

BZYET-143
INSECT VECTORS
AND VECTOR BORNE
DISEASES

Block

2**MEDICALLY IMPORTANT INSECT VECTORS-I**

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Acknowledgement:

- Prof. Neera Kapoor and Mr. Ajit Kumar, Suggestions for figures and Cover Design.
- Mr. Vikas Kumar, JAT for word processing and CRC preparation.

March, 2022

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ISBN:

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Printed and published on behalf of Indira Gandhi National Open University, New Delhi by the Registrar, MPDD, IGNOU.

Printed at:

BLOCK 2: MEDICALLY IMPORTANT INSECT VECTORS-I

Among the many complex relationships between insects and microorganisms such as viruses, bacteria and parasites, some have resulted in the establishment of biological systems within which the insects act as a biological vector for infectious agents. It is therefore advisable to understand the identity and biology of these vectors in depth, in order to define procedures for epidemiological surveillance and anti-vector control.

In Block 1, you have studied about taxonomy, morphology and physiology of insects. In Block 2, you will study about medically important orders and subsequently about fleas, lice and bugs in further units. Block 2 comprises four units.

Unit 6 discusses about four orders that comprise significant vector transmitting diseases of human concern. These are Hemiptera (bugs), Diptera (mosquitoes and flies), Siphonaptera (fleas) and Anoplura (lice). In this unit you will study detailed features about order containing vectors, and identify the medically important insects.

Unit 7 will tell you about fleas. The life cycle of flea will be discussed. The clinical forms of plague will be explained. You will learn the differences between sylvatic and urban plague. Preventive and control measures of flea will also be discussed.

Unit 8 will explain about lice as disease vector. You will appreciate the differences among head louse, body louse and pubic louse. Their morphology, life cycle, medical importance and preventive and control measures are explained at length.

Unit 9 will give an account of general description of bugs. Types of bugs i.e. bed bug and Reduviid bug will be explained. The medical importance of bugs as mechanical and biological vectors is also discussed. Preventive and control measures for bugs are also described.

Objectives

After studying this block you will be able to:

- explain the significance of insects as disease vectors.
- list the orders comprising disease-transmitting insects,
- explain the detailed features of orders containing insect vectors,
- identify the medically important insects based on their morphological features,
- describe the external morphology and life cycle of a typical flea,
- distinguish adult human flea from other fleas,
- describe the clinical forms of plague,
- give an account of control measures for fleas.
- describe the external morphology and life cycle of adult body louse head louse and pubic louse,
- describe the medical importance of lice,
- explain the control and prevention of lice,

- classify and identify bugs,
- appreciate the role of bugs as mechanical and biological vectors in the transmission of diseases,
- explain the life cycle of bed bug and Reduviid bug, and
- discuss the prevention and control of bugs.



UNIT 6

MEDICALLY IMPORTANT INSECT ORDERS

Structure

6.1	Introduction	6.5	Order Siphunculata
	Objectives		Morphological Characters
6.2	Order Hemiptera		Life History and Importance
	Morphological Characters	6.6	Summary
	Life History and Importance	6.7	Terminal Questions
6.3	Order Diptera	6.8	Answers
	Morphological Characters		
	Life History and Importance		
6.4	Order Siphonaptera		
	Morphological Characters		
	Life History and Importance		

6.1 INTRODUCTION

In the previous units, you have learnt about the general features of insects, variation in the morphology of insects based on their habit and habitat, and the concept of carrier and vector of various diseases. You are now aware that insects are important disease vectors which transmit several diseases of variable severity to human beings, such as malaria, filariasis, dengue, typhus, relapsing fever, trench fever, plague, etc.

In Block 1, Unit 4, you learnt about different insect orders and their characteristic features. Among these, four orders comprise significant vectors transmitting diseases of human concern. These are Hemiptera, Diptera, Siphonaptera and Anoplura. This unit explains the detailed features of these orders which are medically important. You will learn about detailed life cycle of vectors, diseases transmitted by them, methods of disease transmission, the disease symptoms and prophylaxis etc. in the subsequent Units.

Objectives

After studying this Unit, you should be able to:

- ❖ explain the significance of insects as disease vectors.
- ❖ list the orders comprising disease-transmitting insects,
- ❖ explain the detailed features of orders containing insect vectors, and
- ❖ identify the medically important insects based on their morphological features.

6.2 ORDER HEMIPTERA

Order Hemiptera comprise true bugs, scale insects, aphids, white flies (Fig. 6.1). A few hemipterans are beneficial for human beings, while others are either phytophagous causing harm to different parts of the plants, act as predators or disease vectors in human beings. The common examples of disease vectors include sanguivorous bugs, such as bedbugs and kissing or vampire bugs.



Fig. 6.1: Different kinds of Hemiptera.

Distribution: The order Hemiptera is cosmopolitan in distribution. These insects are commonly present in our surroundings. More than 80,000 species have been recognized with diverse structures and habitats. They can be found in terrestrial as well as aquatic habitats. While many hemipterans feed on the plant sap and other material, a few feed on animal sources, such as the blood of mammals, birds and haemolymph of other arthropods.

6.2.1 Morphological Characters

The name "Hemiptera" has been derived from the Greek words; *hemi* (half) and *pteron* (wing). This denotes the forewings of many hemipterans, which are hardened near the base, but membranous at the ends. These wings are

termed **hemelytra** (singular: *Hemelytron*), as an analogous structure with the completely hardened elytra of beetles.

Hemipterans are highly diverse insects, ranging in size, colour and shapes. These are small to large-sized insects, ranging from 1 to 150 mm in length. Let us try to understand their characteristic morphology.

(a) **Morphology of the Hemiptera Head**

The head of a hemipteran may be **hypognathous** or **prognathous**. The antennae typically consist of four or five segments, though they can be quite long, made of 10-25 segments. Compound eyes are well developed except in ectoparasites. Ocelli may be 2, 3 or may be absent.

The **mouthparts** are piercing and sucking type with a distinctive **rostrum** formed by labium.

- The mandibles and maxillae are modified into **stylets**. The mandibular stylets have serrated ends and they surround the smoother and longer maxillary stylets (Fig. 6.2).
- The stylets are sheathed within a modified labium. The serrated mandibular stylets help to cut into the feeding substrate through which maxillary stylets can pierce plant or animal tissues.
- The maxillary stylets enclose two **grooves**, the smaller groove releases anticoagulant-containing salivary secretion into the human blood to let it flow freely which is then sucked by the larger groove (Fig. 6.2).

Hemipterans do not have chewing mouthparts and any food source that is going to be ingested has to be in liquid form.

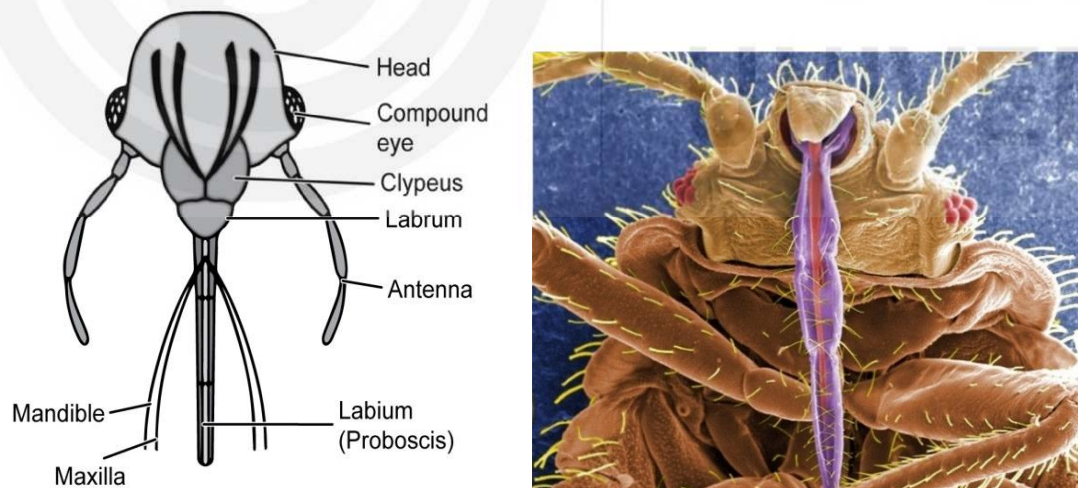


Fig. 6.2: Piercing Mouthparts of a bug; (a) Diagrammatic, (b) Scanning Electron Microscopic Image.

(b) **Morphology of the Hemiptera Thorax**

Thorax of the hemipterans has a distinct and large prothorax, while mesothorax and metathorax are smaller. Most of the hemipterans have **two pairs of wings**. The forewings are of harder consistency than hindwings; which may or may not be uniform. Based on this, hemipterans can be divided into two kinds.

- (i) **Homoptera:** The forewings of these are of uniform consistency; which may be tough or membranous. At rest, all four wings are held over the body like a tent (Fig. 6.3).
- (ii) **Heteroptera:** The forewings of these insects have a harder and leathery basal region and the membranous apical region, called hemelytra. At rest, all four wings are folded flat over their back. These cross-over to form "X"-pattern on back forming a triangle structure, **scutellum**, at the centre of their back (Fig. 6.4).

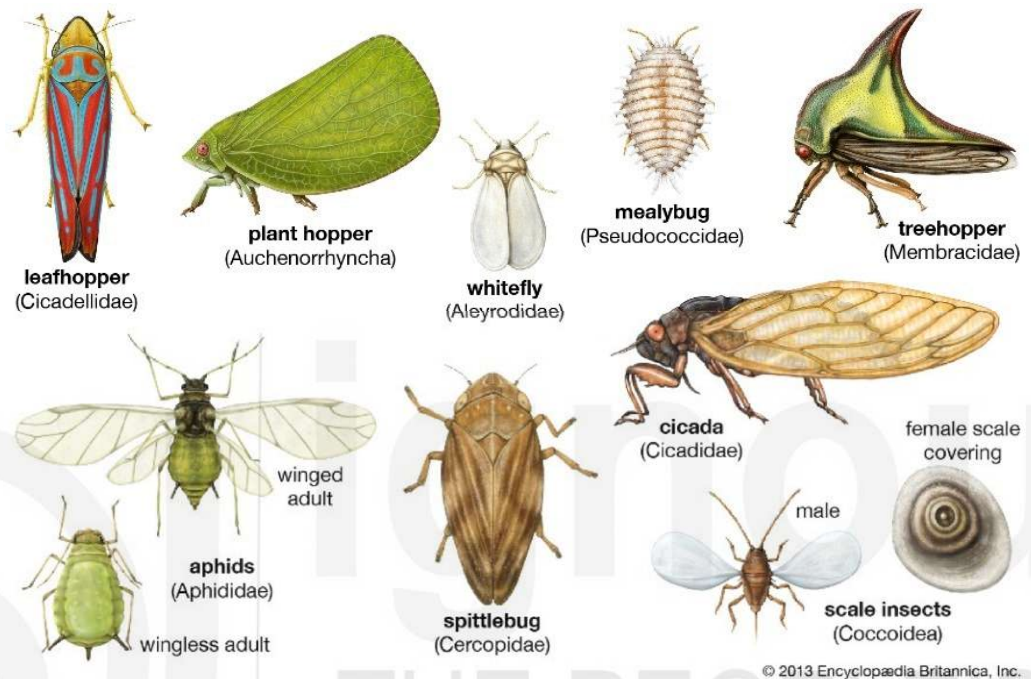


Fig. 6.3: A few Examples of Homoptera.

