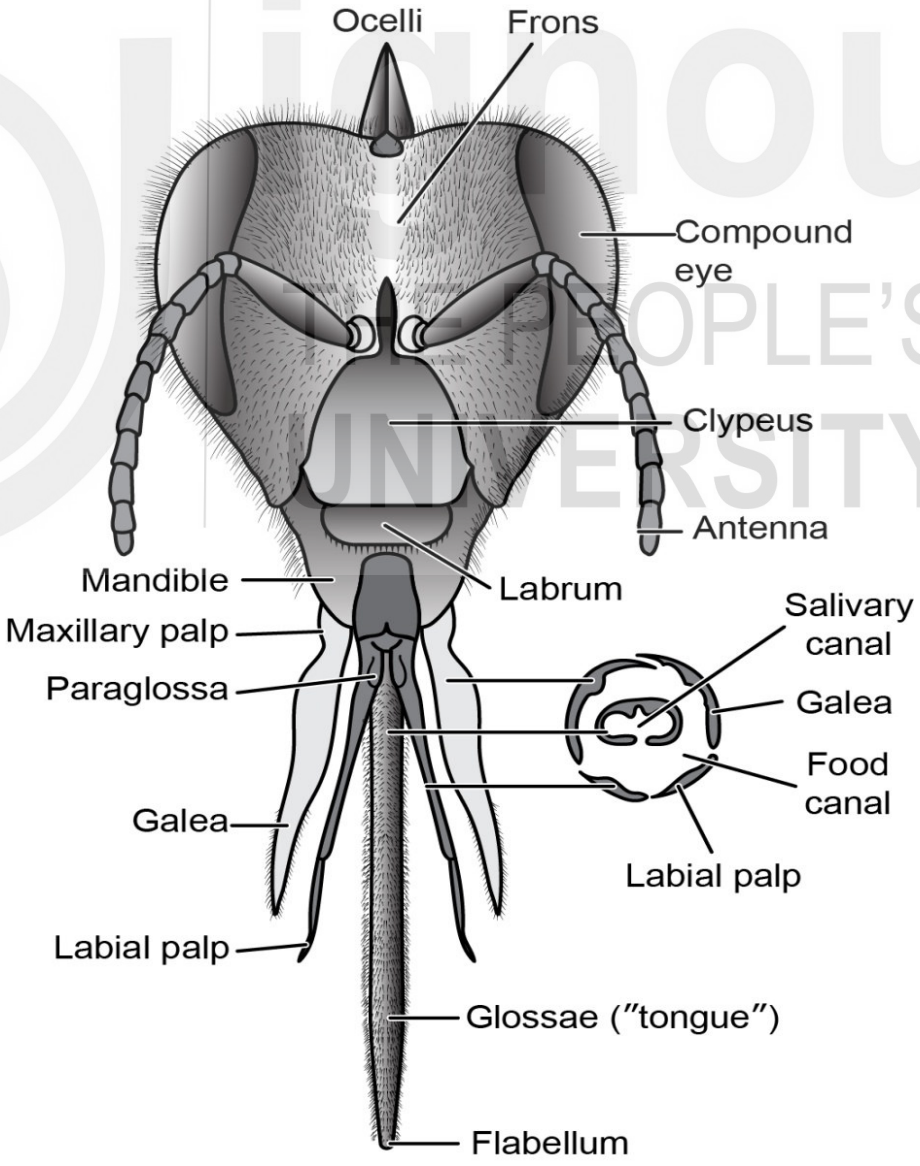


Fig 2.1: Frontal view of the head of a worker honey bee, *Apis mellifera*, with transverse section of proboscis.

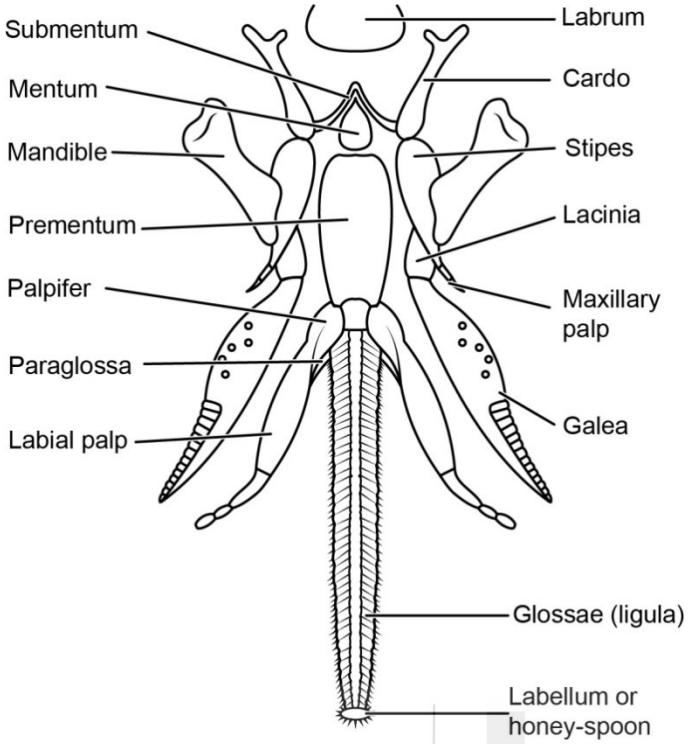


Fig. 2.2: Mouth parts of a honey bee.

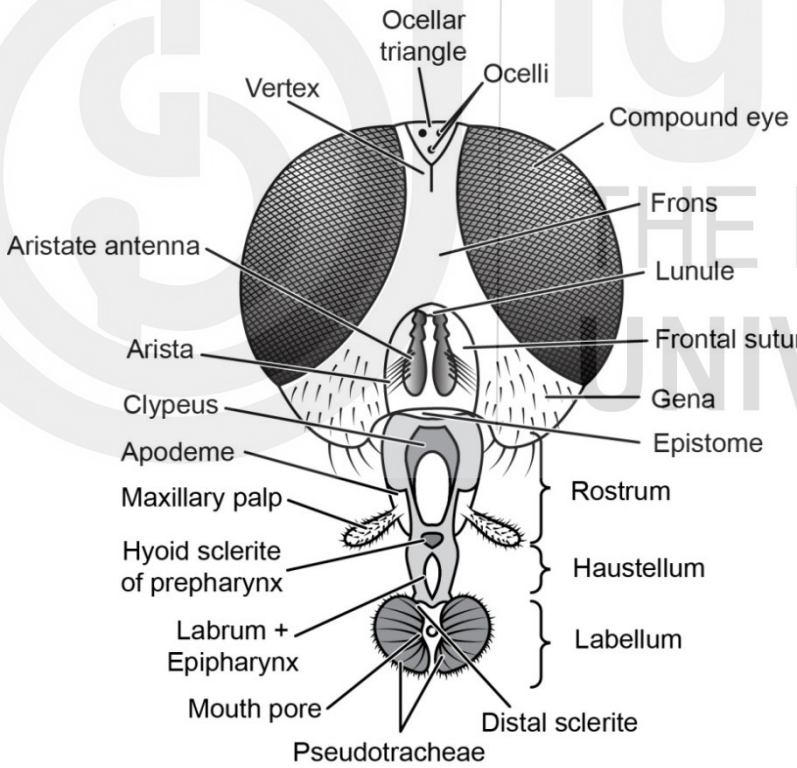


Fig. 2.3: House fly head and mouth parts.

III. Siphoning Mouth Parts

Siphoning mouth parts are found in the moths and butterflies. The mouth parts are highly modified to suck the fruitjuice and nectar. These mouth parts have following characteristic features.

- **Mandibles:** The mandibles are highly reduced.
- **Maxillae:** The maxillary palps are vestigial. The galeae of maxillae are greatly elongated forming sucking tube or *proboscis* (Fig 2.4). Two

galeae are applied together by interlocking spines and hooks. They are grooved on their inner surface which forms a suctorial food canal through which the nectar is sucked up.

- **Labium:** It is represented by a triangular plate bearing labial palps.

The proboscis is coiled uplike a watch spring and kept beneath the head when not in use. During feeding, the proboscis is uncoiled by the rise in blood pressure. It is extended so that it can reach the nectaries of flowers and suck the nectar.

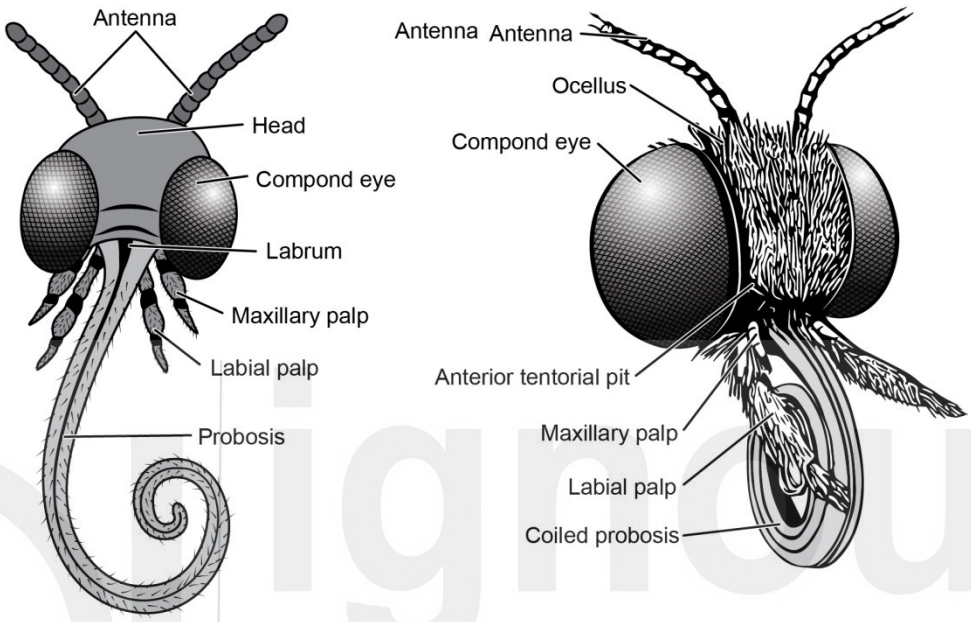


Fig. 2.4: Head and mouth parts of butterfly.

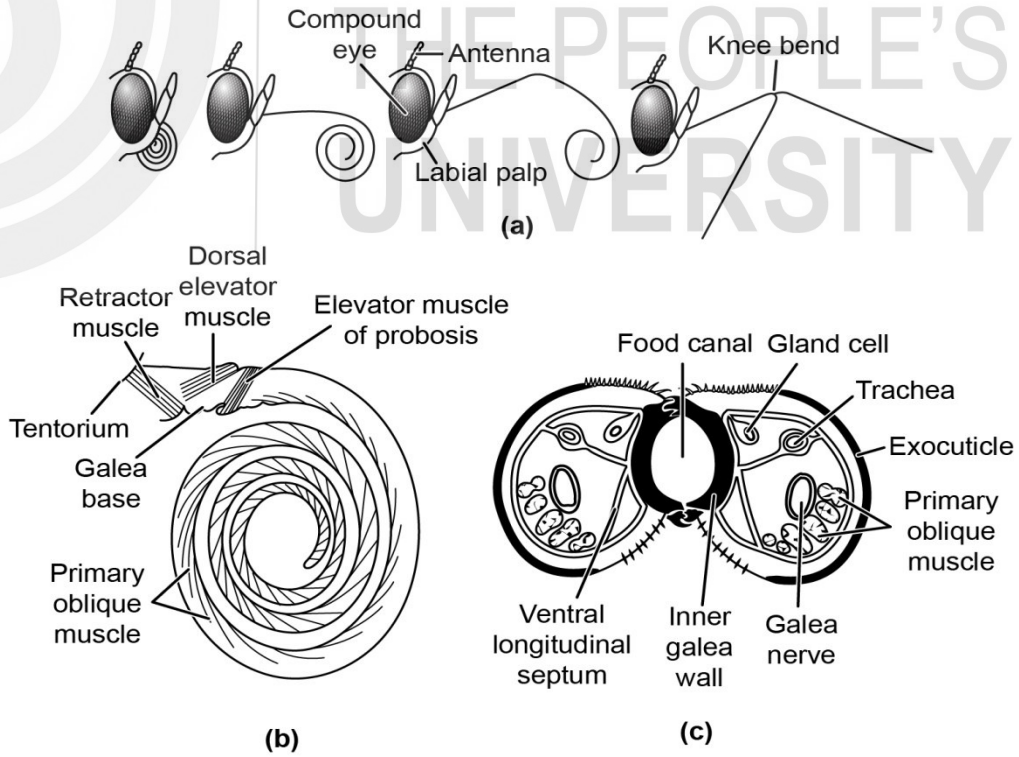


Fig. 2.5: Mouthparts of the cabbage white or cabbage butterfly, *Pieris rapae* (a) Position of the proboscis showing, from left to right, at rest, with proximal region uncoiling, with distal region uncoiling, and fully extended with tip in two of many possible different positions due to flexing at knee bend. (b) Lateral view of proboscis musculature. (c) Transverse section of the proboscis in the proximal region. (Eastham & Eassa 1955).