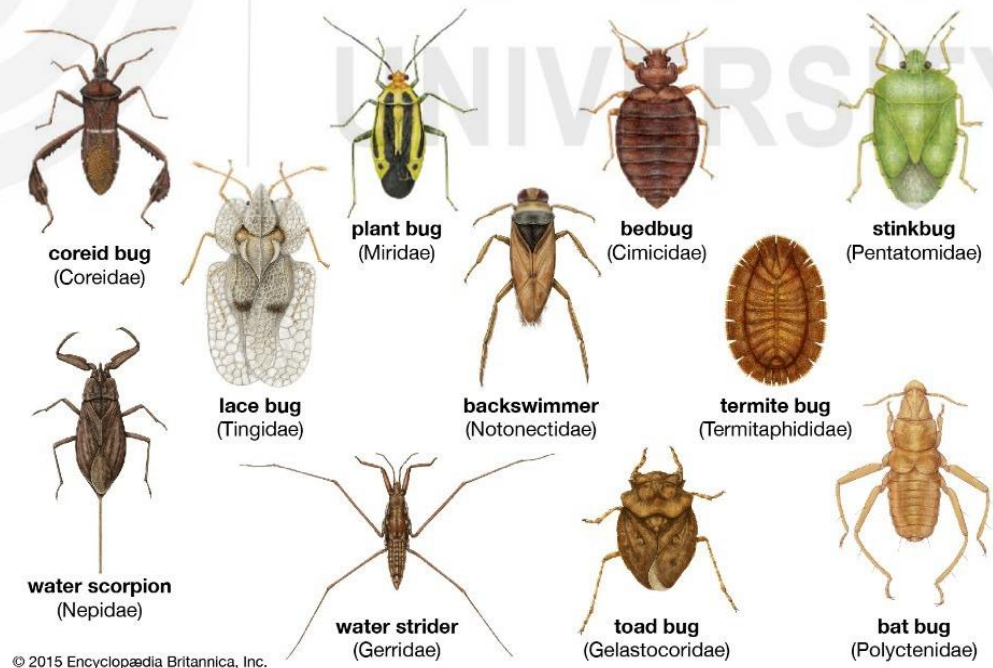


Fig. 6.4: A few Examples of Heteroptera.

A few hemipterans, such as bed bugs are devoid of wings. Hemipterans exhibit various modes of locomotion, such as swimming, skating on a water surface, jumping, walking and flying. Legs of hemipterans are well-developed

and adapted for their mode of living. The hindlegs are usually longer. The tarsi of the legs are frequently three-segmented and sometimes shorter.

(c) **Morphology of the Hemiptera Abdomen**

Abdomen of hemiptera is generally 11-segmented with reduced 9th and 10th segments. However, variation can be seen in diverse hemipterans. The abdomen lacks cerci in both males and females.

Many hemipterans, such as Cicadas, produce sound for communication. The male cicadas have sound producing organs (**Tymbal organs**) on the underside of first abdominal segment. The "song" of male cicadas is considered as the loudest of any insect and is produced to attract females. Few other hemipterans, such as water bugs also produce shrilling sounds by rubbing their tibial combs.

6.2.2 Life History and Importance

Hemipterans are **hemimetabolous** insects. They develop through a series of nymphal instars which look like the adults. During development, the nymphs moult several times and attain higher resemblance to the adults. The final transformation results in the development of functional sexual organs and wings. A few hemipterans, such as aphids develop **parthenogenetically** developing through unfertilized eggs.

Most of the hemipteran species are phytophagous and are significant **agricultural pests**; such as aphids, hoppers, etc. They damage crops by sucking sap and transmitting serious viral diseases. Various species are predators of insect pests and are used in biological control. Hemipterans have also been cultured for **beneficial purpose**, such as lac insects for shellac and cochineal scale insect for dye, etc.

However, a few species, such as bed bug and kissing bugs can **transmit serious diseases** to human beings. You will learn about their life cycle and disease transmission in Unit 9.

SAQ 1

Mark the following statements as *True* or *False*.

- a) All hemipterans have two pairs of wings.
- b) The Heteropterans are characterized by hemelytra and a triangular scutellum.
- c) The smooth mandibular and serrated maxillary stylets of hemipteran insects are enclosed in a grooved labium.
- d) We can obtain dyes from cochineal scale insects.

6.3 ORDER DIPTERA

The order Diptera is one of the largest insect order represented by approximately 1,20,000 species, which includes all true flies, mosquitoes,

gnats and midges, etc. (Fig. 6.5). They have obtained their name from two Greek words; *di* (two) and *ptera* (wings) denoting the presence of just one pair of wings.

They live in variety of habitats and perform diverse functions of human importance. Many dipteran species are highly important due to their vectorial capacity and role in disease transmission.

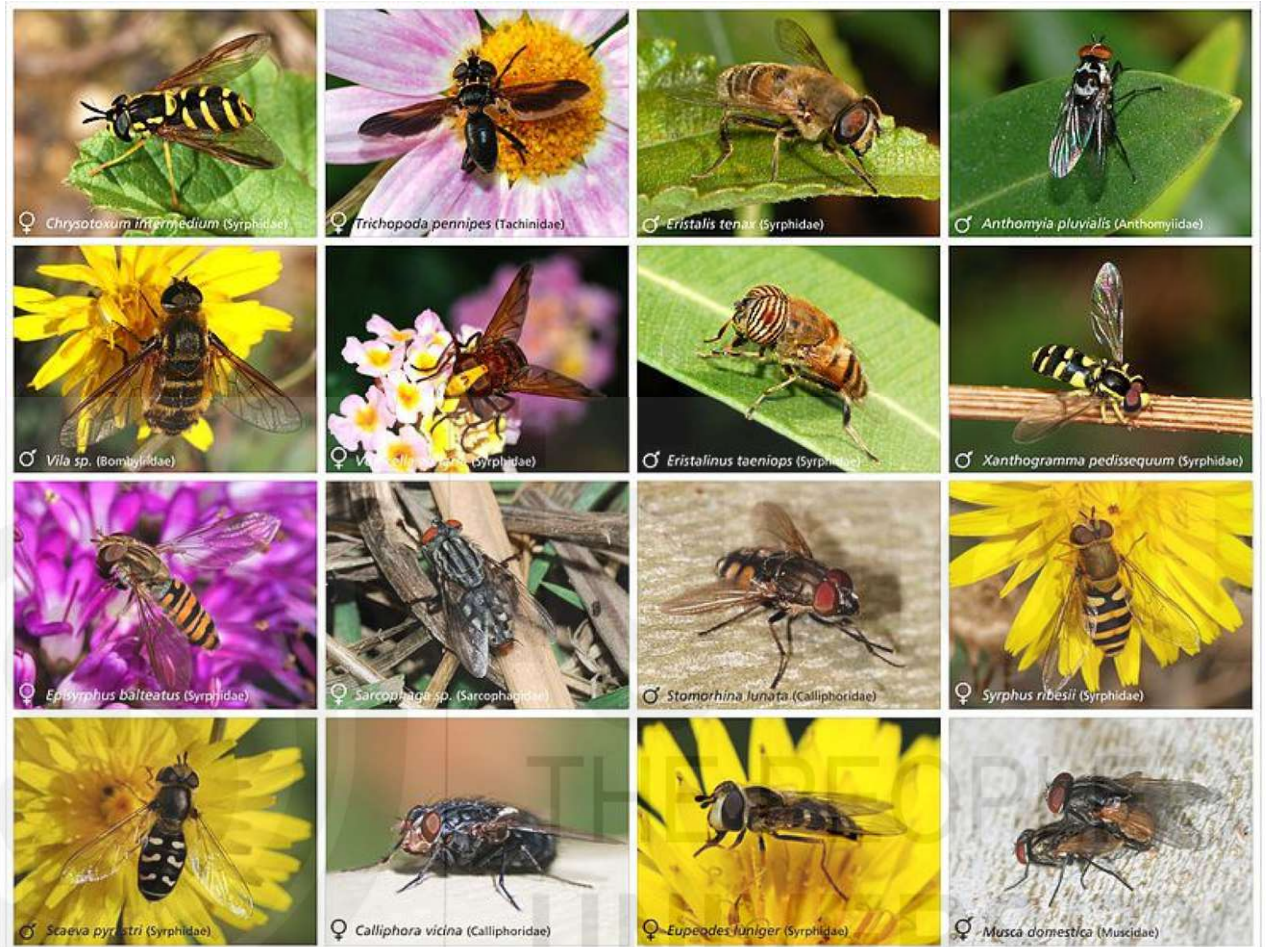


Fig. 6.5: Diversity in Order Diptera.

Distribution: The dipterans are cosmopolitan in distribution and found in all habitats. They can be located in the tropics, sub-arctic, at sea level and even on high mountains. They colonize beaches to low-tide level, and even inhabit deeper water.

6.3.1 Morphological Characters

The Diptera includes small to medium-sized insects. The characteristic morphological features of these insects are discussed below.

(a) Features of Dipteran Head

Dipterans have a mobile head, distinct from the thorax. It may be prognathous or hypognathous with a pair of large compound eyes. Ocelli are usually 3 in number and are present in a triangular form. Antennae are of diverse kinds; such as plumose, pylose, filiform, aristate, etc.

The **mouthparts** exhibit diverse modifications according to their habitat and feeding habits. These can be categorized in primarily two kinds:

- (a) **Piercing and sucking** – These are found in species; such as mosquitoes, sand flies, robber flies, etc. These flies include vectors, parasites or predators of small arthropods (Fig. 6.6).

In mosquitoes, the labium is transformed into **proboscis** with a groove on mid-dorsal side. The sensory **labellum** present on its tip help to identify the suitable host. The mandibles, maxilla and hypopharynx are enclosed in this groove in the form of long, pointed stylets. The fused **labrum-epipharynx** forms a food canal and covers the proboscis (Fig. 6.7a).

When a female mosquito sits on the host, it presses the proboscis against the skin and the proboscis bends. The mandibles and maxillae come out of the groove and make a puncture on the skin. The labrum-epipharynx and **hypopharynx** are inserted into the wound. The saliva, containing haemolysin anti-coagulant, is injected into the blood through hypopharynx. The blood is sucked then through the food canal.

- (b) **Lapping and sponging** -Many species of flies have mouthparts modified for feeding on honeydew, nectar or the exudates of dead or alive plants and animals.

Houseflies with sponging mouthparts feed on the liquefied organic matter, open wounds, exposed food and faecal matter, etc. Their proboscis is divisible into rostrum, haustellum and labellum. **Rostrum** encloses pharynx and salivary duct. **Haustellum** bears a median groove on its dorsal side, which encloses the hypopharynx containing the salivary canal and labrum-epipharynx with food canal. **Labellum** is sensory in nature, and can sense taste and smell of the food. The under surface of the labella has **prestomial teeth** (Fig. 6.7b).

When a housefly sits on the food, the haustellum and labella thrust out and labella are pressed against the food. The teeth break food particles into small pieces and saliva liquefies them. This liquefied food is sponged up via food channel by the capillary action.

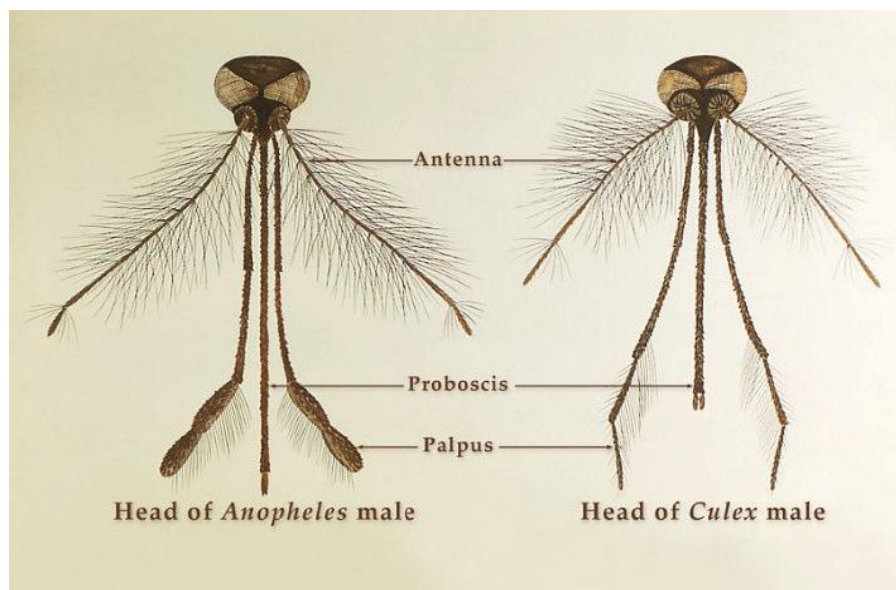


Fig. 6.6: Mouthparts of male mosquito.

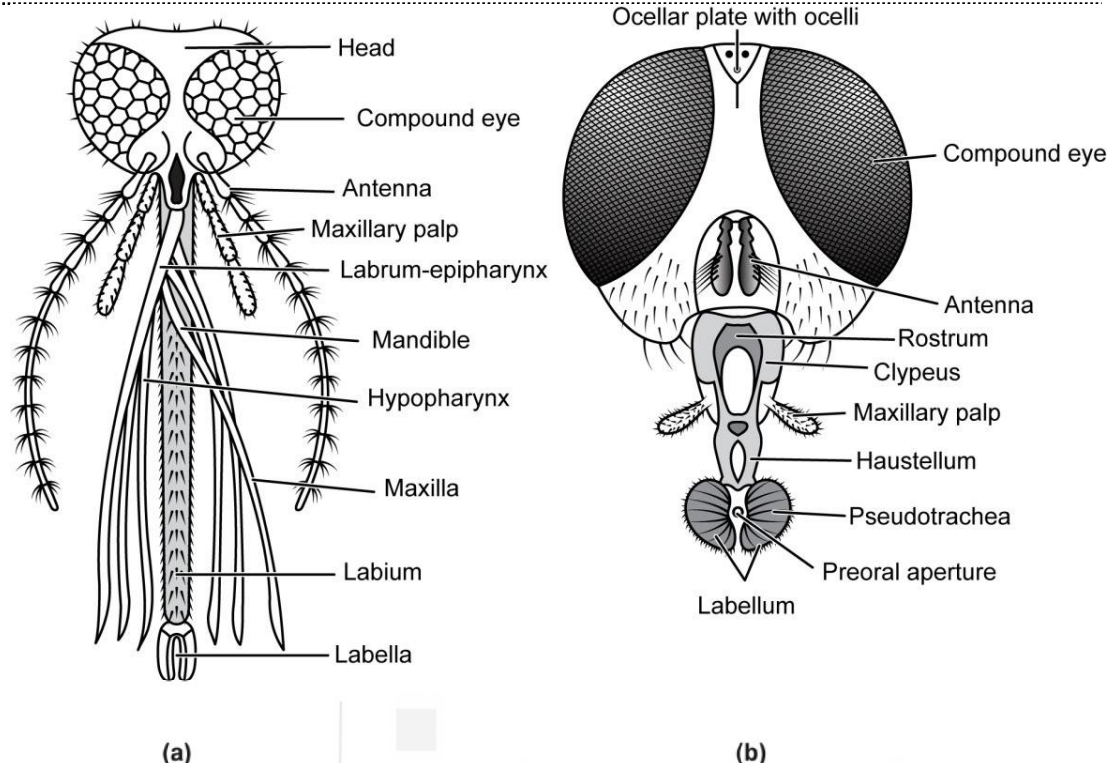


Fig. 6.7: Mouthparts of (a) a female mosquito; (b) a housefly.

(b) Features of Dipteran Thorax

Major part of the thorax is made up by mesothorax, though all thoracic segments are fused together. The most distinctive feature of all dipterans is the presence of only forewings, which assist in flight. The hind wings are reduced to small, drumstick-shaped structures called **halteres**. These vibrate during flight producing a buzzing sound and also help the flies to maintain balance. Their wing arrangement gives them great manoeuvrability in flight.

The legs are slender or stout, and variably developed for different functions but mostly adapted for clinging. The 5-segmented tarsi are provided with claws and pads which enable them to cling to smooth surfaces.

(c) Features of Dipteran Abdomen

The abdomen is distinctly segmented, though a few segments, especially first two, are reduced. The last abdominal segments of female flies are modified into ovipositor, while that of males form male genitalia assisted with claspers.

Drosophila, produce salivary mucopolysaccharides that **glue the puparium** to the substrate. Some fungus gnats produce mucoid secretions as a **slime trail**, just like in terrestrial snails, to facilitate larval locomotion; and larvae of some gnats use this slime secretion to capture prey.

6.3.2 Life History and Importance

Flies undergo **complete metamorphosis**. The larvae lack true limbs (apodous) and can be found in aquatic, semi-aquatic, or moist terrestrial environments. A variety of larval forms can be observed in diptera; such as wrigglers in mosquito and maggots in houseflies. The pupa also exists in diverse forms; and may be with (**puparium**) or without cocoon.

Most of the flies, however, feed on dead and decaying organic matter. These not only help in the decomposition of organic matter, but also act as carriers of disease agents. A few dipteran species are herbivores. They help to pollinate plants and also act as pests of agricultural plants. Some dipterans parasitize other organisms, especially vertebrates, molluscs and arthropods; and transmit diseases to humans and domestic animals. The human diseases include dengue, Chikungunya, Filariasis, encephalitis, malaria, Zika, etc.

You will study variations in life cycle of dipterans and the diseases transmitted by them in detail in the Blocks 3 and 4.

SAQ 2

Answer the following questions.

- Name the reduced hindwings of diptera and write their functions.
- How do mosquitoes detect their host for sucking of blood?
- Write the location of prestomial teeth in sponging mouthparts.

6.4 ORDER SIPHONAPTERA (APHANIPTERA)

Order Siphonaptera comprises fleas, the apterous, holometabolous and ectoparasitic insects living on the blood of mammals or birds. The order has obtained its name from two Greek words; *Siphon* (Tube) and *aptera* (wingless). The most important genera of fleas (Fig. 6.8) in context with human health are -

- Xenopsylla cheopis* – Rat flea
- Pulex irritans* – Human flea
- Ctenocephalides canis*– Dog/cat flea



(a)



(b)



(c)

Fig. 6.8: Common species of fleas; (a) *Xenopsylla cheopis*; (b) *Pulex irritans*; (c) *Ctenocephalides canis*.

Distribution: Fleas are distributed worldwide, most of them present in temperate zones. The order includes more than 200 genera and 2500 species.

6.4.1 Morphological Characters

Fleas are small (1-5 mm long), apterous, active, brown-coloured insects with highly sclerotized exoskeleton. They have a laterally compressed body which helps them to slip easily within the fur or feather of host. Body segments have characteristic bristles and cuticular projections that are directed backwards (Fig. 6.9). These structures are sometimes modified into **combs called ctenidia** that may be found on the head (genae) and prothorax.

The female fleas are larger than the males of their species. In addition, both the dorsal and ventral outline of the female are convex, while the dorsal surface of males is almost straight.

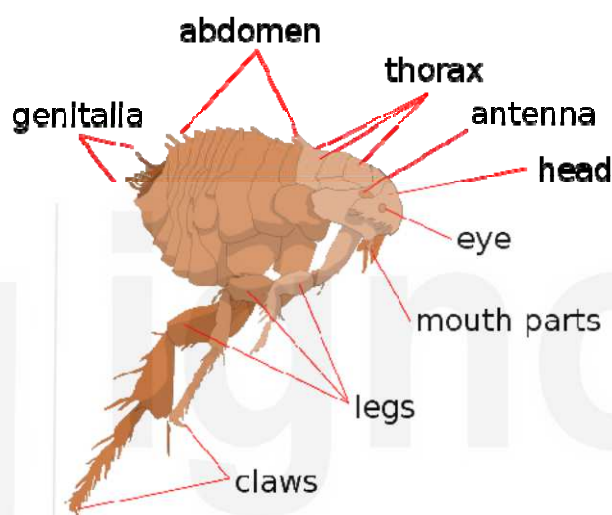


Fig. 6.9: Schematic diagram of the Flea Morphology.

(a) Features of the Flea Head

The head of an adult flea is hypognathous and attached closely to the thorax. It has comb-like row of chitinous spines, called **ctenidia**. The row of long spines/bristles at the lower edge of the head is called **genal comb** (Fig. 6.10).

The presence or absence of ctenidia, along with their location and number, if present, can be used for identification of flea species

The fleas lack compound eyes. A pair of ocelli may be situated laterally on the head or they may be vestigial and even absent. The antennae are short, clavate and are located in pits at the side of the head. Males have longer antenna as compared to the females.

The **mouthparts of the fleas** are piercing and sucking type. Unlike other orders, they lack mandibles. However, the labrum and lacinia of maxilla are transformed into stylets which are enclosed in a maxillary sheath (Fig. 6.10). Just like other haematophagous insects, they pierce the human skin and inject saliva. In return, they suck the blood.

(b) Features of the Flea Thorax

The thorax is 3-segmented and has two pairs of spiracles. The prothorax is characterized by the presence of a row of spines forming **pronotal comb** on the posterior border of the segment (Fig. 6.10).

The legs of fleas are quite long. Hind legs have large coxae and are extremely well adapted for jumping (Saltatorial legs). They are able to leap a distance of some 50 times their body length.

A flea can jump vertically up to 7 in (18 cm) and horizontally up to 13 in (33 cm), a distance of more than 50 times their body length.

Their legs have strong claws which prevent them from being dislodged from the host body by clinging to the host hair and feathers.

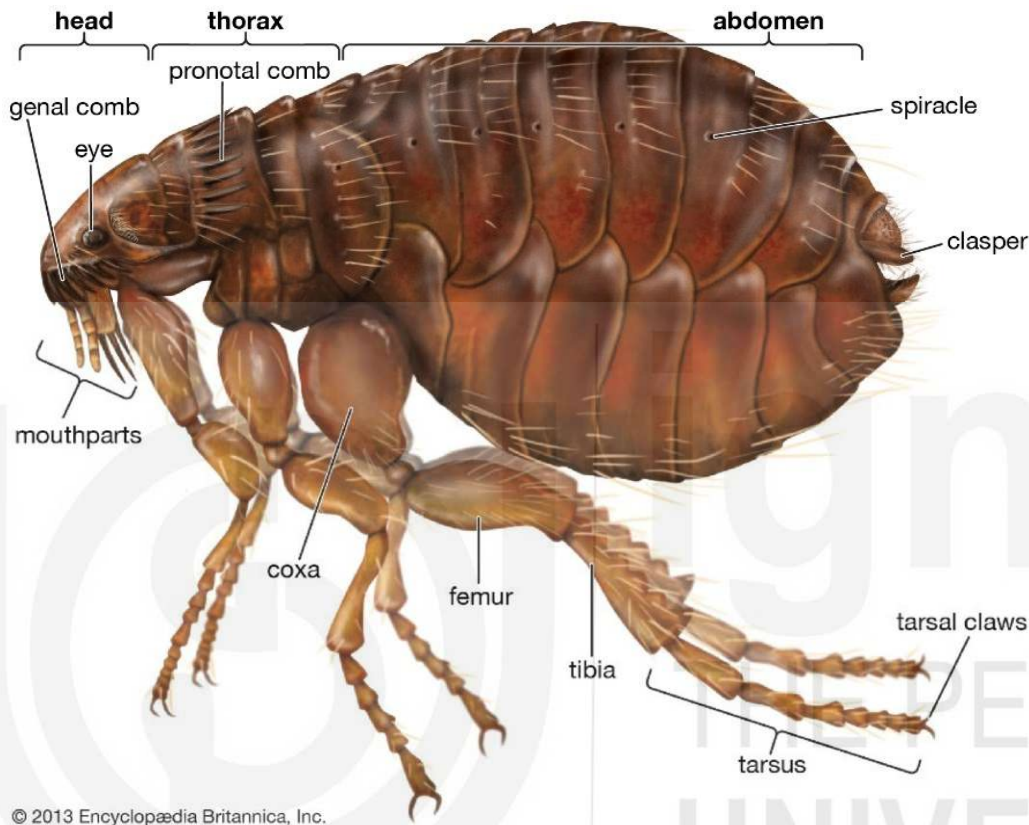


Fig. 6.10: Detailed structure of a flea.