2.4 TERMINAL QUESTIONS

1. Discuss the structure of chewing and lapping type of the mouthpart by giving suitable example. Add a note on mechanism of feeding using these mouth parts.
2. Compare the mouth parts of insects feeding on liquid diet.
3. Write the location and the function of following.
   (a) Honey spoon
   (b) Pseudotracheae
4. Differentiate between the proboscis of a housefly and a butterfly.
5. How do houseflies feed on sugar lumps?

EXERCISE 3

STUDY OF MOSQUITO VECTORS

Structure

3.1 Introduction

Objectives

3.2 Materials Required

3.3 Observation

3.4 Terminal Questions

3.1 INTRODUCTION

Mosquitoes belong to order Diptera. They can be distinguished from other flies by presence of long, 15-segmented antennae, a long proboscis for bloodsucking, scales on the wing fringes and wing veins. Mosquitoes are significant disease vectors. They transmit various infectious pathogens and parasites that cause diseases such as dengue, Zika, Chikungunya, West Nile fever, Filariasis and Malaria. Mosquitoes obtain the germs by biting the affected individuals. These germs grow and multiply within their body and are transferred to a healthy person when they bite them.The mosquito saliva contains an anticoagulant which prevents clotting of blood to facilitate suction, thereby initiating the disease transmission cycle. In this exercise you will learn about three species of mosquitoes viz: *Aedes*, *Culex* and *Anopheles*.

Objectives

After the completion of this exercise, you will be able to

- discuss about three important mosquito vectors i.e., *Aedes*, *Culex* and *Anopheles,*
- explain the morphological features of three species of mosquitoes, and
- differentiate among the adult mosquito vectors.

3.2 MATERIALS REQUIRED

i) Prepared slides/photographs of *Aedes*, *Culex* and *Anopheles,*

ii) Compound Microscope.

3.3 OBSERVATIONS

All the three species of mosquitoes have some similarities and dissimilarities.

I. Similar Features of Mosquitoes

- Mosquitoes are slender and small insects, having size about 3–6mm in length.
- The body is distinctly divided into a head, thorax and abdomen.
- Head is small and spherical connected with thorax by narrow neck.
- Head bears following parts:
  - (a) One pair of kidney-shaped compound eyes.
  - (b) One pair of many-segmented antennae are present on a triangular plate, *clypeus,* present beneath the eyes Females bear whorls of short hairs at every joint of antennae (pilose antennae), while antennae of males have bushy whorls of long hairs at every joint giving them a feathery appearance (plumose antennae).
  - (c) The mouth parts are of piercing and sucking types. For details please refer to Exercise 1.
- The thorax is 3-segmented.Each thoracic segment has one pair of long legs.
- Front wings are long and relatively narrow, pattern of the wing veins arrangement is virtually the same for all mosquito species. The veins are covered with scales which are usually brown, black, white or yellowish.
- Hind wings which are highly reduced and knobbed at the end are called *halteres* or *balancers*.
- The abdomen is composed of 9 segments. The last abdominal segment of a female mosquito terminates in a pair of small finger-like cerci, but in males there is a pair of prominent claspers, comprising part of the male external genitalia.

II. Characteristic Features of *Aedes*

- *Aedes* bites during the daytime. The peak biting periods are early in the morning and in the evening before dusk. *Aedes aegypti* is known to transmit the dengue, dengue hemorrhagic fever, yellow fever, Zika and Chikungunya.
- Most common species found in India are *Aedes aegypti* and *Aedes albopictus.*
- These are small and greyish-black mosquitoes.
- They have unique patterns of light and dark scales on the abdomen and thorax, and alternating light and dark bands on the legs (Fig.3.1).

- *Ae. aegypti* can be distinguished from the other species by presence of a white lyre-shaped mark on its thorax whereas, *Ae. albopictus* has a single line marking on thorax extending up to head (Fig.3.2).
- Maxillary palps are shorter than labium in females but longer and pointed in males.
- Scutellum is tri-lobed.
- At rest, the body lies parallel to the surface.
- *Aedes* lays egg singly on the water surface. It prefers to breed on clean water.

Fig. 3.1*: Aedes* mosquito piercing the skin.

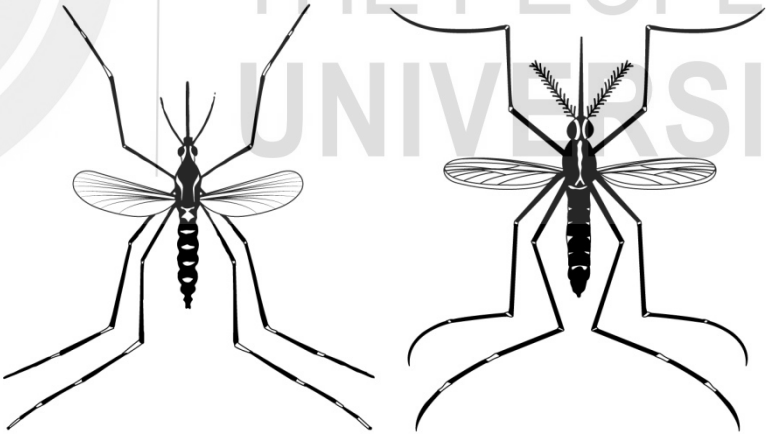


Fig. 3.2: *Aedes aegypti* (Left); *Aedes albopictus* (Right).

III. *Culex* Mosquito

- *Culex* bites during night time. These mosquitoes transmit primarily filariasis and encephalitis fever.
- Most common species found in India are *Culex quinquefasciatus* and *Culex pipiens fatigans.*
- These are small and light brownish mosquitoes. Head has the lightest portion in the center.

- Maxillary palps are shorter than labium in females but longer and pointed in males (Fig. 3.3).
- Scutellum is tri-lobed.
- Thorax is covered with narrow and curved scales.
- Abdomen has pale, rounded but narrow bands on the basal side of each tergite
- At rest, the body lies parallel to the surface.
- They lay eggs on the surface of dirty water in the form of rafts (clusters).

(a) Male **(b) Female**

Fig. 3.3: Adult *Culex* mosquito.

IV. *Anopheles* Mosquito

- *Anopheles* mosquitoes are also night biters and transmit malaria.
- Most common species found in India are *Anopheles stephensi* and *Anopheles culicifacies.*
- Body is delicate and grey-coloured.
- *Anopheles* mosquitoes can be distinguished from other mosquitoes by the palps, which are as long as the proboscis.
- The thorax is not covered with scales. Scutellum is rounded in shape (Fig. 3.4).
- Forewings bear the discrete blocks of black and white scales on the wings on the fore margin. Such wings are called dappled wings.
- Adults can also be identified by their resting position: males and females rest with their abdomens angled at 45º to the surface.

Fig. 3.4: Adult *Anopheles* mosquito.

- Female lay eggs singly and horizontally over the surface of stagnant water. Each egg is provided with air floats, which keeps it afloat on water surface.

3.4 TERMINAL QUESTIONS

1. Name the three kinds of mosquitoes commonly found in India and diseases transmitted by them.
2. Name the balancing organs of mosquitoes. Write their location.
3. Differentiate the *three* species of mosquitoes based on their resting position and mouth parts.
4. Write one specific feature by which you can distinguish *Aedes* mosquitoes from rest of the mosquito species.
5. Fill in the blanks with appropriate words.
   (a) The scutellum of *Culex* is …….... while that of *Anopheles* is …….... .
   (b) The male mosquitoes possess …… antennae and female mosquitoes have …….... antennae.

EXERCISE 4

STUDY OF *PEDICULUS HUMANUS CAPITIS, PEDICULUS HUMANUS CORPORIS* AND *PTHIRUS PUBIS* VECTORS

Structure

4.1 Introduction

Objectives

4.2 Materials Required

4.3 Observation

4.4 Terminal Questions

4.1 INTRODUCTION

Human beings are infested by three types of ectoparasitic lice, the head louse (*Pediculus humanus capitis*), the body louse (*Pediculus humanus corporis*) and the pubic or crab louse (*Pthirus pubis*). Morphologically the head louse and body louse are very similar and are considered as one species, however they do not interbreed outside the laboratories in natural conditions.

Human lice are often inseparable companions of those who dwell in unsanitary unhygienic conditions and have been responsible for a vast amount of human misery and disease. Normally lice are confined to such places where unsanitary living prevails, such as slums of cities, labour camps, jails and prisons. In this exercise you will learn about the morphology of all the three species of lice.

Objectives

After the completion of this exercise, you will be able to:

- explain the three species of lice morphologically; i.e. *Pediculus humanus capitis, Pediculus humanus corporis* and *Pthirus pubis,*
- discuss the morphological difference between these three species, and
- draw the sketch of louse and explain its body parts.

4.2 MATERIALS REQUIRED

Prepared slides/photographs of *Pediculus humanus capitis, Pediculus humanus corporis* and *Phthirus pubis,* Compound Microscope.

4.3 OBSERVATIONS

I. *Pediculus humanus capitis* (Head louse)

Head lice are hematophagous ectoparasites which live in close association with humans, especially the human scalp, and feed exclusively on the human blood. These are common all around the world.

- Head lice are small, 2.5 - 3mm long and dorsoventrally flattened apterous insects (Fig. 4.1).
- They are greyish-white in colour but colour may vary from beige, brown to black according to the environment.
- They may colonize any part of the scalp but are mainly confined at neck and area behind the neck.
- Head is triangular and bears one pair of 5-segmented antennae and one pair of eyes. The mouth parts are piercing and sucking types which remain retracted into the insect's head except during feeding.
- Thoracic segments are fused. Legs projecting from the thoracic segments are short and terminate with a single claw and opposing thumb. The louse clings to the hair of host between its claw and thumb (Clinging legs).
- Lice are incapable of jumping or walking but they can quickly climb up the hair strands allowing them to move and reach another host.
- Abdomen is elongated and 7-segmented.
- Males are slightly shorter than the females and have a pointed abdomen. The front two legs of males are slightly larger than other four legs.
- Females have similar-sized legs and have bifurcated abdomen possessing two W-shaped gonopods at the end.

Head louse generally are not considered as vector of medical importance but they may occasionally be minor vectors in some outbreaks of louse-borne relapsing fever. Rare secondary infections can result from scratching at bites.

Fig 4.1: Dorsal view of adult *Pediculus humanus capitis.*

II. *Pediculus humanus corporis* (Body Louse)

Body louse is also an obligatory ectoparasite which feeds on humanblood. These have a more or less universal distribution, but they are often more confined in temperate areas.

- Adults are small, pale beige or greyish coloured and dorsoventrally flattened wingless insects. They have a soft leathery integument.
- Males measure about 2–3mm and females are about 3–4mm long.
- Head is small and constricted proximally in a neck like manner. The head has a pair of small black eyes and a pair of short five-segmented antennae (Fig. 4.2).
- Mouthparts of the body louse differ from those of most blood-sucking insects as they do not form a projecting proboscis. Instead, they consist of a sucking snout-shaped projection called the *haustellum*, which is armed on the inner surface with minute teeth that grip the host's skin during feeding.
- The three thoracic segments are fused. The legs are stout and well developed. The tibia is short and thick with a small spine on its inner side. The tarsus ends in a curved claw.
- Tibial spine and tarsal claw serve as gripping tool for the body hairs of the host, or clothing.
- Males exhibit dark transverse bands on the dorsal surface of the abdominal segments and the tip of the abdomen is rounded. In females, abdominal tip is bifurcated to grip the fibres of clothing during egg-laying.

Body lice serve as vectors of louse-borne epidemic typhus (*Rickettsia prowazekii*), trench fever (*Bartonella quintana*) and louse-borne relapsing fever (*Borrelia recurrentis*). Several infestations with body louse may result in a condition known as vagabond's disease, hobo disease or sometimes as *morbus errorum*. Sometimes people develop allergies such as dermatitis or severe itching, or have a type of asthmatic bronchitis. Secondary infections such as impetigo, which is very contagious, can also result from large numbers of biting lice.

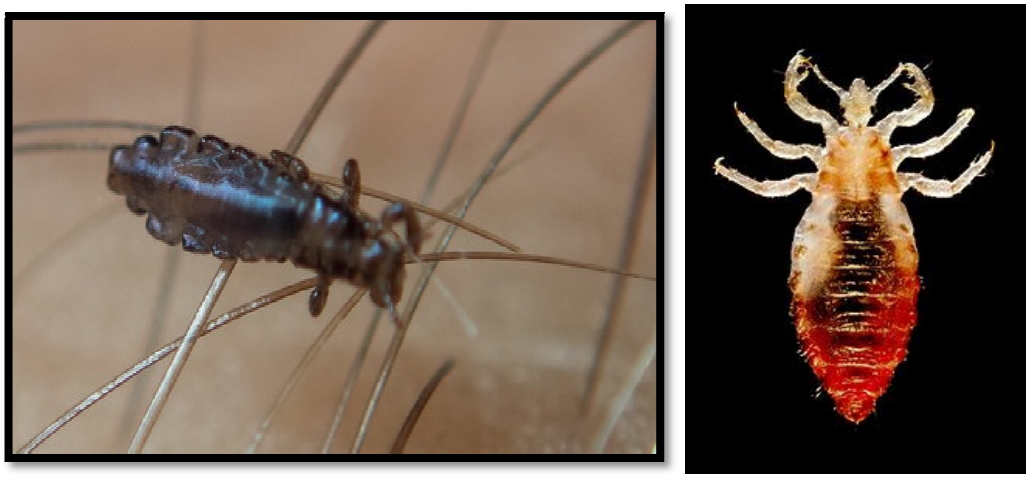


Fig 4.2: Dorsal view of adult *Pediculus humanus corporis.*

III. *Pthirus pubis* (Pubic/Crab Louse)

Public louse occurs in many parts of the world including Israel, Egypt, USA, U.K, Southern Asia, Australia, parts of Europe and Central Africa. The pubic louse gets the nickname of "crab" from its short, broad body appearance with large front claws, which resemble crab.

The crab louse is usually found in the person's pubic hair, though it can also live in other areas of the body that are covered with coarse hair, such as the perianal area, eyebrows, eyelashes, moustache, beard etc.

- The pubic louse is comparatively smaller (0.8-1.2 mm) than both *P. humanus capitis* and *P. humanus corporis.*
- They are white to gray in colour and can be distinguished because of its small and round body (Fig. 4.3).
- The second and third pairs of legs of crab louse are much thicker than the front legs. The claws are much larger than the ones present in front legs.
- They lay eggs usually on the coarse hairs on the genitals and sometimes on hair near the armpit, beard, eyebrows, moustache, and eyelashes.

Pubic lice do not carry any pathogenic agent, thus do not spread infectious diseases. However, it can cause *pediculosis pubis* causing itching and grey blue or slate colouration at the feeding site. The infection may spread through sexual intercourse, or by use of shared towels, clothing or beds. The infestation of the eyelashes leads to *pediculosis ciliaris* or *phthiriasis palpebrarum*.

(a) **(b)**

Fig. 4.3: Adult *Pthirus pubis*; (a) Dorsal view, (b) Ventral view.

4.4 TERMINAL QUESTIONS

1. Name three species of louse and write one identifying feature of each species.
2. Differentiate between:
   (a) Male and female *Pediculus humanus capitis*
   (b) *Pediculus humanus corporis* and *Pthirus pubis*

3. Fill in the blanks with appropriate words:

   (a) The abdominal end of head louse has two …….. .

   (b) Mouth parts of body louse have a snout-shaped projection called the …….. .

4. Which of the three species of human louse is medically most significant? Give reasons.

5. Write characteristic features of the legs of human louse. How do these differ in three species of louse?

EXERCISE 5

STUDY OF *XENOPSYLLA CHEOPIS, CIMEX LECTULARIUS, PHELOBOTOMUS ARGENTIPES AND MUSCA DOMESTICA*

Structure

5.1 Introduction

Objectives

5.2 Materials Required

5.3 Observation

5.4 Terminal Questions

5.1 INTRODUCTION

In this exercise, you will learn about the characteristic features and medical importance of four different vectors *Xenopsylla cheopis, Cimex lectularius, Phelobotomus argentipes* and *Musca domestica. These insects are responsible for* causing biting nuisance to the human host *and transmission of various* pathogens resulting in dreadful diseases.

Objectives

After the completion of this exercise, you will be able to:

- explain the morphological features of above insect vectors which distinguish them from other vectors, and
- discuss about medical importance of *Xenopsylla cheopis, Cimex lectularius, Phelobotomus argentipes* and *Musca domestica.*

5.2 MATERIALS REQUIRED

i) Prepared slides/photographs of *Xenopsylla cheopis, Cimex lectularius, Phelobotomus argentipes* and *Musca domestica*

ii) Compound/Dissecting Microscope

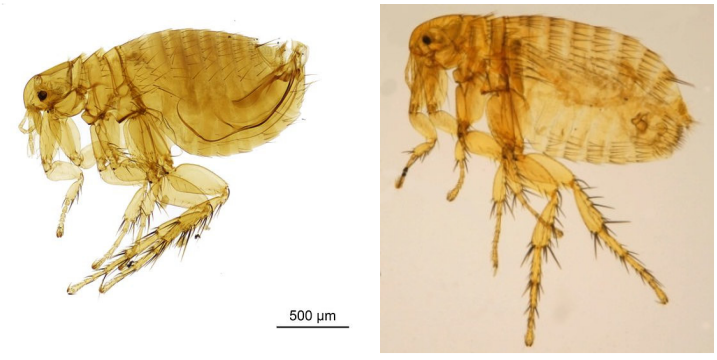
5.3 OBSERVATIONS

I. *Xenopsylla cheopis*

There are about 2500 flea species which are confined in about 220 genera. Among them, only few species are important pests of humans. Adults are quite tolerant to arid climates and moderate temperatures, though they may hide during long, hot and dry spells. The most common flea is *Xenopslla cheopis,* commonly called oriental rat flea.

- Adult rat fleas are relatively small (1–6 mm), more or less oval in shape and are compressed laterally.
- Their colour varies from light to dark brown and body is covered with backwardly-directed rows of bristles (Fig. 5. 1).
- Wings are absent, but they have three pairs of powerful legs, with the hind legs modified for jumping. The legs are covered with bristles and small spines.
- Body is divided into head, thorax and abdomen.
- The head is triangular in shape and, bears a pair of conspicuous eyes and short three-segmented club-shaped antennae which lie in depressions behind the eyes.
- Mouthparts are of piercing and sucking type.
- The thorax is divided into three distinct segments the pro-, meso- and metathorax.
- The adults lack genal comb (spines along the bottom margin of the head) as well as pronotal comb (spines on the posterior margin of the pronotum).
- Male and female are sexually dimorphic. Females have dark-coloured spermatheca in the posterior region of abdomen that acts as reservoir of sperms (Fig. 5.1). Males have complex genitalia.

Both male and female *Xenopslla cheopis* are obligate blood-feeders and feed on mammals, preferably rats. It is a vector of plague (caused by *Yersinia pestis*) and murine typhus fever (caused by *Rickettsia typhi*). You will study about these diseases in Exercise 6.



(a) **(b)**

Fig. 5.1: *Xenopsylla cheopis* (Rat Flea), (a) Male, (b) Female.

II. Cimex *lectularius*

Cimex lectularius, commonly called **bedbug**, belongs to family Cimicidae. They are nocturnal blood-feeders and hide in cracks and crevices during the day. They are attracted by the warmth and odour of the human body.

Fig. 5.2: ***Cimex lectularius*** **(Bedbug).**

- Adult bedbugs are about 5–7 mm long, oval, dorsoventrally flattened and wingless insects (Fig. 5.2).
- They are pale yellow or brown when unfed, but after ingesting a full blood-meal they become a characteristically darker 'mahogany' brown.
- The head is short and broad, and has a pair of prominent compound eyes and four-segmented antennae.
- The proboscis is slender and is normally held closely appressed under the head and prothorax. It is modified for piercing the skin and sucking blood.
- The thorax is divided into a large prothorax and a small mesothorax and metathorax. Metathorax is hidden beneath distinct wing pads termed hemelytra which represent vestigial forewings. Hindwings are absent.
- Three pairs of legs are slender but well developed.
- The abdomen has 11 segments but only eight are visible. In adult males the abdomen is narrower and pointed than in females, and terminates into a curved hook-like clasper.

Both sexes of bedbug take blood-meals and are equally important as pests. They usually feed at night on sleeping people, often just before dawn. However, bedbugs can resume feeding in the day, when they are starved especially in darkened rooms. Although hepatitis B virus and 27 other pathogens have been reported in bedbugs, but there is no evidence that they can transmit any infections to people, so they are not considered as vector. However, they cause a biting nuisance to adult and have been reported for causing iron deficiency in infants.

III. *Phelobotomus argentipes*

The sand flies belong to the family Psychodidae and subfamily Phlebotominae. A total of 1000 species and subspecies of sand flies are known, which are distributed in five or six genera. Three genera – *Phlebotomus*, *Lutzomyia* and *Sergentomyia* are reported to suck blood from vertebrates, while the other two being the more important because they contain disease vectors.

The genus *Phlebotomus* occurs only in the Old World, from southern parts of northern temperate areas, mainly the Mediterranean region, to central Asia, and in tropical areas. *Phelobotomus argentipes* is found predominantly in India.

- Adult phlebotomine sand flies are small in size (1.5–3.5mm long), hairy and delicate insects.
- They have relatively large black eyes and, long and stilt-like legs (Fig 5.3).

- The head, thorax, wings and abdomen are densely covered with long hairs.
- The antennae are long and composed of small bead-like segments having short hairs.
- The mouthparts are short and inconspicuous and specialized for blood-sucking in females.
- Wings are lanceolate in outline and quite distinct from the wings of other biting flies. The wings are held at an angle of about 40 degrees over the body when the fly is at rest or blood-feeding. This is a characteristic identification which distinguishes it from other members of Psychodidae.
- The abdomen is moderately long and, in the females, more or less rounded at the tip. In males, abdomen terminates in a prominent pair of genital claspers.

Phlebotomus argentipes is the predominant vector in India for Visceral leishmaniasis (VL), also known as kala-azar.The epidemiology is largely determined by the species of sand flies, their ecology and behaviour, the availability of a wide range of non-human hosts, and also by the species and strains of *Leishmania* parasite. In some areas, sand flies transmit infections almost entirely among wild or domesticated animals with little or no human involvement, whereas elsewhere animals may be important reservoir hosts of infection for humans.

Fig.5.3: *Phlebotomus species (Sand fly).*

IV. *Musca domestica*

The family Muscidae contains about 4200 species of flies in approximately 190 genera. Among them,the common house fly (*Musca domestica*), is medically most important. These are abundant in hot and humid conditions, observed commonly around human habitations and filthy places.

- *Musca domestica* is medium-sized non-metallic fly about 6–9 mm long.
- The colour varies from light to dark grey with some darker markings, having four rather broad black longitudinal stripes on the dorsal side of the thorax (Fig. 5.4).
- Head is semi-circular and bears a pair of large compound eyes, 3 ocelli, a pair of chemoreceptive antennae and mouthparts.

- Each antenna consists of three segments, the distal one is the largest and cylindrical carrying a prominent hair, called an arista.
- House flies feed on many types of substrates including almost all foods of humans, rotting vegetables, carcasses, and excreta. The mouthparts are sponging type, specialised for sucking up fluid or semifluid foods. The proboscis ends in a pair of oval-shaped fleshy labella, having very fine channels known as pseudotracheae to suck the fluids.
- The thorax bears one pair of membranous forewings and 3 pairs of legs. Hindwings are reduced to drumstick-shaped, halters.
- The legs are covered with hairs and end in paired claws having a pair of fleshy pad-like structures called the pulvilli, which are supplied with glandular hairs.
- Abdomen is also hairy and comprises eight segments in males and nine in females. The last four segments of males form *genital pouch* while that of females form a distinct *ovipositor.*

Fig. 5.4: *Musca domestica (House fly)*

Housefly acts as vectors of helminths, faecal bacteria, protozoans and viruses, resulting in the spread of enteric diseases (e.g. dysenteries and typhoid). They can transmit a number of pathogens including viruses of Coxsackie and infectious hepatitis; polio; rickettsiae of Q fever (*Coxiellaburnetii*); bacteria such as cholera (*Vibrio cholerae*), *Shigella*, anthrax, *Salmonella*, *Staphylococcus aureus, Escherichia coli*, and spirochaetes of yaws (*Treponema pertenue*); and protozoans including *Entamoeba*, *Cryptosporidium* and *Giardia*.