(c) Features of the Flea Abdomen

The abdomen of fleas is 10-segmented. Eight segments are distinct and have lateral spiracles. A complex saddle-shaped sensory apparatus, called **sensillum**, is located at the apex of the abdomen. It is covered by minute hairs which help in the detection of changes in air currents. It, thus, helps the flea in finding a host.

The male fleas have a complex **copulatory organ** in the hindmost end of the abdomen, while the females have a **spermatheca** for the storage of sperms.

The morphology of the spermatheca is sometimes used as an aid for distinguishing the flea species.

6.4.2 Life History and Importance

The fleas are **holometabolous**. The white eggs are deposited on the ground. Their larvae have a vermiform body, with sparse bristles, reduced head, mandibulate mouthparts and lack eyes. Instead of living on the host body, they

are found in its nest or bedding and feed on adult faeces and organic debris left on their host's skin. The pupation takes place within a thin **silken cocoon**. In the absence of a host, the pupa can survive in the cocoon for more than a year and emerges into adult suddenly when the presence of a host is detected.

Only adult fleas live on the blood of their hosts; mammals or birds. These are generally **host-specific**, but in the absence of their host, they can change their host species. Fleas inflict irritating bites on the host usually during night during which these transmit pathogens cause deadly disease in humans and other animals. These include typhus fever and plague.

Adults may live for a year or more and can survive for weeks or months without a blood meal. You will learn about life cycle of fleas and diseases transmitted by them in detail in the next Unit.

Adult fleas have developed many adaptations for a parasitic existence on the bodies of their hosts.

- Apterous forms to live in the fur and feathers of their hosts.
- Laterally compressed body to move between hair and feathers of the host.
- Heavily sclerotized body to protect itself from damage.
- Armed with combs or bristles that engage fur and resist dislodgment from the host during grooming.
- Short antennae fitted into grooves for protection from damage. Piercing-sucking type mouthparts for feeding on warm-blooded animals.

SAQ 3

Answer the following questions:

- Write the name of ctenidial rows present on the head and thorax of fleas.
- How do siphonopteran piercing and sucking mouthparts differ from that of other orders?
- Do all the stages of flea are haematophagous? Give reasons for your answer.

6.5 ORDER SIPHUNCULATA (ANOPLURA)

The Order Siphunculata comprises sucking lice, the ectoparasitic insects which feed on human blood. Their scientific name comes from the Latin word *siphunculus*, which means little pipe or siphon.

Humans are parasitized by **three species** of Anoplura. These comprise two genera; *Pediculus* and *Phthirus*. The genus *Pediculus* contains the body louse

(*Pediculus humanus corporis*) and the head louse (*Pediculus human capitis*), while *Phthirus* exists as a single species, pubic or crab louse (*Phthirus pubis*).

Each species of human louse specializes in infesting particular parts of the body (Fig. 6.11).

- **The head louse (*Pediculus humanus capitis*)** are located on the scalp of human beings, usually behind the ears and at the back of the neck, near the neckline. These hold on to the head hair and feeds on the blood.
- **The body louse (*Pediculus humanus corporis*)** lives in the human clothing and bedding; and feeds on the body blood.
- **The pubic or crab louse (*Phthirus pubis*)** is found on any coarse body hair, such as the eyelashes and genital hair.

The amount of blood drunk by a head louse in a single feeding session is very small - from 0.0000387 ml to 0.0001579 ml.

The important sucking lice that attack domestic animals belong to the genera *Haematopinus* and *Linognathus*. For example, the short-nosed cattle louse, *H. eurysternus*; the hog louse, *H. suis*; the horse louse, *H. asini*; the long-nosed cattle louse, *L. vituli*; and the dog louse, *L. setosus*.



(a)



(b)



(c)

Fig. 6.11: Different species of human louse; (a) *Pediculus humanus capitis*; (b) *Pediculus humanus corporis*; (c) *Phthirus pubis*.

The lice infesting seals and walruses, so called marine lice belong to the family *Echinophthiriidae*. They either breathe air trapped in the host's body hair or they trap a layer of air between their specially modified body hair.

Distribution: The sucking lice have a more or less world-wide distribution, but are often common in temperate areas. There are approximately 565 species of sucking lice belonging to 15 families.

6.5.1 Morphological Characters

Adult lice are small-sized, apterous insects. They have almost transparent skin. Shortly after feeding on blood, they attain reddish colour which turns brownish as soon as the blood gets digested. All lice, however, have some pigment in their bodies, the amount of which varies depending on the origin of the head louse.

The pigmentation in lice is an adaptive feature for parasitic mode of life. The highly-pigmented lice are found in those geographical areas, where the population has dark skin or dark hair, so that it is difficult to detect them. Similarly, less-pigmented lice are present in areas with a population of lighter skin and blond hair.

The body is **dorsoventrally flattened** covered with a soft leathery integument. It enables them to lie close along the hairs or seams of the clothes for attachment or feeding. Males are smaller than the females. Males generally measure about 2.5-3.5 mm, while size of the females ranges from 3.5-4.5 mm.

(a) Features of the Louse Head

The head of the louse is narrower than the thorax. It bears a pair of reduced and inconspicuous compound eyes and ocelli are absent. A pair of short 3 to 5-segmented antennae are present which are sensory in nature. The mouthparts are adapted for **piercing and sucking** (Fig. 6.12).

- The mouthparts of the louse consist of a flexible, sucking, almost tube-like mouth, called the **haustellum**.
- It is armed with minute teeth on the inner surface, which act like small barbs. They grip the host's skin with the help of these barbs during feeding.
- The mandibles and maxillae are transformed into delicate **thin stylets** which are contained within a stylet sac below the pharynx.
- During the blood meal, these are thrust forwards to pierce the mammalian skin. The **anticoagulant-containing salivary secretion** is then released into the human blood to let it flow freely for easy sucking.
- The blood is sucked through the tube and reaches the stomach for digestion.

The mouthparts are retracted within the head when louse is not feeding. Thus, louse does not have external projecting mouth-parts.

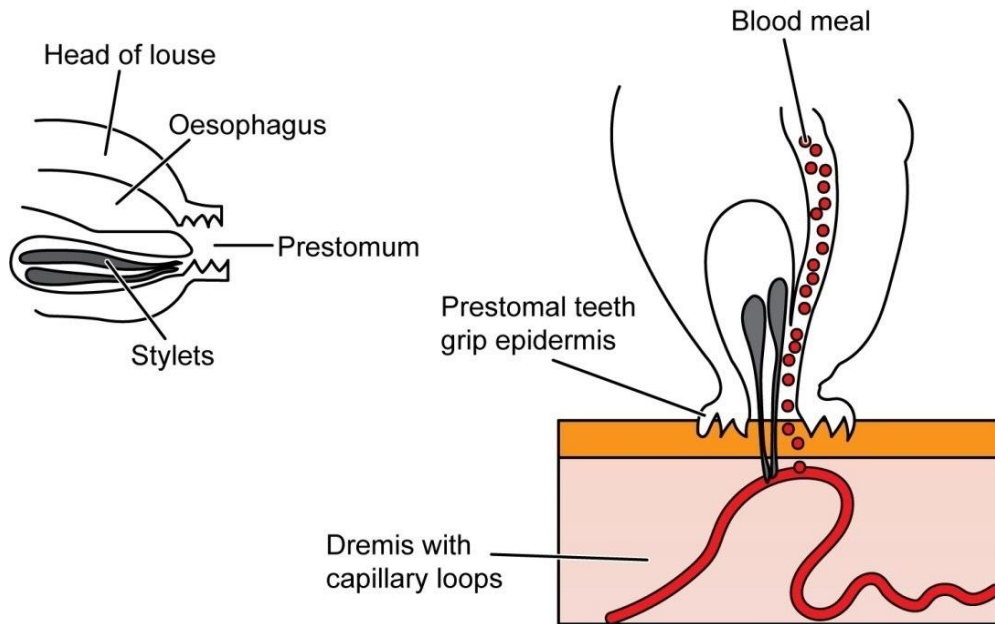


Fig. 6.12: Blood Sucking by a Louse.

Exclusively sanguivorous insects, lice do not get a well-balanced diet. They obtain additional nutrients with the help of bacteria present in their gut.

(b) Features of the Louse Thorax

Thoracic segments of anoplurans are fused and possess single pair of spiracles. Three pairs of legs are present, which are short, stout and stumpy. The anterior legs of males are much stouter and larger than the rest two pairs. It is used for holding the female during copulation.

The tibia of the anopluran legs is short and thick with a small thumb-like spine on its inner side at the apex. The short tarsus terminates into a large, strong curved claw. Hairs of the host or his clothing are gripped between this spine and claw.

The legs of anoplurans with hair-clasping organs, are, thus called **clinging** types. It is quite difficult to dislodge them unless done forcefully. They move from hair to hair using clawed legs. Such legs also render them incapable of jumping, or even walking efficiently on flat surfaces.

The legs of head louse are equipped with sensory receptors which warn them regarding any interruptions in the hair; such as scratching head or combing hair. The louse senses this and moves quickly away from such areas.

(c) Features of the Louse Abdomen

The abdomen has eight to 10 visible segments. The lateral margins of the abdominal segments are sclerotised and much darker than the rest of the segments. First six segments have a pair of distinctly visible spiracles.

A clear distinction can be made between males and females lice through the abdominal features (Fig. 6.13), though it is not important to do so as both sexes suck blood and are thus equally important in disease transmission. Males have a narrower abdomen with slightly pointed tip in comparison to

females, the abdomen of which is **broader and rounder**. In addition, the tip of the abdomen is **bifurcated and W-shaped** in female lice (Fig. 6.13). A pair of small gonopods with a small genital opening, lying in between the bifurcation, can be seen after careful examination of the ventral surface. The abdomen of males, however is **not bifurcated, lacks gonopods**, but a small **distinct penis** is visible.

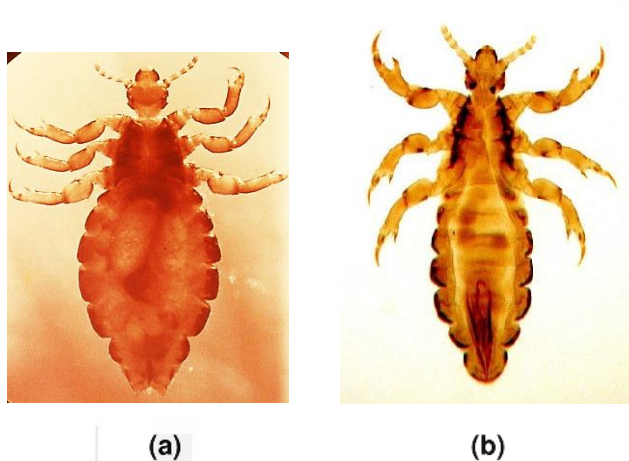


Fig. 6.13: Difference in the body structure of (a) Female Head Louse, and (b) Male Head Louse.

6.5.2 Life History and Importance

All anoplurans are **ectoparasitic** on mammals and survive by sucking their blood. Lice are obligatory ectoparasitic insects which spend their entire life cycle on the host. They never leave their host voluntarily, except when they are transferred to a new host. It is important to note that both male and female adults, and all nymphal stages suck human blood. The lice are highly host-specific. Thus, if an **animal-specific louse** is transferred to a human being, it will not be able to establish infestation; and *vice-versa*.

The adult sucking louse, or true louse, glues her eggs, called **nits**, to the host's hair or seams of the clothing (Fig. 6.14). These eggs, called nits, are even harder to remove from the host's hair than the adults, which makes it very difficult to completely eliminate all lice from a host. The egg hatches into young nymphs, which resemble adults, become sexually mature after several moults. Observe the figure 6.15 to understand the life stages. You will learn the detailed life cycle of louse in the Unit 8.



Fig. 6.14: (a) Eggs laid by crab louse (b) A Louse egg glued to the human hair.