5.4 TERMINAL QUESTIONS

1. Differentiate between:
   (a) Male and female bedbug
   (b) Male and female rat flea
2. Fill in the blanks with appropriate words:
   (a) The distal part of housefly antenna carries a prominent hair, called …… .
   (b) The abdomen of male sandfly terminates in a prominent pair of …… .
   (c) The wing pads of bedbugs are called …… .
3. Differentiate between sand flies and house flies based on their mouth parts.
4. Write one identifying feature of rat flea, sand fly, bedbug and house fly.

EXERCISE 6

STUDY OF DISEASES SPREAD BY *AEDES*

Structure

6.1 Introduction

Objectives

6.2 Materials Required

6.3 Observation

6.4 Terminal Questions

6.1 INTRODUCTION

Several diseases are transmitted by different species of *Aedes* mosquitoes. These include dengue, Chikungunya, Zika, yellow fever, West Nile virus, Saint Louis Encephalitis virus, Eastern Equine Encephalitis virus. Among these, dengue is the most prevalent disease in India.

In this exercise, you will learn about the symptoms, diagnostic features, preventive measures and treatment of dengue and dengue haemorrhagic fever transmitted by *Aedes aegypti* (Fig. 6.1) and *Aedes albopictus* in India.

Objectives

After the completion of this exercise, you will be able to

- differentiate between dengue and dengue haemorrhagic fever;
- discuss about the symptoms and diagnosis of dengue and dengue haemorrhagic fever; and
- explain the preventive measures and treatment of these diseases.

6.2 MATERIALS REQUIRED

Charts or models of dengue and dengue haemorrhagic fever disease

6.3 OBSERVATIONS

Dengue is a viral disease which is transmitted by the infective bite of *Aedes aegypti* mosquito.Human develops disease after 5-6 days of being bitten by an infective mosquito. It occurs in two forms: Dengue Fever and Dengue Haemorrhagic Fever (DHF). Dengue Fever is a severe, flu-like illness while

Dengue Haemorrhagic Fever (DHF) is a more severe form of disease, which may cause death.

Fig. 6.1: Adult *Aedes aegypti.*

Pathogen

Dengue is caused by Dengue virus (DENV), a mosquito-borne *Flavivirus*. DENV is a single positive-stranded RNA virus of the family Flaviviridae. DENV causes a wide range of diseases in humans, from a self-limited Dengue Fever (DF) to a life-threatening syndrome called Dengue Hemorrhagic Fever (DHF) or Dengue Shock Syndrome (DSS). There are four antigenically different serotypes of the virus based on the antigens on their surface - DENV-1, DENV-2, DENV-3 and DENV-4. Infection by a particular serotype induces long-life protection against that, but only a short time cross-protective immunity against the other types.

Transmission

Dengue viruses are transmitted from person to person by *Aedes* mosquitoes in the domestic environment. Mosquito acquires virus while biting a dengue-infected person during viremic phase. *Aedes* mosquito acquires dengue virus through three ways -

1. Mosquito acquires virus while biting a dengue-infected person during viremic phase. This is called as **urban cycle.**
2. Wild monkeys are reservoir hosts for the dengue fever virus and can spread the virus from the jungle to humans. This is called **sylvatic** or **per-urban cycle**.
3. The virus can be transmitted to the next generation of mosquitoes through eggs. This is known as **vertical transmission**.

The infection from one person to the other is known as **transverse transmission.**

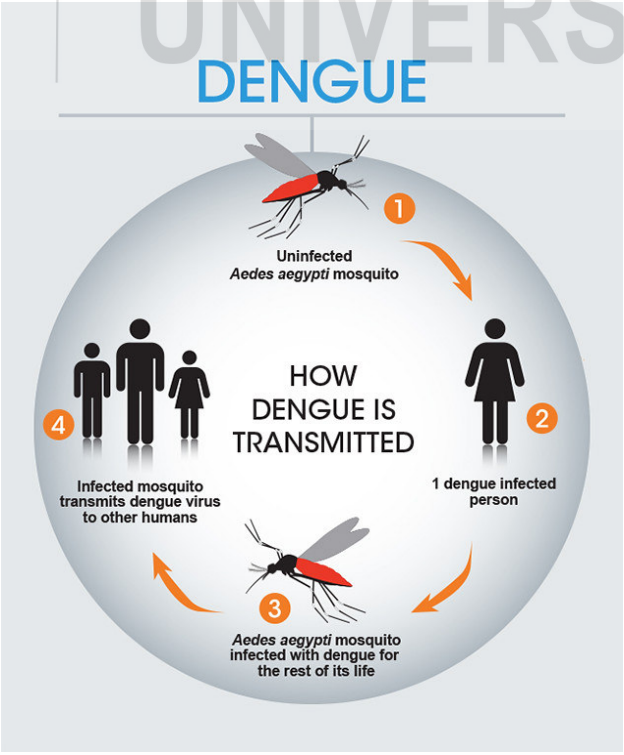


Fig. 6.2: Transmission Cycle of dengue.

Symptoms and Clinical Features

(a) **Dengue:** Classic dengue fever, or "break bone fever," is characterized by

- Abrupt onset of high fever for 3-14 days after mosquito bite
- Severe frontal headache and joint pain
- Loss of sense of taste and appetite
- Measles-like rash over chest and upper limbs
- Nausea and vomiting.
- Retro-orbital pain, myalgias, arthralgias
- Haemorrhagic manifestations, rash, and low white blood cell count.

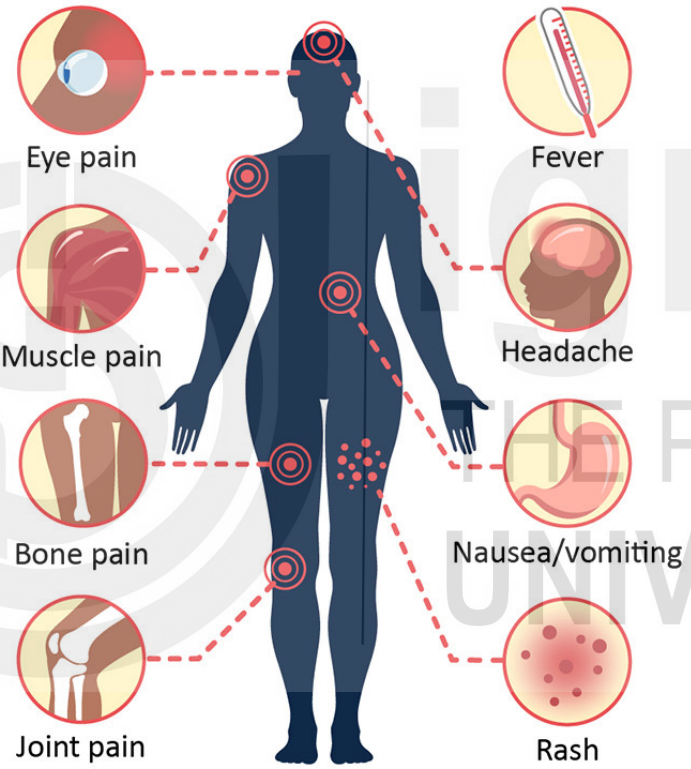


Fig. 6.3: Symptoms of dengue fever.

(b) **Dengue Haemorrhagic Fever (DHF):** DHF, the fatal form of disease is characterised by:

- Severe abdominal pain
- Persistent vomiting, marked changein temperature (from fever to hypothermia)
- Haemorrhagic manifestations - Nasal bleeding, gastrointestinal bleeding, gum bleeding, skin haemorrhage, hematuria
- Irritability, confusion, restlessness
- Cold clammy skin, rapid weak pulse

Treatment

- Take antipyretics to control the temperature.
- Take plenty of fluids and plenty of rest.
- Avoid aspirin and other nonsteroidal,anti-inflammatory medications because they increase the risk of haemorrhage.
- Hemodynamic assessments, baseline haematocrit testing and platelet counts can keep a track on the severity of the disease.

Control Measures

Dengue fever/DHF control is primarily dependent on the control of *Ae. aegypti*, since no vaccine is yet available for the prevention of dengue infection and there are no specific drugs for its treatment. A few measures of *Aedes* control are as follows:

- Control vector using Pyrethrum extract 2%, Malathion technical 95% and Temephos (Abate).
- Use thermal fogs and ultralow volume sprays for vector control at larger scale
- As the vector breeds in clean water and in keen proximity with the human host, weekly surveillance of the home for any stagnated water will keep the breeding check.
- **Use insect repellent on body parts.**
- **Wear long-sleeved, thick and light-coloured shirts and long pants.**
- Use screens on windows and doors to prevent entry.
- Don't litter garbage.
- Don't allow wild herbs etc.to grow around your house.
- Use biological control agents in ponds and water bodies, such as,*Gambusia affinis, Poecilia reticulata, Mesocyclops, Utricularia macrorhiza*, etc.

6.4 TERMINAL QUESTIONS

1. Write any three diagnostic features of dengue and dengue haemorrhagic fever.
2. List the three ways, *Aedes* mosquito can acquire dengue virus.
3. Fill in the blanks.
   (a) Classic dengue fever is also known as …….. fever.
   (b) Two mosquito larvivorous fishes are …….. and …….. .
   (c) The dengue infection from one person to the other is known as …….. transmission.
4. Write the measures which can be adopted to control and prevent dengue fever.

EXERCISE 7

STUDY OF DISEASES SPREAD BY *ANOPHELES* AND *CULEX*

Structure

7.1 Introduction

Objectives

7.2 Materials Required

7.3 Observation

7.4 Terminal Questions

7.1 INTRODUCTION

Anopheles and *Culex* belong to order Diptera and family Culicidae and have several characteristics features. They have long, segmented antennae, a long-specialized proboscis specialized for bloodsucking, they bite only night and creating nuisance and transmit diseases like malaria and Japanese encephalitis.

Objectives

After the completion of this exercise, you will be able to

- discuss the diseases vectored by *Anopheles* and *Culex,*
- describe the lifecycle of pathogens/parasites causing these diseases, and
- list the prevention and control measures of these diseases.

7.2 MATERIALS REQUIRED

Chart or model about the diseases transmitted by *Anopheles* and *Culex*

7.3 OBSERVATIONS

(a) *Anopheles*-borne Disease-Malaria

Malaria is caused by *Plasmodium* parasite and transmitted by *Anopheles* mosquitoes. It is caused by different species of *Plasmodium;P. vivax*,*P.falciparum*, *P. malariae* and *P. ovale*. Among these various species, *P.*

falciparum and *P. vivax* pose the greatest threat. *P. falciparum* is the deadliest malaria parasite and the most prevalent on the African continent while *P. vivax* is the dominant malaria parasite in most countries outside of sub-Saharan Africa. According to WHO report 2020,there were an estimated 229 million cases of malaria worldwide along with 409 000 mortalities.Children aged under 5 years are the highly vulnerable group affected by malaria.

Fig. 7.1: Female *Anopheles stephensi.*

Life Cycle of Malaria Parasite

The life cycle of the malaria parasite involves two hosts; female *Anopheles* as the primary host and human being as the secondary host. During a blood meal, a malaria-infected female *Anopheles* mosquito (Fig. 7.1) inoculates sporozoites into the human host. These sporozoites infect liver cells and mature into schizonts (exo-erythrocytic schizogony). The parasites undergo asexual multiplication and form merozoites. Merozoites infect red blood cells and multiply there (erythrocytic schizogony). The merozoite transforms into a trophozoite and feeds on the haemoglobin breaking it down into haem pigment and globin protein. The ring stage trophozoites mature into schizonts, which rupture releasing merozoites. The ruptured cell releases toxic pigment (haem converts to haemozoin) which causes chills and fever.Some parasites differentiate into sexual erythrocytic stages (gametocytes). Blood stage of parasites are responsible for the clinical manifestations of the disease.

The merozoites form two kinds of gametocytes: male gametocytes (microgametes) and female gametocytes (macrogametes). They get ingested by a mosquito, while sucking the blood. The gametocytes mature into gametes and fuse inside the mosquito's midgut to form zygotes which then elongate and develop into *ookinetes*. The motile ookinetes penetrate the midgut wall and a cyst is formed around them forming oocysts. The cysts undergo meiotic division and eventually release sporozoites. These migrate into the salivary glands from where they are injected into human blood. The development of *Plasmodium* inside a mosquito takes about two weeks and make a mosquito capable to transmit the disease. *Plasmodium* cannot complete its life cycle at temperatures below 20 ℃.

The life cycle of *Plasmodium* in liver cells is called **exoerythrocytic cycle**, while inside blood cells it is termed as **erythrocytic cycle**. On the other hand, the life cycle completed in mosquito is named as **sporogonic cycle** (Fig. 7.2).