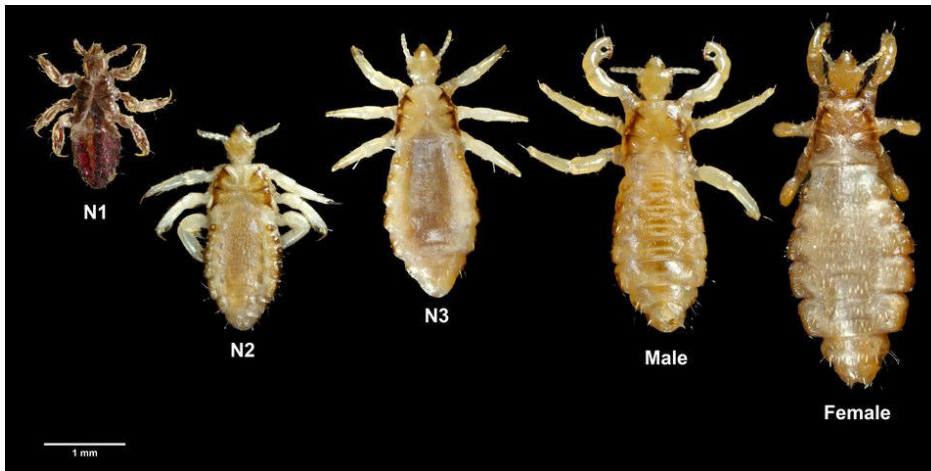


Fig. 6.15: Life Stages of the body louse; N1 to N3 – Nymphal stages.

The anoplurans are medically important insects. They not only constitute a highly irritating pest leading to frustrations in human beings and domestic animals but also are capable of **transmitting serious diseases** in human beings; such as typhus fever, relapsing fever and trench fever.

You will learn about these diseases in the Unit 8.

The blood-feeding habits of sucking lice and their close association with mammalian hosts are assumed to have evolved gradually.

- It is believed that their ancestors were free-living and had chewing mouthparts. They used to live in nests and burrows of vertebrates, in close association with them. It provided them protection as well as unlimited food supplies; such as sloughed skin, feathers, fur, fungi, dung, organic debris, etc.
- Over time, a few of these organisms became directly dependent on their hosts and transitioned from opportunistic associates to obligate parasites. They started feeding directly on the host blood and developed specialized mouthparts

SAQ 4

Give answers for the following questions.

- Why are the legs of louse called clinging legs?
- Write one point of difference between the abdominal end of male and female louse.
- Which term is used for describing the louse eggs?

6.6 SUMMARY

Let us summarise what you have learnt so far:

- Four insect orders contain important diseases vectors and are considered medically significant. These include Hemiptera, Siphunculata, Diptera and Siphonaptera.

- Order Hemiptera contains sanguivorous bugs; Order Siphunculata includes lice; Order Diptera has mosquitoes, sand flies, etc.; and Order Siphonaptera encompass fleas.
- The insect vectors are haematophagous and possess piercing and sucking mouthparts for feeding on mammalian blood.
- Hemipterans can be divided into two groups; Homoptera and Heteroptera based on the consistency of forewings. The forewings of Homoptera are of uniform consistency, while that of Heteroptera are hemelytra with a harder basal region and the membranous apical region.
- Most of the hemipteran species are phytophagous, a few are predators of insect pests while some are beneficial for mankind. A few hemipterans, however, are harmful transmitting serious diseases to humans.
- Dipterans have fully developed forewings, which assist in flight. The hind wings are reduced to halteres, which vibrate during flight producing a buzzing sound and help the flies to maintain balance.
- Most of the dipterans feed on dead and decaying organic matter and a few are herbivores. Some dipterans parasitize other organisms and transmit diseases to humans and domestic animals.
- Fleas are highly sclerotized insects with a laterally compressed body and characteristic bristles and cuticular projections over body segments that are directed backwards. The head and thorax of fleas have characteristic ctenidial rows, genal comb and pronotal comb, respectively.
- The legs of fleas are saltatorial types because of which they are able to leap a long distance in search of host.
- The body of louse is dorsoventrally flattened covered with a soft leathery integument, while the legs are clinging types with hair-clasping organs.
- Orders Siphonaptera and Siphunculata comprise exclusively parasitic insects which act as disease vectors too.
- In Siphonaptera, only adults live on the host blood, while all stages of Siphunculata, nymphs as well as the adult feed on mammalian blood.

6.7 TERMINAL QUESTIONS

1. Name four insect orders which are of medical importance. Write at least one conspicuous feature and three examples of each order.
2. Give reasons for the following features found in insects.
 - a) Fleas have a laterally compressed body.
 - b) Forewings of a few hemipterans are called hemelytra.
 - c) Hind legs of fleas are saltatorial types with large coxae.

- d) Saliva of haematophagous insects contain anticoagulant.
 - e) Heteroptera have a characteristic scutellum which is absent in homopterans.
 - f) The under surface of the housefly labella has prestomial teeth.
3. Distinguish between the following pairs of terms based on the clue given in parentheses.
- a) Halteres and Haustellum (Function)
 - b) Male and Female flea (Abdominal end)
 - c) *Pediculus humanus capitis* and *Phthirus pubis* (Habitat)
 - d) Homoptera and Heteroptera (Wings at rest)
4. Name a hemimetabolous order which is exclusively parasitic. Explain its morphological features in brief.
5. Write the important features of Order Siphonaptera which make them important disease vectors.

6.8 ANSWERS

Self Assessment Questions

1. a) False, b) True, c) False, d) True.
2. a) Halteres; help the flies to maintain balance.
- b) The sensory labellum present on the tip of labium helps them to identify the suitable host.
- c) Under surface of labella.
3. a) Genal comb, Pronotal comb
- b) The fleas lack mandibles. Instead, the labrum and lacinia of maxilla are transformed into stylets which are enclosed in a maxillary sheath.
- c) No, the larvae of fleas feed on adult faeces and organic debris left on their host's skin; while adult fleas live on the blood of their hosts.
4. a) Louse clings on the host hair and his clothing with the help of the spine and claw present on each leg.
- b) Tip of the female louse abdomen is bifurcated and W-shaped with small gonopods lying in between them, while the male abdomen is not bifurcated and lacks gonopods.
- c) Nits.

Terminal Questions

1.
 - a) Order – Hemiptera; Forewings are of harder consistency than hindwings; Forewings either of uniform consistency or with harder base and membranous apex. Examples–Bed bugs, Kissing bugs, Aphids
 - b) Order – Siphonaptera; Laterally compressed body with characteristic backward directed bristles and cuticular projections on body segments. Examples – *Xenopsylla cheopis*, *Pulex irritans*, *Ctenocephalides canis*
 - c) Order – Diptera; Have only fore wings, hindwings reduced to halteres. Examples – Mosquitoes, Housefly, *Drosophila*
 - d) Order – Siphunculata; Dorsoventrally flattened body with clinging legs. Examples – *Pediculus humanus capitis*, *Pediculus humanus corporis*, *Phthirus pubis*
2.
 - a) It helps them to slip easily within the fur or feather of host.
 - b) The wings of a few hemipterans are hardened near the base, but membranous at the ends.
 - c) Saltatorial legs help fleas to leap long distances in order to look for suitable host, if needed.
 - d) It lets the host blood flow easily for sucking by these insects.
 - e) Wings in heteropteran cross-over to form “X”-pattern on back forming a triangle scutellum, however in homoptera, wings are held over the body like a tent and do not cross-over.
 - f) Teeth break food particles into small particles which are then acted upon by enzymes.
3.
 - a) Halteres - reduced hind wings of diptera which help in balancing; Haustellum - sucking organ of insects which helps to suck liquified food.
 - b) Male fleas - a complex copulatory organ in the hindmost end of the abdomen; Female flea - a spermatheca for the storage of sperms.
 - c) *Pediculus humanus capitis*- on the scalp of human beings, usually behind the ears and at the back of the neck; *Phthirus pubis*- on any coarse body hair, such as the eyelashes and genital hair.
 - d) Homoptera - all four wings are held over the body like a tent; Heteroptera -all four wings are folded flat over their back.
4. Refer to the sub-section 6.5.1.
5. Refer to the Section 6.4.

Acknowledgement of Figures

Fig. 6.2: (b) <http://www.freestockphotos.biz/stockphoto/16720>

Fig. 6.3: <https://www.britannica.com/animal/homopteran>

Fig. 6.4: <https://www.britannica.com/animal/heteropteran>

Fig. 6.5: <https://commons.wikimedia.org/wiki/File:Diptera1.jpg>

Fig. 6.6: http://www.publicdomainfiles.com/show_file.php?id=13546405216844

Fig. 6.8: (a) https://commons.wikimedia.org/wiki/File:Xenopsylla_cheopis_ZSM.jpg

(b) https://commons.wikimedia.org/wiki/File:Pulex_irritans_ZSM.jpg

(c) https://commons.wikimedia.org/wiki/File:Ctenocephalides_canis_ZSM.jpg

Fig. 6.9: https://commons.wikimedia.org/wiki/File:Scheme_flea_anatomy-en.svg

Fig. 6.10: <https://www.britannica.com/animal/flea>

Fig. 6.11: (a) https://commons.wikimedia.org/wiki/File:Fig._1._Male_of_head_louse.jpg

(b) https://commons.wikimedia.org/wiki/File:Body_lice.jpg

(c) [https://commons.wikimedia.org/wiki/File:Crab_louse_\(251_23\)_Female,_from_a_human_host.jpg](https://commons.wikimedia.org/wiki/File:Crab_louse_(251_23)_Female,_from_a_human_host.jpg)

Fig. 6.13: (a) http://www.publicdomainfiles.com/show_file.php?id=13527372619374

(b) https://commons.wikimedia.org/wiki/File:Fig._1._Male_of_head_louse.jpg

Fig. 6.14: (a) [https://commons.wikimedia.org/wiki/File:Crab_louse_\(251_25\)_Male_adult_and_eggs,_from_a_human_host.jpg](https://commons.wikimedia.org/wiki/File:Crab_louse_(251_25)_Male_adult_and_eggs,_from_a_human_host.jpg)

(b) <https://www.flickr.com/photos/sanmartin/4900274585>

Fig. 6.15: http://www.publicdomainfiles.com/show_file.php?id=13533871824288

SIPHONAPTERA AS DISEASE VECTORS

Structure

7.1 Introduction	Tungiasis
Objectives	Treatment
7.2 External Morphology of Fleas	7.7 Prevention and Control
7.3 Life Cycle	Personal Protection
7.4 Relation with Host	Rodent Flea
7.5 Medical Importance	Cat and Dog Flea
Flea-Annoyance	7.8 Summary
Plague	7.9 Terminal Questions
Murine Typhus	7.10 Answers
Cestodes	
Other Diseases	
7.6 <i>Tunga penetrans</i>	
External Morphology	
Life Cycle	

7.1 INTRODUCTION

Siphonaptera is a relatively small order with approximately 2500 species and 550 subspaces of fleas. Fleas are small wingless insects, about 2 – 10 millimeters. Most species are parasites of mammals (94%), and the remaining species (6%) occur on birds. Fleas are almost worldwide in distribution. However, many, including the genus *Xenopsylla* have a more restricted distribution. *Xenopsylla* carries a critical disease-causing pathogen and is restricted to tropical and subtropical habitats. The most critical medically significant rat flea, *Xenopsylla cheopis*, is thought to be a vector of the bacteria *Yersinia pestis* and *Rickettsia typhi*, which cause plague and flea-borne typhus (*Murine typhus*). *Ctenocephalides canis* (dog flea), *Ctenocephalides felis* (cat flea), and *Pulex irritans* (Human flea) act as intermediate hosts for an ordinary

tapeworm called *Dipylidium caninum*, *Nosopsyllus fasciatus*, and *Xenopsylla cheopis* may serve as vectors for the rat tapeworm, *Hymenolepis diminuta*. *Hymenolepis nana*, the mouse tapeworm, may develop in *X. cheopis*, *C. felis*, *C. canis*, and *P. irritans*. Human acquires all three species by ingestion of infected fleas with tapeworm. Fleas (*Tunga penetrans*), commonly called Jigger flea or sand flea, may also be a vector of the bacterium *Francisella tularensis* that causes tularaemia and burrow into people's feet.