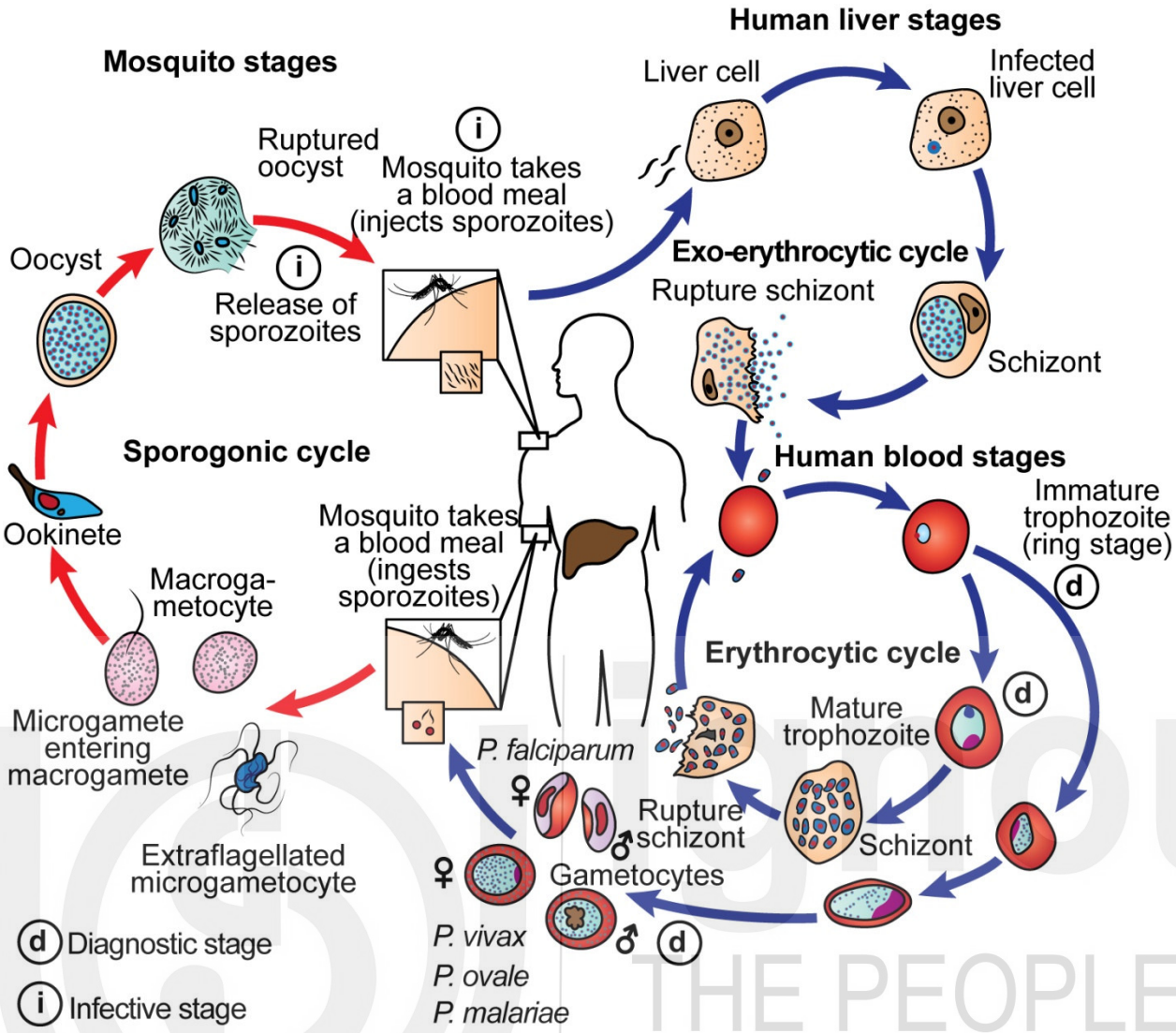


Fig. 7.2: Life cycle of malaria parasite.

Symptoms and Clinical Features

After being bitten by an infected mosquito, symptoms usually begin in the human beings within 10–30 days. These include

- fever and chills,
- headaches,
- nausea and vomiting, and
- general weakness and body aches.
- Some less noticeable manifestations are enlargement of the spleen (Splenomegaly) or liver (Hepatomegaly), increased breathing frequency, mild anaemia and mild jaundice.

Symptoms of severe malaria include; breathing difficulties, coma, confusion, death, focal neurologic signs, seizures and severe anaemia. Some less noticeable manifestations of severe malaria are abnormalities in blood coagulation, presence of haemoglobin in the urine, high acidity of the blood, hypoglycemia (low blood glucose), hypotension (low blood pressure) and kidney failure.

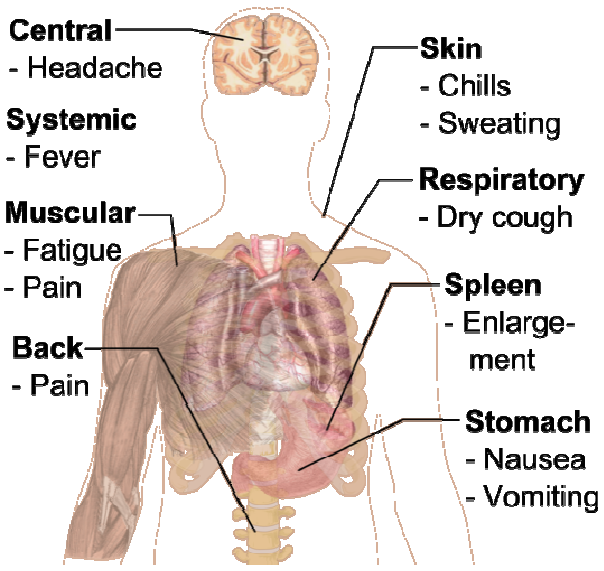


Fig. 7.3: Symptoms of Malaria.

Treatment

Common prescribed drugs for malaria treatment are

- Artemisinin-containing combination treatments (for example, artemether-lumefantrine, Artesunate-amodiaquine)
- Atovaquone-proguanil
- Chloroquine
- Doxycycline
- Mefloquine
- Quinine
- Sulfadoxine-pyrimethamine.

However, the development of resistance in *Plasmodium* to the antimalarial drugs has made the treatment difficult.

Control measures for *Anopheles*

Vector control is an important component of malaria control and elimination strategies as it is highly effective in preventing infection and reducing disease transmission and mortality.

- Use of insecticide-treated nets (ITNs), Long lasting insecticide nets (LLINs) and indoor residual spraying (IRS) are important interventions for the control of malaria. Pyrethroids, such as permethrin, are used in these nets which caused knockdown of mosquitoes preventing their bites.
- Attractive-toxic sugar baits (ATSBs) are combinations of a concentrated sugar-based food source, an olfaction stimulant and a systemic insecticide. Vectors searching for natural sugar sources are diverted and attracted to baits. Vectors ingest a toxin orally as they feed on and are killed.

- Genetic modification of mosquitoes impairs their ability to transmit the malaria parasite; such as the sterile insect technique (SIT), incompatible insect technique (IIT),introduction of chromosomal translocations and aberrations, and use of cytoplasmic incompatibility for producing hybrid sterility.
- For traditional control interventions, refer to Exercise 6.

(b) *Culex*-borne Diseases

In context with the Indian perspective, *Culex* (Fig. 7.4) species transmit primarily two diseases, Filariasis and Japanese encephalitis.

Fig. 7.4: *Culex* mosquito.

(i) Japanese Encephalitis

Japanese Encephalitis (JE) is the virus borne disease which is vectored by *Culex* mosquitoes and is prevalent in in Asia and the western Pacific region of the world.

Pathogen

JE virus is neurotropic arbovirus and primarily affects central nervous system. The infection leads to classical symptoms similar to any other virus causing encephalitis.Natural hosts of JE virus include water birds of Ardeidae family (mainly pond herons and cattle egrets).

Symptoms and Clinical Features

JE may result in

- febrile illness of variable severity associated with neurological symptoms which may range from headache to meningitis or encephalitis.
- headache, fever, meningeal signs
- stupor, disorientation, coma,
- tremors, paralysis (generalized), hypertonia, loss of coordination, etc (Fig. 7.5).

Less than 1% of people infected with Japanese encephalitis (JE) virus develop clinical illness. The incubation period (time from infection until illness) is typically 5-15 days. Seizures are common, especially among children.

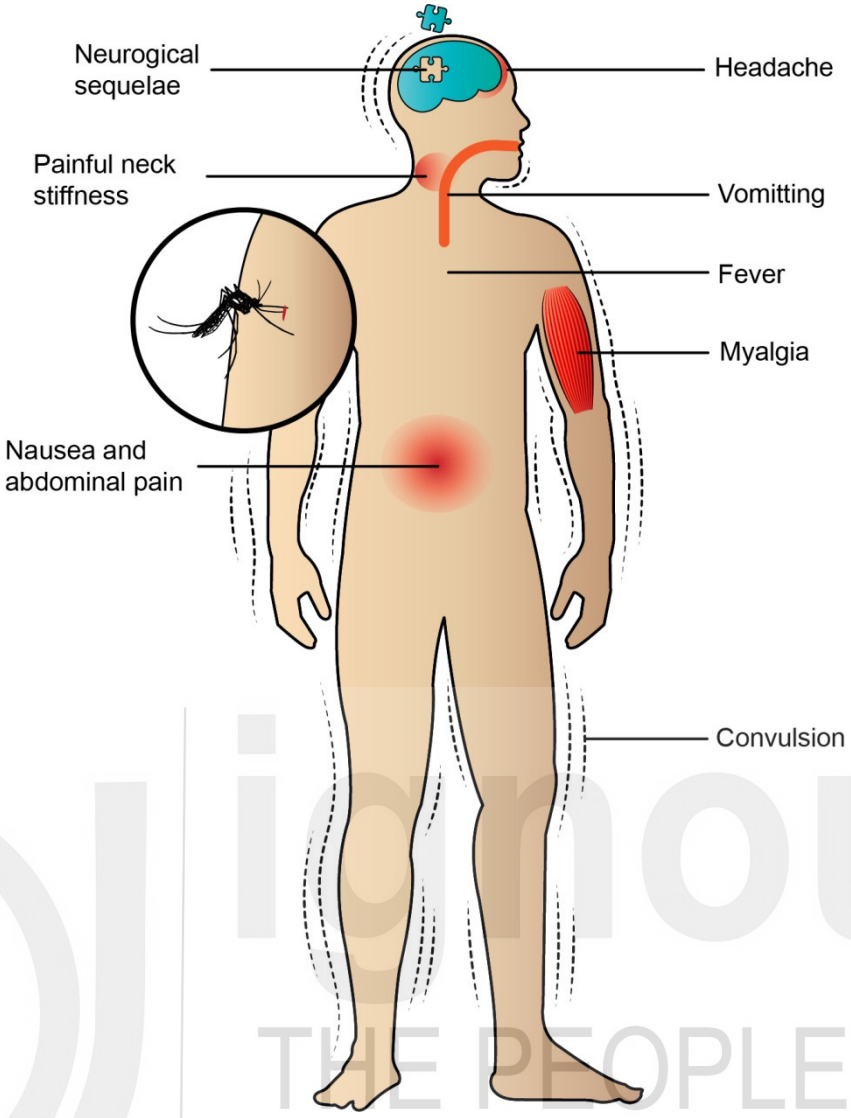


Fig. 7.5: Symptoms of Japanese Encephalitis.

Treatment

There is no specific treatment available for JE and thus patients are treated symptomatically. Pain relievers and medication used to reduce fever along with rest, may relieve some symptoms. Maintaining fluid and electrolyte balance in the body is important. Maintenance of airway is crucial for the patient to recover.

(ii) Filariasis

Filariasis is confined to tropical and sub-tropical regions and is prevalent mainly in developing countries.In India, it is chiefly distributed in the Southern area especially along the sea coast affecting more than hundred million people.

Pathogen

Three nematode parasites can cause lymphatic filariasis in human beings;*Wuchereria bancrofti*, *Brugia malayi* and *Brugia timori*. Of these, only *Wuchereria bancrofti* and *Brugia malayi* are found in India. In mainland India, *Wuchereria bancrofti*, transmitted by *Culex quinquefasciatus,* has been the predominant infection contributing to 99.4% of the problem in the country.

The adult parasites live in the lymph vessels and lymph nodes, particularly in the groin regions.After copulation, the females liberate numerous juveniles or microfilariae which appear in the blood circulation after six months to one year of infection. They move with the blood stream and ultimately migrate to reside in the deeper blood vessel. During night, they appear in the peripheral blood vessels, especially between 10 pm to 4 am, to be sucked by *Culex*, where they undergo development for 10-14 days to form infective larvae. The ingested microfilariae first penetrate the stomach wall and then migrate to the thoracic muscles for development. Finally, they reach the proboscis and are deposited at the site of mosquito bite. The larvae attracted by the warmth of human body invade the skin and enter the lymphatic system. In the human host, the infective larvae undergo two moults and develop into adult male and female worms (Fig. 7.6). The adult worms survive for about 5–8 years or sometimes as long as 15 years or more.