Objectives

After studying this unit, you should be able to:

- ❖ describe the external morphology of a typical flea,
- ❖ distinguish adult cat and dog flea from rat flea,
- ❖ distinguish adult human flea from other fleas,
- ❖ describe the general life cycle of fleas,
- ❖ describe the general life cycle of *Tunga penetrans*,
- ❖ differentiate between sylvatic and urban plague,
- ❖ describe the clinical forms of plague,
- ❖ give an account of control measures for fleas.

7.2 EXTERNAL MORPHOLOGY OF FLEAS

The most distinctive features of flea morphology are co-related with their parasitic lifestyle. They are small wingless insects measuring 1 mm to 6 mm in length, heavily sclerotized and distinct by the bilaterally compressed body. Females have a downward sloping, rounded abdomen, and males have an upturned pointed abdomen. There are one or two distinctly coiled chitinous brownish spermathecae in females between the sixth and eighth abdominal segments. The male has a coiled aedeagus in the abdomen. To separate male from female is not essential epidemiologically because both suck the blood and play an essential role in transmitting the disease-causing agents. Fleas can be light to dark brownish and are generally shiny and covered with bristles and small spines (Fig. 7.1).

Tularemia is a rare infectious disease. It mainly affects rabbits, squirrels, etc., it attacks skin, lungs, eyes, and lymph nodes. This disease does not occur naturally in humans.

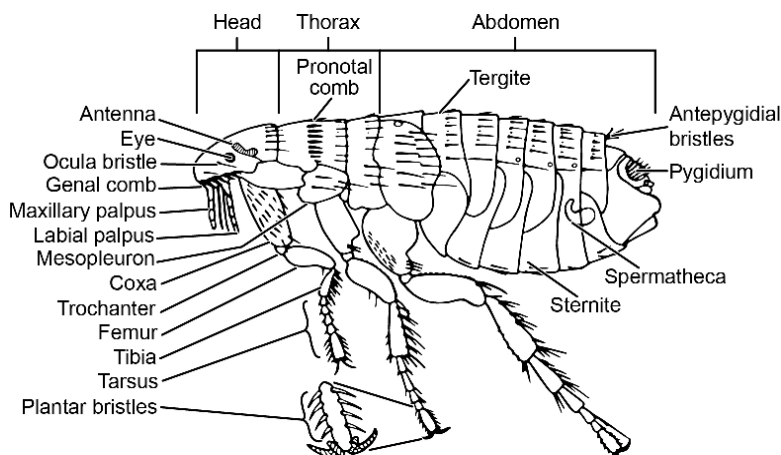


Fig. 7.1: Lateral view of a female adult flea.

The head is generally triangular in shape and bears a pair of conspicuous eyes/ (ocelli-like structures), some species lack eyes altogether. The short club-shaped antennae have three segments lying in grooves on either side of the head. Antennae are sensitive to touch, smell, heat, humidity, and vibrations, thus enabling easy movement through the hosts' feathers or fur. Male antennae are typically longer than those of females that are used for clasping during mating (Fig. 7.2).

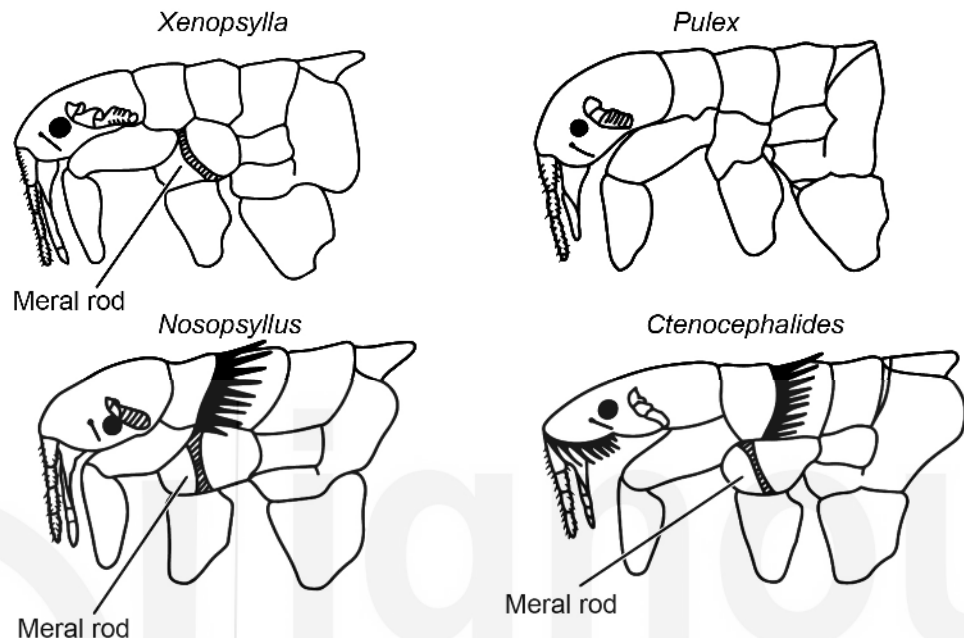


Fig. 7.2: Diagrams of the head and thoracic segments of adult fleas.

Mouthparts are directed downwards. Such a condition is called hypognathous. Mouthparts are specialized for piercing the host's skin and sucking the blood. The rows of the tooth-like spines are arranged along the body areas called combs. A comb in some species along the bottom margin of the head is called genal comb or genal ctenidium.

Thorax consists of three distinct segments: the prothorax, mesothorax, and metathorax. In addition, many species have a row of tooth-like spines, termed as pronotal combs or proctenidium, that projects from the posterior edge of the pronotum. The presence or absence of combs is often taxonomically significant. For example, humans and rat fleas lack both genal and pronotal combs and are called combless fleas. In cat and dog fleas, they have both genal and pronotal combs, but the northern rat flea (*Nosopsyllus fasciatus*) has pronotal comb, while the genal comb is absent.

In several genera, including *Xenopsylla*, a sternite termed mesopleuron located above the middle pairs of legs, is divided into two parts by a thick vertical rod-like structure called the mesal rod or mesopleural suture.

The genus, *Xenopsylla* is characterized by the presence of mesal rod and absence of both combs, genal and pronotal. The legs are relatively long, the third ones with especially large coxae to enable jumping, and five segmented tarsi have prehensile claws. The adult is highly adapted for jumping, facilitated by the protein resilin. Resilin is present in the pleural arch, between internal ridges, metapleuron, and metanotum. The abdomen is divided into seven segmented pregenital and three-segmented genital regions.

A sensory dome/convex-shaped structure/plate called sensillum or pygidium lies on the dorsal surface of the abdomen posterior to tergite VIII. It is covered with several circular depressions, each having a long seta in the center. The sensillum is sensitive to detecting vibrations, temperature changes, and host detection. Just anterior to the pygidium in most of these fleas are paired stout bristle present on each lateral side, run over the pygidium/sensillum termed as antesensilial setae or antepygidial bristles.

Because the alimentary tract is essential in the transmission of *Yersinia pestis*, it is critical to understand its structure and functions. The alimentary tract is made up of an anterior elongated chamber called the pharynx, which leads to a long oesophagus and then to a more or less conical organ called the proventriculus, which is located at the foregut-midgut junction (Fig. 7.3).

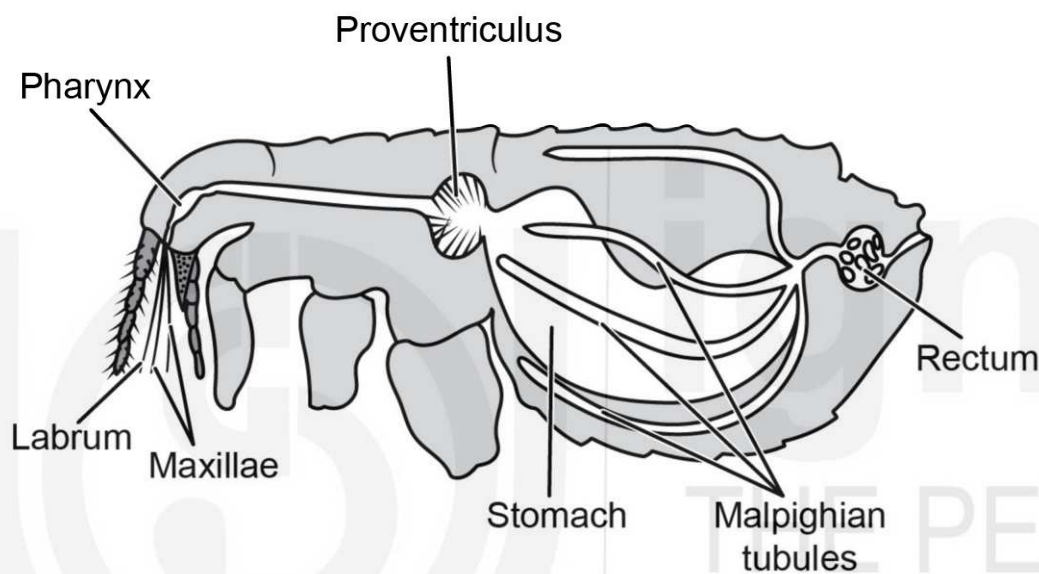


Fig. 7.3: Diagrammatic representation of the alimentary canal of an adult flea.

The pharynx is the first digestive tract chamber to be reached. The proventriculus is equipped with long, backwardly directed spines to prevent blood meal regurgitation from the midgut. The midgut/stomach can expand and accommodate a large number of blood meals. The midgut is where the digestive process takes place. Four excretory malpighian tubules are located at the junction of the midgut and hindgut and are responsible for excretion. Hindgut leads to a small dilated rectum, where blood meal is influenced by the secretion of the so-called rectal glands. Finally, the undigested remains pass out of the body in the form of a very minute, round, almost black, tarry drop.

7.3 LIFE CYCLE

Fleas belong to one of the orders of Insecta, i.e., Siphonaptera which exhibits a complete metamorphosis. The life cycle is completed in four stages viz., egg, larva, pupa, and adult. If the conditions are favourable, the female flea lays eggs throughout the year. Both males and females take the blood meal. As a result of this, both are important for plague transmission.

The general description of the life cycle of fleas is being given here...

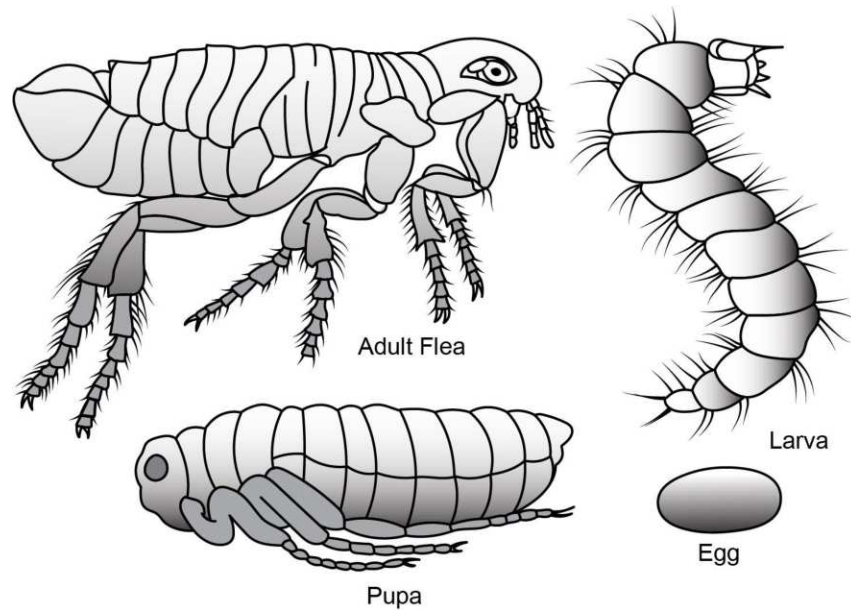


Fig. 7.4: Life cycle of Flea.