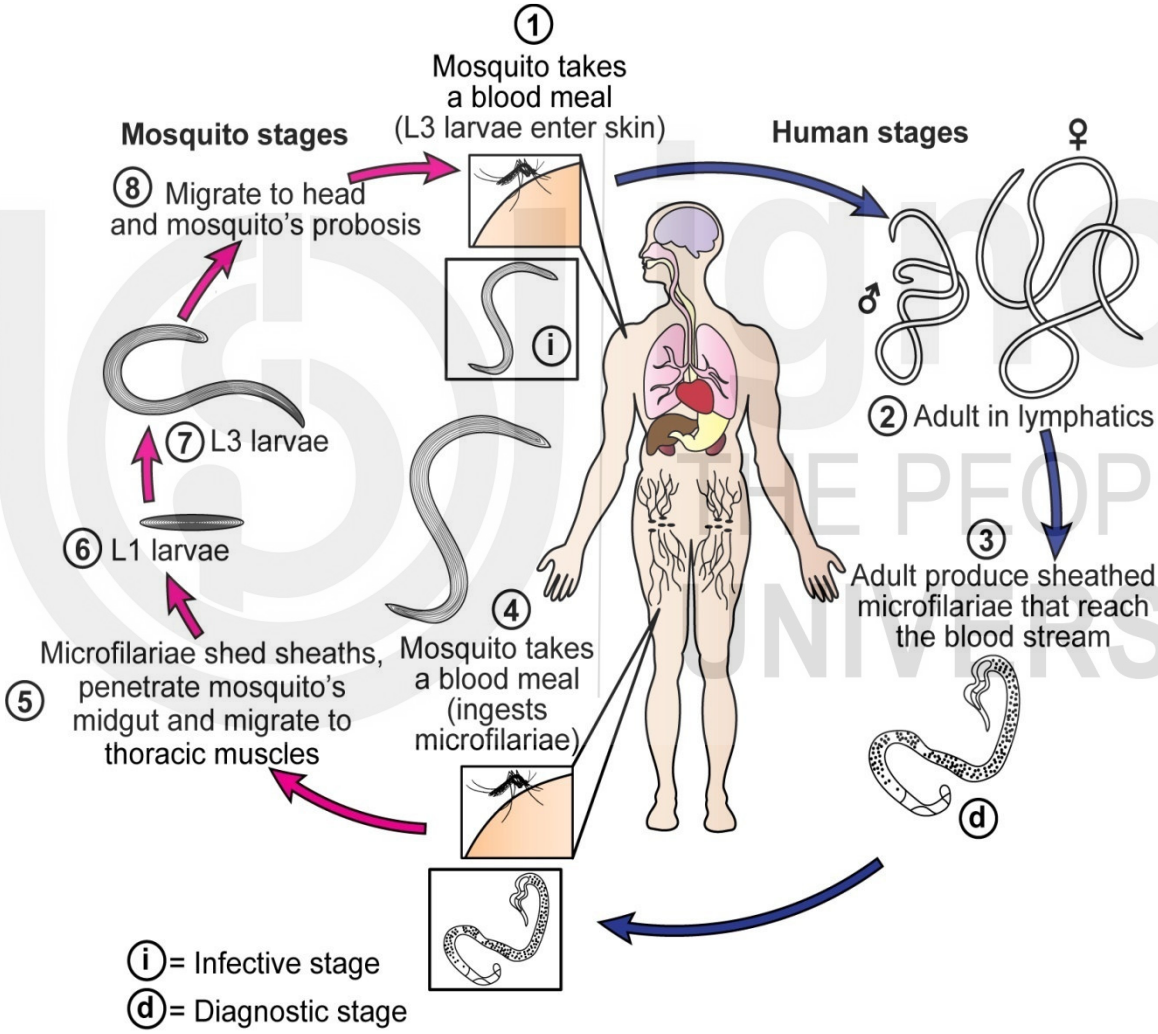


Fig. 7.6: Life cycle of Filarial worm, *Wuchereria bancrofti.*

Symptoms and Clinical Features

Various pathogenic effects caused by filarial worm are:

a) **Lymphangitis:** Inflammation of the lymphatic system leading to extreme pain and cord-like swellings.

b) **Lymphadenitis:** Inflammation of the lymph nodes accompanied by high fever for 3-5 days and increase in neutrophils.

c) **Hydrocoele:** Accumulation of fluid in the serous membrane surrounding the testes.

d) **Chyluria:** Excretion of milky-white urine due to the presence of chylecontaining fat particles, albumin and fibrinogen along with microfilariae and RBCs.

e) **Elephantiasis:** Blockage of the lymph flow in the body due to their accumulation in the lymph nodes.The affected part of the body becomes edematous and enlarge enormously becoming solid like a tumour. The surface of the skin becomes rough, dry, thick and papillomatus. *Wuchereria bancrofti* can affect the legs, arms, vulva, breasts, and scrotum.

Treatment

- Administration of single dose of anti-filarial drugs to the entire community (mass drug administration), yearly once for 5-6years.
- Diethylcarbamazine (DEC) and albendazole for mass drug administration.
- Ivermectin, Benzimidazole, Levamisole, Piperazine, Mebendazole, Imidazole

Control of *Culex* mosquito

- Prevent mosquito breeding by not allowing water to remain accumulated for long.
- Application of kerosene, fuel oil, burnout diesel, mosquito larvicidal oil etc., in stagnant water once a week, to prevent aerial respiration by mosquito larva.
- Introduction of larvivorous agents such as *Gambusia* and *Lebistes* (Guppy); naiads of dragonfly and mayfly; and cyclopoid copepods in water bodies.
- Spraying or fumigation of the houses and neighbouring areas with insecticides**,** such as lindane, malathion, pyrethroids etc.
- Use of mosquito net with not less than 150 holes/sqinch.
- Screening of building with copper and bronze gauze.
- Use of mosquito coils, mosquito mats and repellent creams to keep the mosquito away.
- Wearing long-sleeved shirts and long pants.
- Use of genetic methods, such as sterile male technique, chromosomal translocation, sex distortion and gene replacement methods. However, these methods have limitations and are expensive.

7.4 TERMINAL QUESTIONS

1. Name the different species of *Plasmodium,* describe the life cycle and write the pathogencity caused.

2. List the nematodes responsible for filariasis. Which one is prevalent in India? Briefly describe its transmission in human beings.

3. Fill in the blanks with suitable words:

   (a) Filarial worm causes inflammation of …….. and …….. .

   (b) The life cycle of *Plasmodium* in liver cells is called ……. cycle, while inside blood cells it is termed as …… cycle.

   (c) JE virus primarily affects …….. .

4. Write the drugs used in the treatment of malaria and filariasis.

EXERCISE 8

STUDY OF DISEASES SPREAD BY *LICE*

Structure

8.1 Introduction

Objectives

8.2 Materials Required

8.3 Observation

8.4 Terminal Questions

8.1 INTRODUCTION

You have learnt in Exercise 4 aboutthree speciesof ectoparasitic lice which live in close association with humans, the head louse (*Pediculus humanus capitis*), the body louse (*Pediculus humanus corporis*) and the pubic or crab louse (*Pthirus pubis*). In this exercise you will learn about the diseases transmitted by these three species of lice.

Objectives

After the completion of this exercise, you will be able to:

- explain the diseases transmitted by different species of lice, and
- list the symptoms, prevention and control measures of these diseases.

8.2 MATERIALS REQUIRED

Chart or model about the diseases transmitted by *Pediculus humanus capitis*, *Pediculus humanus corporis* and *Pthirus pubis.*

8.3 OBSERVATIONS

(a) *Pediculus humanus capitis* (Head louse)

Head lice are hematophagous ectoparasites which live in close association with humans, especially the human scalp, and feed exclusively on the human blood. Infestation with head lice is most common among children going to preschool and elementary school; and their household members and caretakers.

Head lice mainly spread by direct contact with the hair of an infected person. The most common way of transmission of head lice is head-to-head contact with a person who is infested with head lice.

Signs and Symptoms

Head lice are not known to transmit any disease; however, secondary bacterial infection of the skin resulting from scratching can occur with any lice infestation.

- **Itching:** A lice infestation causes itching on the scalp, neck and ears due to allergic reaction to their bites.
- **Sores on the scalp, neck and shoulders:** Scratching can lead to small, red pustules that may sometimes get infected with bacteria. The liquid oozing out from these pustules can also attract fungus forming a fungal carapace on the head.

Prevention and Control

It is difficult to prevent the spread of head lice among children, especially in schools because of the close contact. Transmission through personal items is quite less, however, head-lice infestation can be controlled by

- Keeping clothes separately
- Avoiding sharing combs, brushes, scarves, etc.
- Avoiding sleeping beds or pillows used by person infested by head lice

Treatment

Commercial formulations containing ivermectin, permethrin or malathion are recommended.

(b) *Pediculus humanus corporis* (Body louse)

Body lice are known to transmit several diseases. These include Epidemic typhus fever, Trench fever, and Epidemic relapsing fever.

(i) Epidemic typhus

Epidemic typhus is also called louse-borne typhus,camp fever, jail fever, and war fever that suggest overcrowding, underwashing, and lowered standards of living. It is an uncommon disease caused by a bacterium called *Rickettsia prowazekii.* Epidemic typhus spreads to people through contact with body lice infected with bacteria. Though epidemic typhus was responsible for millions of deaths in previous centuries, it is now considered a rare disease.

Transmission

The louse gets infected by feeding on the diseased person. The rickettsiae enter the insect's gut along with the blood and invade the intestine epithelial cells. The bacterial multiply repeatedly due to which the cells burst and a large number of rickettsiae are released into the louse's intestine lumen. These either re-infect other cells or are excreted along with the louse's faeces. The

louse-infested individuals get infection by crushing the lice, scratching a louse bite,rubbing the louse's infected faeces into the wound by abrasion or inoculation of contaminated faeces into conjunctivae.

Signs and Symptoms

Symptoms of epidemic typhus begin within 2 weeks after contact with infected body lice. Signs and symptoms may include:

- Fever and chills
- Headache and loss of appetite
- Rapid breathing
- Body and muscle aches
- Rashes on the body (Fig.8.1)
- Cough
- Nausea and Vomiting
- Confusion

If the disease is untreated, spots of gangrene on the fingers, genitals, nose, and ears appear.

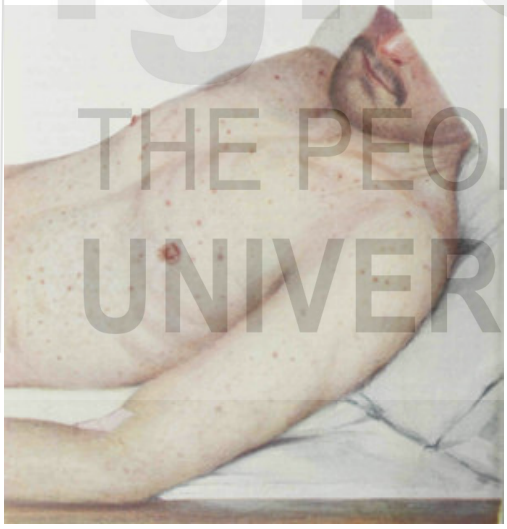


Fig. 8.1: Rashes caused by Epidemic Typhus Fever.

Prevention and Control

There is no vaccine to prevent epidemic typhus.The infection is treated with antibiotics, such as tetracycline, chloramphenicol and doxycycline. Prevention can be done by managing the population of the body louse, which can be achieved by maintaining the proper hygiene, washing of infested clothes, and use of insecticides. Clothes treated with permethrin can eliminate lice even after several washings.

(ii) Trench fever

Trench fever, also called **Quintana fever** or 5-day fever, is another disease transmitted by the human body louse which is caused by *Bartonella*

(Rickettsia) quintana, an aerobic Gram-negative rod bacterium. It is most commonly associated with homelessness or areas of high population density with poor sanitation. Trench fever received its name during World War I, when many soldiers fighting in the European trenches were infested with infected body lice and got sick with the disease.

Transmission

Bartonella quintana is carried predominately by a body louse in the intestinal lumen, unlike *Rickettsia prowazekii,* which multiplies in the cells.The infected louse transmits the disease *via* inoculation of contaminated faeces into exposed skin or conjunctivae by rubbing or scratching. Crushing the lice also transmits the disease. Hence, expedited transmission can be detected in crowded living conditions and poor hygiene, such as homelessness and its associated alcohol abuse.