The Life cycle of *Tunga penetrans* will be discussed later on. A gravid female usually oviposits eggs while on the host. However, they are never cemented to the hosts' hair and so fall off the body of the hosts and get deposited on the floors of the houses or in the nests and sleeping places of their hosts. High humidity favours the oviposition. Eggs are minute, oval, white, or yellowish, measuring 0.1 mm to 0.5 mm long. The eggs hatch within 2-5 days during favourable conditions, but this is prolonged during the unfavourable conditions. The longevity of adult fleas ranges from 10 days to 6-12 months or even longer. In its life span, female deposits about 300-1000 eggs over a period of 3-25/day, and eggs are laid in a patch.

A small worm-like, legless, eyeless larva emerges from the egg. Larva has 13 segments with numerous stout body setae, especially abdominal segments. The last segment of the larva has finger-like ventral projections called anal sturts. Larvae are blind and avoid sunlight. Setae are arranged in a circle at the posterior border of each segment. The mouthparts of larvae are adapted for biting and feeding any decaying organic refuse. Larvae are active and harborage in cracks and crevices, among the refuse of the floors of houses in the nests or animal burrows. The head encloses a pair of mandibular and silk glands, the secretion of which is used to construct the pupal cocoon.

Larva moults twice, i.e., there are three larval instars, but there are two larval instars in a few species. The larval period is usually 2-3 weeks (for the mammals which serve them with blood) but may be prolonged to 200 days or more during adverse conditions such as limited food supply and low temperature. A mature larva is about 4-10 mm long. Larvae are susceptible to low humidity. The last larval instar spins loose, silken cocoon from salivary secretions, picks up debris, dust particles, and sand from the surroundings, and helps to camouflage. Therefore, it is challenging to notice pupa from their surroundings. Larva takes 2-3 days to construct their cocoon. The pupation period is about 5-14 days, but this period is influenced by surrounding temperature and host availability.

Vibrations occur through the host's movements, carbon dioxide exhaled from hosts within its dwellings, and seasonal rise in humidity stimulates the adult emergence from the cocoon. Under favorable conditions, adults may remain alive in their cocoons for 4 -12 months. Some species may complete the life cycle within 2-3 weeks but may get considerably prolonged to many months in others. Fleas (adults) can jump vertically up to 18 cm and horizontally up to 33 cm.

7.4 RELATION WITH HOST

An adult requires a blood meal immediately after reaching maturity and then reproducing. Without a host to provide a meal, the flea life is a few days under favourable conditions. Fleas can remain alive for up to one and a half years. Some species remain there on these hosts and feed almost continuously, while others live usually in burrows or certain types of the nest, visit the host for feeding for a short period and then leave. During taking the blood meal, fleas eject faeces composed of semi-digested blood of the previous meal and then ingest a large amount of blood during the act of feeding.

Host Specificity

In general, as the size of the host species decreases, the specificity of the host species decreases as well, which is a negative feedback loop. Another factor is the ability of fleas to switch host species; as a result, fleas are not very host-specific, but they do have preferred hosts. Most species can transfer from one of their main hosts to another host or a host of different species. For example, cat and dog fleas transfer and feed on humans and other wild animals; human fleas transfer to pigs, and rat fleas to humans without their main hosts.

The following are four categories grouped according to their degree of attachment to the host.

1. Some species are found in large numbers in the nest but rarely on a host. Example: *Conorhinopsylla*.
2. Most species spend their time on the primary host but can transfer quickly from one host to another. Example: Cat flea and dog flea.
3. Fleas are found attached permanently to the host skin with their mouthparts. Example: Sticktight flea.
4. Female burrows into the skin and remains there permanently as parasites. Therefore, such fleas do not play any role in disease transmission. Example: Chigoes.

Fertility could be reduced if fleas take blood from less acceptable hosts. Fleas leave the dead host and find new ones. This behaviour has importance epidemiologically in plague transmission.

7.5 MEDICAL IMPORTANCE

The following are medically essential features of fleas.

7.5.1 Flea-Annoyance

- (1) Flea bite causes dermatitis in persons who are hypersensitive to flea saliva.

- (2) Flea bite appears as red bumps or red halo around the bite center. Flea bite causes discomfort, irritation, and itching. Excessive scratching can further damage the skin, and secondary bacterial infection may be acquired. Flea bites are common in areas such as the waist, armpits, breasts, groin, and the folds of the elbows and knees, to name a few.
- (3) People may be sensitive to flea faeces upon inhaling/contacting them.
- (4) Larval exuviae may cause asthmatic symptoms.

7.5.2 Plague

The infection causes plague with a gram-positive bacterium, *Yersinia pestis*. This disease is also called "**black death**". The organism, *Yersinia pestis*, was isolated first by Swiss bacteriologist Alexandre Yersin in 1894. Symptoms of infection include fever, weakness, and headache. Usually, symptoms start after 1 to 7 days of exposure. In the bubonic plague, swelling of lymph nodes also occurs, while in the septicemic form, tissue turn black and dies, and in the pneumonic form, shortness of breath, cough, and chest pain may occur. Two ecological forms of plague are recognized:

(1) Sylvatic plague (campestral plague/rural plague)

Sylvatic is derived from the Latin word "silva" meaning trees. In this type, plague is maintained in several species of rodents, mammals, and their fleas in rural areas away from the human populations. Over 200 species of rodents and other species have been recognized to harbour plague bacilli. Many types of wild rodents are ground squirrels, rock squirrels, gerbils, voles, chipmunks, marmot, rabbits, etc., which can be affected by the plague. Sylvatic plague is primarily transmitted among wild rodents and other mammals through flea bites and contact with contaminated fluid or tissue through predation or scavenging. Human hunters can acquire plague from wildlife through a flea bite. In addition, wild carnivores can be infected by eating other infected animals.

(2) Urban plague

Plague bacteria circulate at a low rate in some rodents, resulting in an unusually high number of deaths. These infected animals and their fleas serve as long-term reservoirs for the bacteria. It is known as the enzootic cycle. Sometimes, other species can become infected with the virus, resulting in an animal outbreak known as an epizootic. Humans are at risk both during and after the outbreak. Urban plague is an infectious disease carried in domestic rats (commensal rats) and fleas in cities and towns. Urban plague is caused by *Yersinia pestis*. Shared reservoir hosts of urban plague are house mice, black rats, and Norway rats (Fig. 7.5).

The plague bacteria can be spread in the following ways:

a) Flea bites

Plague bacteria are inoculated into the body by the bite of an infected flea. During or after the epizootic plague, rodents may die. Fleas leave the rodents and search for other rodents to feed their blood. Therefore,

people and animals who travel to areas where rodents have recently died due to the plague are at risk of contracting the disease through a flea bite. In addition, a plague-infected flea is brought into the house by dogs and cats. A flea bite can cause primary bubonic plague or septicemic plague, which are both contagious diseases.

The important vectors are *Xenopsylla cheopis*, *X. astia* and *X. brasiliensis*. However, *X. cheopis* is exceptionally a suitable vector of plague.

It is essential to understand how bacilli transmit to the host. *X. cheopis* sucks in bacilli while feeding a bacteremic rat (the blood of the rat is poisoned with bacilli). The blood meal and bacilli are passed to the proventriculus and stomach and multiply significantly. Eventually, this results in occlusion (blockage) of the proventriculus and blockage of the gut. It prevents the flow of the blood meal from the foregut to the hindgut. As a result, blood meal in the midgut is digested. Now flea becomes starved. Starved flea tries its best to attempt to get a feed immediately. During its attempts to open the blockage of the proventriculus. The flea repeatedly regurgitates in order to succeed. During this regurgitation, some of the bacilli are dislodged with the blood and are injected into the host.

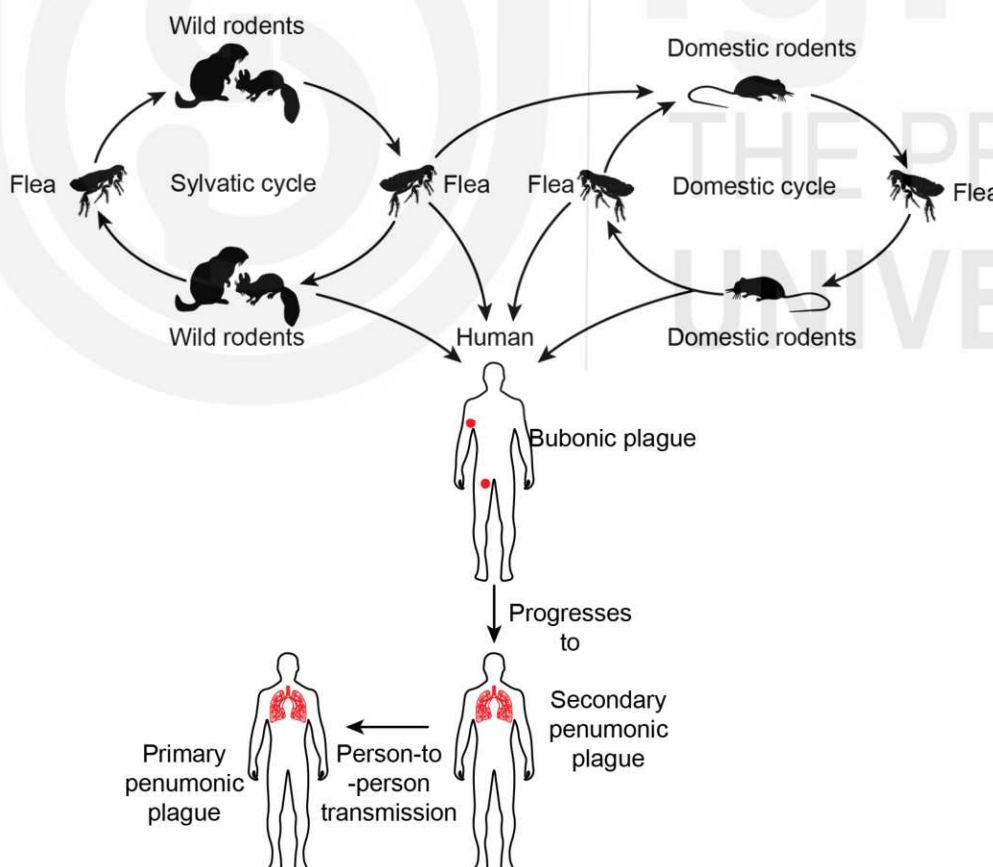


Fig. 7.5: *Yersinia pestis* transmission cycle.

b) Contact with contaminated fluid or tissue

When humans come into contact with plague-infected animal tissue or body fluid, they may become infected. For example, a hunter who skins

a rabbit or other infected animal without taking the necessary precautions may become infected with plague bacteria, leading to death.

c) By Breathing bacilli

Coughing bacilli-containing droplets into the air is common among those suffering from plague pneumonia. If these bacteria (bacilli)-containing droplets are inhaled by another person while breathing, pneumonic plague is transmitted.

d) Rubbing flea's faeces into the wound

Another rare method of infection is by rubbing flea's faeces into the wound into the skin made during a bite or coming into contact with mucous membranes.

There are three clinical forms of plague

Bubonic plague

It is transmitted through the bites of infected fleas. Symptoms begin to develop within six days. If left untreated, the mortality rate is 50-90%. After inoculation, bacilli multiply within the lymph system (The organs within the lymphatic system are the tonsils, spleen, thymus, etc.). The period between becoming infected and the start of symptoms is called the incubation period. Then, the swollen lymph nodes form the characteristic buboes associated with the disease.

Septicemic plague

Septicemic plague develops when bacilli enter the bloodstream. Symptoms of the disease are rapid heart rate, severe headache, vomiting, etc. It is also spread through the bites of an infected flea. The incubation period is 2-5 days, and external buboes are absent. Untreated septicemic plague is usually fatal. However, early treatment reduces the mortality rate by between 4 and 15%. People often die on the same day of symptoms.

Pneumonic plague

It occurs when the lungs become infected with bacteria that cause plague. This disease is most often transmitted when respiratory droplets from an infected person or animals are breathed. However, it can also develop if the bubonic or septicemic plague is left untreated. The incubation period is 1-3 days. Symptoms are coughing, bloody sputum, chills, fever, and usually, death occurs within three days if left untreated. In pneumonic plague, there is no involvement of flea vector.