Symptoms

The disease is a five-day fever with about 14-30 days incubation period. The onset of symptoms is usually accompanied by:

- high fever and severe headache
- pain behind the eyes (retro-orbital pain)
- soreness of the muscles of the legs and back
- severe pain in back and shins.

Most people recover within about two months, however, there may be relapses. After effects may include neurasthenia, cardiac disturbances and myalgia.

Control measures

The tetracyclines and chloramphenicol are used as standard therapy. Doxycycline has been shown to be effective in a single oral dose, but the standard recommended treatment is 200 mg once a day for 5 days.

(iii) Relapsing fever

Louse-borne relapsing fever is caused by *Borrelia recurrentis* and often occurs during epidemics, particularly in regions affected by war and in refugee camps.

Transmission

Humans are the only reservoir of pathogen. Lice that feed on infected humans acquire the *Borrelia recurrentis* which multiplies in the gut of the louse and finally reach the haemolymph. When the infected louse feeds on an uninfected human, the pathogen enters the human body *via* crushing the louse or scratching the abraded area where the louse feeding. *Borrelia recurrentis* infects the person *via* mucous membranes and then invades the bloodstream.

Symptoms

Most people who are infected develop sickness between 5 and 15 days after the bite. The symptoms may include

- sudden fever
- chills and headaches
- muscle or joint aches
- nausea, and
- rashes.

The symptoms usually continue for 2 to 9 days, then disappear.

Control measures

The control measures of the disease are same as in typhus and trench fever.

(c) *Pthirus pubis* (Crab louse or pubic louse)

Pubic lice are not known to transmit any disease. The most common symptom of their infestation is itching (pruritus) in the pubic and groin area, called pediculosis pubis transmitted by sexual contact.

Symptoms

- **Discoloured skin:** Pale blue spots may develop on the site of continual feeding by lice.
- **Secondary infections:** As with other lice infestations, intense itching leads to scratching which can cause sores and secondary bacterial infection of the skin.
- **Eye irritation:** Children having pubic lice on their eyelashes may develop pink eye or conjunctivitis.

Generally, infestations are asymptomatic. However, when noticed, symptoms may include a tickling feeling of something moving in the hair, itching caused by an allergic reaction to louse saliva, and irritability.

Prevention

Avoiding sexual contact or sharing bedding or clothing with louse-infested person can prevent the transmission.

Control measures

Pubic lice can be treated at home. Available treatments may vary from country to country and include mainly permethrin containing creams and lotions applied to cool dry skin.

8.4 TERMINAL QUESTIONS

1. Name different diseases transmitted by body louse. Write their pathogens and two characteristic symptoms.
2. Differentiate between:
   (a) Itching caused by head louse and public louse
   (b) Symptoms of Typhus fever and Trench fever

3. Fill in the blanks with appropriate words.

   (a) Two insecticides used for louse control are …….. and …….. .

   (b) Two antibiotics used for lice treatment are …….. and …….. .

4. How does body louse transmits diseases to human beings?

5. Where does different pathogens multiply in the body louse?

EXERCISE 9

STUDY OF DISEASES SPREAD BY *FLEA, BEDBUG, SANDFLY* AND *HOUSEFLY*

Structure

9.1 Introduction

Objectives

9.2 Materials Required

9.3 Observation

9.4 Terminal Questions

9.1 INTRODUCTION

In this exercise you will learn about the diseases spread by four different vectors –*Xenopsylla cheopis, Cimex lectularius, Phelobotomus argentipes* and *Musca domestica. These vectors* cause biting nuisance to the human host and transmit the pathogens.

Objectives

After the completion of this exercise, you will be able to:

- explain the diseases vectored by *Xenopsylla cheopis, Cimex lectularius, Phelobotomus argentipes* and *Musca domestica,* and
- list the symptoms, prevention and their control measures.

9.2 MATERIALS REQUIRED

Chart or model about the diseases transmitted by *Xenopsylla cheopis, Cimex lectularius, Phelobotomus argentipes* and *Musca domestica*

9.3 OBSERVATIONS

(a) *Xenopsylla cheopis* (Oriental rat flea)

i) Plague: Plague is an infectious disease caused by a zoonotic bacterium, *Yersinia pestis*, usually found in small mammals, primarily rodents and fleas (Fig 9.1). The organism is transmitted

to humans when bitten by fleas that have fed on infected rodents or by humans handling infected animals.

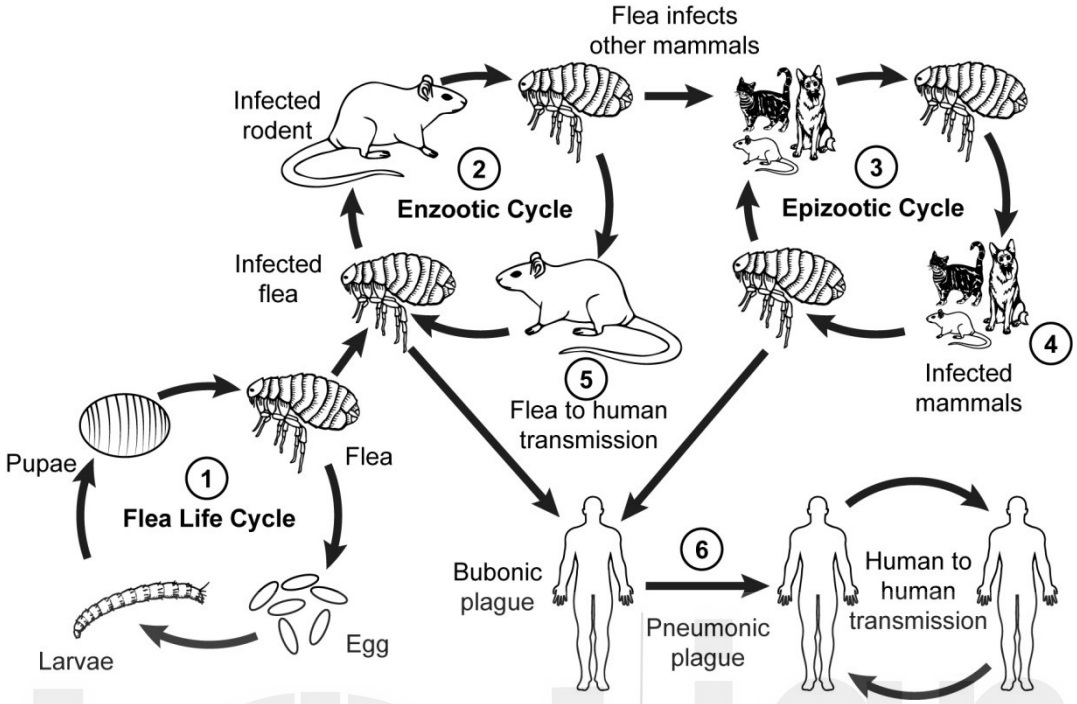


Fig. 9.1: Transmission of Plague.

Plague, also known as **black death,** is a very severe disease. It dangerously affects the people particularly in its septicaemic (systemic infection caused by circulating bacteria in bloodstream) and pneumonic forms and can result in the case-fatality ratio of 30% to 100%, if left untreated.

In fourteenth century, plague has been a widespread pandemic with high mortality causing more than 50 million deaths in Europe, thus named as the "Black Death". However nowadays, plague is easily curable with antibiotics and the useof standard precautions to prevent acquiring infection.

Forms of the plague infection

- **Bubonic plague:** This is the most common form of plague infection and is caused by the bite of an infected flea. The bacillus, *Y. pestis*, enters the human body through the bite and travels through the lymphatic system to the nearest lymph node where it replicates in large numbers. It leads to the inflammation of lymph nodes which is highly painful and tense. These inflammatory lymph nodes are called **buboes**.

  At advanced stages of the infection the inflamed lymph nodes can turn into open sores filled with pus. Other bubonic plague signs and symptoms may include sudden onset of fever and chills, headache, fatigue or malaise and muscle aches.

- **Pneumonic plague:** The advancement and spread of bubonic plague to the lungs is the more severe type of plague called pneumonic plague. Person infected with pneumonic plague may transmit the disease *via* respiratory droplets to other healthy humans. Untreated pneumonic plague can be fatal. The recovery rates are high if it is detected and treated on time (within 24 hours of onset of symptoms).

- **Septicemic plague:** Septicemic plague occurs when plague bacteria multiply in the bloodstream. The symptoms include fever, chills, extreme weakness, abdominal pain, diarrhoea, vomiting; bleeding from mouth, nose or rectum; shock and blackening and death of tissue (gangrene) in extremities.

Treatment

Early diagnosis and treatment is essential for survival and in further reducing the complications. Supportive therapy and antibiotics,if given on time, can reduce the fatality.

Control

- **To identify and stop the source of infection:** The source of infection should be identified in the area of reported human case(s), especially in clustered areas with large numbers of small animal deaths. Appropriate infection, prevention and control measures should be followed. First the vector control should be initiated followed by rodent control. Killing rodents before vectors will cause the fleas to jump to new hosts, which should be avoided.
- **Protect health workers:** Health Workers in direct contact with pneumonic plague patients must follow standard precautions and should receive a chemoprophylaxis for the duration of seven days or at least as long as they are in contact with infected patients.
- **Ensure correct treatment:** Patients should be given appropriate antibiotic treatment.
- **Isolate patients with pneumonic plague:** Patients should be kept in isolation for spreading the infection. Providing masks for pneumonic patients can further reduce spread.

ii) Endemic Typhus Fever: Endemic typhus fever is another disease transmitted by infected rat fleas. It is caused by bacteria called *Rickettsia typhi* or *Rickettsia mooseri*. The disease is also known as **murine typhus**.

Transmission

Rat fleas become infected when they feed on the blood of a rat with endemic typhus fever. Like, *Rickettsia prowazekii,* these bacteria multiply in gut epithelial cells and are passed out of the body *via* faeces. The pathogens can then infect the site of the bite or other small cuts on the skin of the person. It is believed that endemic typhus fever can also spread by breathing in dried faeces of infected rat flea.

Symptoms

The symptoms of endemic typhus fever are similar to those of epidemic typhus fever, but are less severe (Refer to Exercise 8). Symptoms may appear from 6 to 14 days after exposure.

Common symptoms include fever, headache, tiredness, joint pain and muscle aches. The infected individuals can also experience nausea, vomiting and develop a flat red rash that lasts for a short period of time.

Prevention

There is currently no commercially available vaccine for endemic typhus fever. It can be prevented by eliminating exposure to rats through good hygienic conditions.

Treatment

Endemic typhus fever is treated with antibiotics selected based on the patient's symptoms and severity.

(b) *Cimex lectularius* (Bedbug)

Bedbug belongs to family Cimicidae and is widely distributed in tropical and non-tropical countries. Though bedbugs are not considered important vectors, but they cause a biting nuisance to humans and have been associated with iron deficiency in infants.

Both sexes of bedbug are involved in taking blood-meals at night, often just before dawn. However, bedbugs can resume feeding in the day, when they are starved especially in darkened rooms.

A few studies have also reported that bed bugs may transmit *Bartonella quintana, Trypanosoma cruzi,* hepatitis B virus and 27 other pathogens. However, public health reports have thus far failed to produce evidence that major infectious disease outbreaks have been associated with bed bugs.

Control

The best way to treat a bedbug bite is to avoid scratching the area and apply antiseptic creams or lotions and take an antihistamine.

Insect repellents and insecticide-impregnated bed-nets are suggestive personal protection against bedbugs. Insecticides such as carbamate (bendiocarb), organophosphates (malathion) and a range of pyrethroids (cypermethrin, permethrin) and insect growth regulators (IGRs) are used for spraying the floors and walls of infested houses.

Cold treatment can also relieve from the bedbug infestation. Clothes can be placed in sealed plastic bags and placed in a freezer (–18 °C) for 24 hours to kill the bedbugs.

(c) *Phlebotomus argentipes*

Sand flies are grouped under family Psychodidae which transmit different type of leishmaniasis. In India and other parts of the Old World, *Phlebotomus argentipes* transmits the VL (Visceral Leishmaniasis) caused by the pathogen *Leishmania donovani*. Until now *Phlebotomus argentipes* is the only known vector of Kala-azar in India.

Visceral Leishmaniasis (Kala-azar)

Visceral leishmaniasis is a chronic disease of reticulo-endothelial system caused by *Leishmania donovani* (Fig 9.2). It is also known as Dum-Dum fever, Asian fever, Assam fever or infantile splenomegaly in various parts of the world. The pathogen is an obligate intracellular parasite of man and other mammalian hosts. It exists in two forms:

- **Amastigote form:** It is the non-flagellar stage of the parasite, found inside monocytes, polymorphonuclear leucocytes or endothelial cells of **human beings**.
- **Promastigote form:** These are found in the digestive tract of **sand fly**. The fully developed promastigotes are 15-25 µm long, slender and spindle-shaped. The body has a single centrally located nucleus and a kinetoplast which lies transversely near the anterior end.

Life cycle of *L. donovani*

In Human: The female sand fly transmits the **metacyclic promastigote** form of the parasite in human beings while taking blood meal. These promastigotes are immediately phagocytized by macrophages and other types of mononuclear phagocytic cells; and transform into the amastigotes (Fig 9.2). The infected cell eventually becomes packed with the parasite, gets enlarged and ruptures. These liberated **amastigotes** now infect new cells and the cycle is repeated and infect other mononuclear phagocytic cells.

In sandfly: The macrophages infected with amastigotesor free forms are ingested by female sand fly during a blood meal from infected host. The **amastigotes** are liberated from the macrophages and enter the midgut of sand fly where they transform into **metacyclic promastigotes**. These migrate to the proboscis of sandfly and the cycle is repeated.

Mode of transmission

The infection is transmitted to human mainly by the bite of *Phlebotomus argentipes.*The infection may also be transmitted sexually and by blood transfusion, congenital infection and, accidental inoculation of cultured promastigotes in the individuals.

Symptoms

The common symptoms of kala-azar include fever, splenomegaly (enlarged spleen), hepatomegaly (enlarged liver), jaundice, anaemia, leukopenia (low count of WBCs), thrombocytopenia (low count of platelets) and skin lesions.

iii) Phlebotomus fever

Phlebotomus fever, also known as Sandfly fever,Pappataci fever, or 3-day fever is a disease that mimics other conditions. It causes fever, myalgia and malaise along with abnormalities in liver enzymes and haematological test results.

The disease is caused by **Phlebovirus** carried by sand fly. After a few days of the infective bite, the abdominal distress and chills develop followed by fever of 39 ℃ to 40 ℃, severe frontal headaches, muscle and joint aches, flushing of the face and a fast heart rate. After two days the fever starts subsiding and the temperature returns to normal. Fatigue, a slow heart rate and low blood pressure may persist from few days to several weeks before complete recovery.

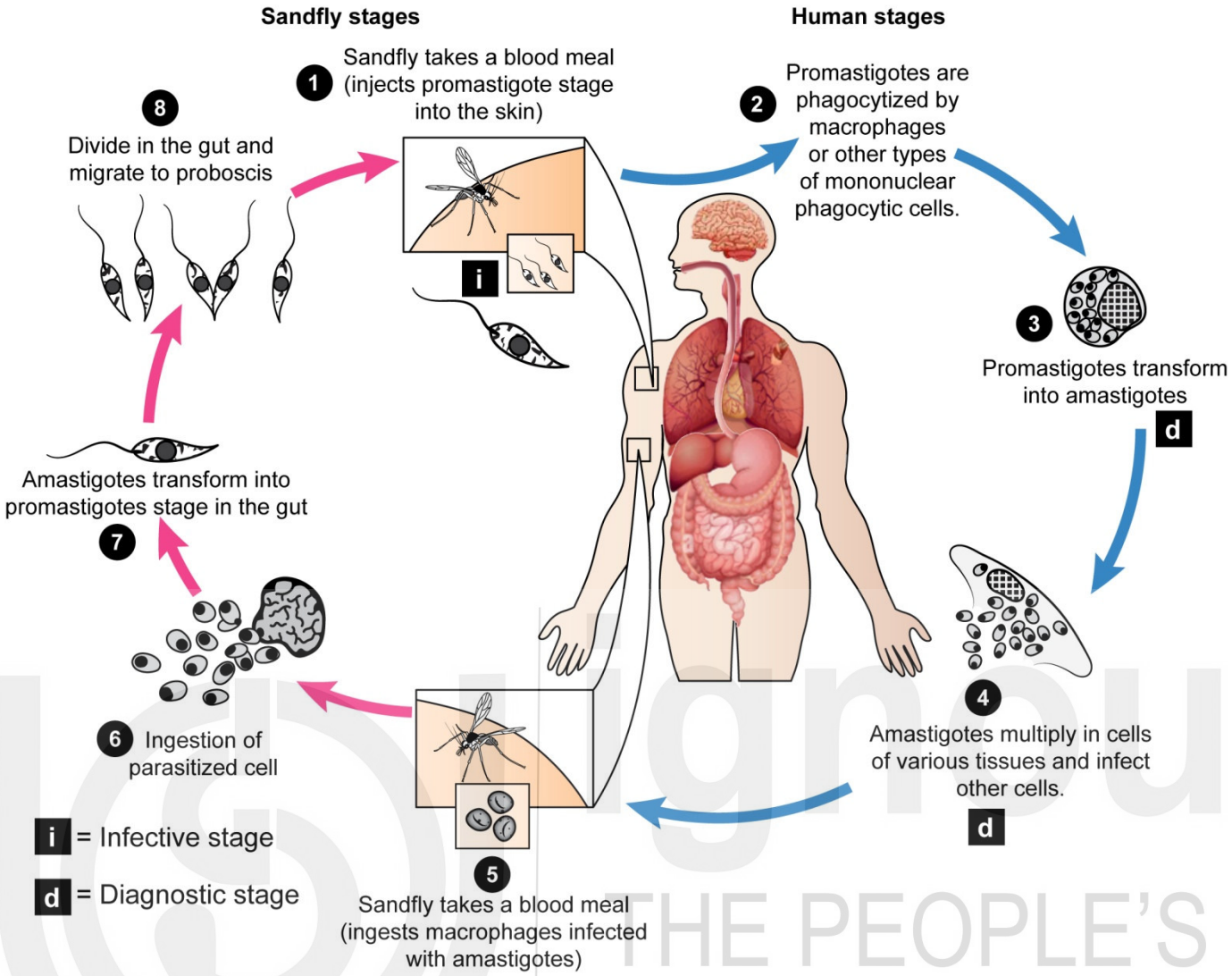


Fig. 9.2: Life cycle of *Leishmania donovani.*

Control

Phlebotomine sand flies are susceptible to several insecticides, such as organochlorines and pyrethroids. Resistance to several insecticides has been reported in some of the sand fly species. Indoor residual spraying of houses and animal shelters is an effective control strategy in achieving the interruption of the disease transmission in peri-domestic environments. The impact of IRS (Indoor Residual Spray) can be maximized if synchronized with case detection.

The objective of IRS is to ensure safe and correct application of the insecticide to indoor surfaces of houses and animal shelters so as to obtain a marked reduction in vector population and consequently a significant reduction of Kala-azar transmission in the target area. Application of insecticides to outdoor resting sites (if known) can also be effective.

The use of protective clothing, insect repellents and insecticide-impregnated bed nets are effective in reducing human-sand fly contact.Measures such as resurfacing walls to cover cracks and holes, demolition and removal of uninhabited buildings, and removal of organic waste and unwanted vegetation can help to discourage sand fly breeding.

iv) *Musca domestica* (House fly)

Houseflies are dipterans and belong to Muscidae family. Common housefly *Musca domestica* is worldwide in distribution. Originally from Asia, they are now found all over the world around hovering over human habitation, near garbage bins and dirty places.

They contaminate our food and water and are responsible for millions of infant deaths. The sponging type of mouthparts allow them to feed on the liquid food. It is holometabolous insect and thus its life cycle comprises egg, larva, pupa and adult stage.

The housefly is a mechanical vector of many pathogens - virus, bacteria, protists, fungi and nematodes. The fly picks up disease-causing organisms while crawling and feeding.

Transmission of Diseases

Transmission of diseases takes place when the pathogen-carrying fly makes contact with the people or their food Most of the diseases can also be contracted more directly through contaminated food, water, air, hands and person-to-person contact. The housefly can transmit disease in the following ways.

1. **Contact transmission:** The houseflies carry the microorganisms, eggs and cysts of various parasites on their feet, hairy legs and other parts of the body. They deposit them on our food and drinking water causing infection.
2. **Vomit drop (Regurgitation):** The housefly has a habit of frequent regurgitation while sitting on food items and water. The regurgitated stomach content contains rich bacterial culture which infects our food and water.
3. **Defecation:** The excrement of housefly has been found to contain many microorganisms, cysts and eggs of intestinal parasites and thus act as a source of the transmission of diseases.

The pathogens that stick to the outside surfaces of the fly may survive for only a few hours, but those that are ingested with the food may survive in the fly's crop or gut for several days.

Houseflies are the potential vector for diseases like typhoid, paratyphoid fever, cholera, gastroenteritis, amoebiasis, salmonellosis, diarrhoea, dysentery, anthrax, tuberculosis, trachoma, yaws, and conjunctivitis. Eggs and larvae of tapeworm (*Taenia*) and roundworm (*Ascaris*) may also be transmitted by housefly.

Myiasis

Myiasis is a disease caused by the invasion of the body parts of humans or animals by the housefly eggs or larvae. Houseflies can oviposit on or in human tissues if personal hygiene is not maintained. The flies sometimes can lay eggs on open wounds, nasal passage, anus, vagina, eyes, etc. The larvae that hatch out cause serious disordersin these organs. Eggs and larvae ingested with contaminated food and water can cause intestinal disorders.

The symptoms of myiasis depend upon the area invaded by the larvae. A few types and the symptoms of the disorder are as follows.

a) **Cutaneous myiasis:** The maggots invade the skin and form painful ulcers that can last for long time.

b) **Nasal myiasis:** Maggots enter the nasal passages and obstruct them causing severe irritation. It can also result in facial edema and fever.

c) **Aural myiasis:** The larvae cause crawling sensations and buzzing noises in the ears. Entry of larvae in the middle ear can make their way to the brain.

d) **Ophthalmo-myiasis:** Myiasis in the eyes cause severe irritation, edema, and pain.

e) **Intestinal myiasis:** Myiasis of the gastrointestinal tract may be asymptomatic or can lead to abdominal pain, vomiting and diarrhoea.

Control

The best and the easiest method to control house flies is to eliminate their breeding places and take proper care of sanitation and hygiene, not only at home but also of the environment around us. Food and materials on which the flies can lay eggs must be removed, destroyed as a breeding medium, or isolated from the egg-laying adult.

Proper disposal of any organic matter, such as vegetable or other food by-products can prevent breeding of houseflies. All such materials should be put in the tightly tied-in garbage bags. Alternatively; garbage, kitchen waste or refuse should be stored in bins and covered with tight-fitting lids.

1. Waste should be finally disposed by incineration, composting or sanitary landfill.

2. Open air defecation should be prohibited. Instead, sanitary latrines should be used.

3. Sanitary disposal of animal excreta helps to control housefly breeding.

4. **Fly traps;** such as sticky traps, ultraviolet light traps and pheromone traps; placed at different places in homes or in business places can reduce housefly population.

5. The sex pheromone (Z)-9-tricosene, called as **muscalure**, functions as an aggregation pheromone. Muscalure is added with sugar as a commercially available fly bait for local population suppression, as well as enhancement for population monitoring.

6. Fly baits, such as QuickBayt® and Golden Malrin®, are usually sugar-based and contain a compound that attracts the adult flies. Flies that feed on these baits are killed by the insecticide.

9.4 TERMINAL QUESTIONS

1. What is plague? Why is it called as Black death? Describe the transmission and different stages of plague in human beings.
2. Explain the term myiasis. List different types of myiasis, and their symptoms. Add a brief note on the measures by which it can be controlled.
3. Differentiate between:
   (a) Amastigote form and Promastigote form of *Leishmania donovani*
   (b) Regurgitation and Contact transmission by House fly
4. Can we consider bedbugs an important disease vector? Justify your answer.
5. How is murine typhus fever different from endemic typhus fever? Explain in context of vector, pathogen and symptoms.

Acknowledgement of Figures

Fig. 4.1: https://commons.wikimedia.org/wiki/File:Pediculus-humanus-louse.jpg

Fig. 4.2: https://en.wikipedia.org/wiki/Body_louse

Fig. 5.1: https://commons.wikimedia.org/wiki/File:NHMUK010177265_The_plague_flea_-_Xenopsylla_cheopis_cheopis_(Rothschild,_1903).jpg; and

https://commons.wikimedia.org/wiki/File:Xenopsylla_cheopis_ZSM.jpg

Fig. 6.2: https://www.flickr.com/photos/sanofi-pasteur/8076922557

Fig. 6.3: https://www.cdc.gov/dengue/symptoms/index.html

Fig. 7.3: https://commons.wikimedia.org/wiki/File:Symptoms_of_Malaria.png

Fig. 8.1: https://en.wikipedia.org/wiki/Epidemic_typhus