Treatment

Antibiotics often used are: (i) Streptomycin (ii) Chloramphenicol (iii) Tetracycline (iv) Gentamycin and (v) Doxycycline.

7.5.3 Murine Typhus

Murine typhus is a disease caused by *Rickettsia typhi*, which is found in fleas and other insects. It is also known as endemic typhus, flea-borne typhus, rat

typhus, urban typhus, or shop typhus. Flea infection occurs when the flea consumes *R. typhi* bacteria while feeding on the infected person. *R. typhi* invades the midgut epithelial cells of the flea and begins to multiply there.

Bacilli do not block the proventriculus. All the midgut cells are infected after 7-10 days. The midgut cells rupture and release the *R. typhi*, back into the lumen of the gut. From the lumen, they are ejected out of the body along with the faeces and fall on the surface of the skin of the host. These infected faeces are rubbed into abrasions or come into contact with mucous membranes. Transmission may also occur by entering/release of *R. typhi* from crushed fleas into abrasions.

Murine typhus is primarily maintained by a cycle involving commensal rodents of the genus *Rattus* and their ectoparasite, *Xenopsylla*, which is abundant in the area. The primary reservoirs for *R. typhi* are *Rattus rattus* (black rat) and *Rattus norvegicus* (Norway rat). Infections also have been recorded in other rodent animals such as a peridomestic rat, house mice, giant pouched rat, house shrew, *Virginia opossum*. According to research, at least 11 different species of fleas have been found to be infected with *R. typhi*. *Xenopsylla cheopis* represents the principal vector. Other vectors are *Nosopsyllus fasciatus*, *C.canis*, *C.felis* *P. irritans*, *X. brasiliensis*, and *X. astia*.

Clinical symptoms of murine typhus are rashes, fever, chills, loss of appetite, prostration, delirium, nausea, vomiting, cough, stomach pain, and coma, especially in severe cases. The incubation period ranges from 6 to 14 days.

Treatment: Use of doxycycline and tetracycline. Murine typhus does not exhibit pathological effects on fleas. In contrast, the *R. prowazekii* (epidemic typhus) louse vector becomes infected and dies due to the infection. *X. cheopis* can maintain and transmit *R. typhi* transovarially (transmission of the pathogen from ovaries to eggs, larvae, pupae, and adults). As a result, *X. cheopis* serves both as a reservoir and a vector.

7.5.4 Cestodes

Dipylidium caninum mainly infects dogs and cats and is occasionally found in children. A flea can transmit this to both pets and humans in the following way. Gravid proglottids are passed intact in pets' faeces, or rarely proglottids, rupture and egg packets are seen in the stool, and proglottids become dry on exposure to air. Flea larvae bite into dried proglottids; this results in the release of eggs, which they then swallow. An oncosphere (1st stage larvae) is liberated in the intestine and then penetrates the intestinal wall, entering the haemocoel. Onchosphere larvae develop into the infective stage, cysticercoid larvae. Flea larva develops into an adult, and cysticercoid larva remains trapped there. The dogs are principal definite hosts and acquire infection by licking their coats and swallowing infected adult fleas. Infection occurs when humans or children consume a flea contaminated with cysticercoid parasites. It takes about a month for the cysticercoid larva to mature into an adult tapeworm in the small intestine after it is first introduced (Fig. 7.6).

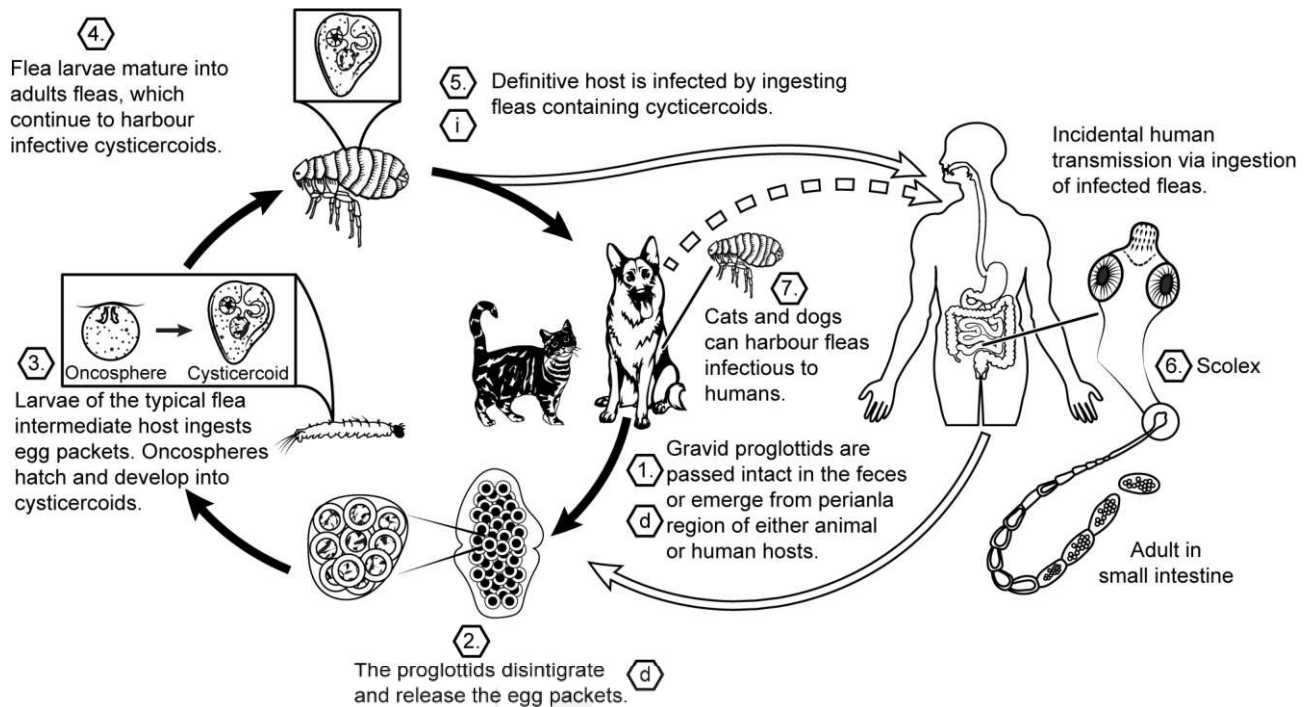


Fig. 7.6: *Dipylidium caninum* transmission Cycle.

7.4.5 Other Diseases

Bartonella henselae, a Gram-negative parasite, causes cat scratch disease. This agent is transmitted from cat to cat by the cat flea. *B. henselae* is a parasite found in the faeces of the cat flea. Because of this, cats may become infected with *B. henselae* through ingestion of flea faeces containing *B. henselae* or through intradermal inoculation with the parasite's eggs. In addition, means of transmission from cat to children/humans may be inoculation with flea faeces containing *B. henselae* through a contaminated cat scratch or by cat saliva transmitted in a bite.

Tularaemia: It is caused by infection with *Francisella tularensis*. Humans acquire infection through exposure to infectious vectors, contact with infected animals, or ingesting contaminated food or water. Ticks are the primary vectors.

SAQ 1

Fill in the blanks with the correct option given in the parenthesis:

- (Male/Female) has coiled aedeagus in the abdomen of the flea.
- Fleas belong to one of the orders of Insecta, which exhibit a (Complete/Incomplete) metamorphosis.
- (Adults/Nymphs) require blood meal immediately after reaching maturity and then to reproduce.
- Fleas leave the (live/dead) host and find new ones.
- Plague is caused by infection with (Gram-positive /Gram-negative) bacterium *Yersinia pestis*.

- vi) Murine typhus is also known as (epidemic/endemic) typhus.
- vii) (Dog/Human) acquires infection by ingesting the cysticeroid contaminated flea.
- viii) (Dog/Cat) scratch diseases is caused by *Bartonella henselae*.

7.6 TUNGA PENETRANS

Tunga penetrans is commonly called Jigger or sand flea, or chigoe. This flea burrows into the tissue of humans and some domestic animals and does not act as a vector.

7.6.1 External Morphology

T. penetrans is very small and measures 1mm in length. Both pronotal and genal combs are absent. It has a sharply angled head (Fig. 7.7). It is abundant in tropical and subtropical climates all over the world. *T. penetrans* is easily distinguished from other fleas by their very compressed thoracic segments and paucity of spines and bristles on the body. Female is smaller than male. Females have depression at their abdominal end, whereas males have their protrusive copulatory organ in the same region.

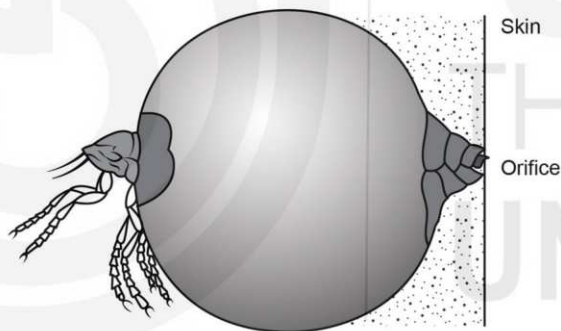


Fig. 7.7: Female Jigger Flea with the extended abdomen.

7.6.2 Life Cycle

Eggs are dropped onto the house floor or on the ground outside and size about 604 µm long. The larva hatches within one to six days and undergoes two moultings, i.e., there are three larval instars under favorable conditions. The larval period lasts between 6 and 8 days, and the final stage larva constructs a cocoon around their bodies and pupates within it. The pupation period lasts between 9 and 15 days.

Newly emerged adults jump and crawl on the ground in search of hosts. Both sexes feed on blood. Males remain mobile after a blood meal, but females burrow their heads into the host's soft skin, like between the toes or under toe nails. Later, the host's skin envelops the female completely except for the tip of its abdomen, visible through an orifice in the skin lesion. Only once the female burrows into the skin does the male mate her. Male dies after copulation. This orifice allows the flea to breathe, defecate, mate, and expel the eggs. It lives in

the cutaneous and subcutaneous dermal layers, where the female feeds on blood. The abdomen begins to swell by gulping host fluids and reaches the size of a pea after 8-10 days of embedding. The abdomen contains 100 to 1000 eggs. The eggs are released through the orifice and fall onto the ground. The life cycle is completed within 4 to 6 weeks after the oviposition female dies.

7.6.3 Tungiasis

Tungiasis is an inflammatory skin disease caused by injection with the female ectoparasite. *Tunga penetrans*. Tungiasis causes skin inflammation and severe pain itching at the site of infection that is characterized by a black dot at the center of a swollen red lesion surrounded by what looks like a white halo. Desquamation (skin peeling) of the skin is always seen. Secondary infection may be established, resulting in ulceration and accumulation of pus. If the flea dies but remains within the skin, it can lead to severe complications, such as secondary infection from bacteria trapped within the skin. Toe nail loss, toe deformations, and gangrene are possible long-term consequences.

7.6.4 Treatment

The recommended course of action is surgical extraction of fleas, followed by the application of topical antibiotics. A surgical extraction is complex, and it is preferable to treat the lesion topically with 0.08% ivermectin or 0.2% trichlorfon lotions to kill fleas *in situ*.

7.7 PREVENTION/CONTROL

Following are the prevention and control measures of Tungiasis.

7.7.1 For Humans

- i. Flea bites can be treated with anti-itch creams, usually antihistamines, hydrocortisone, or calamine lotion.
- ii. Use of DEET or Permethrin impregnated clothing may provide some personal protection by repelling fleas.

7.7.2 Rodent Fleas

Chemicals used to kill fleas are called pulicides. Flea control is necessary to reduce the risk of disease transmission and parasitization of pets by fleas. Burrows and runways of rats were treated with dust containing bendiarb, propoxur, diazinon, malathion, a synthetic pyrethroid, and other pesticides such as permethrin, deltamethrin, and cypermethrin. In the absence of dust formulation, if needed, spray formulation may be applied to runways and burrow entrances such as bendiocarb, pirimiphos-methyl, malathion, a synthetic pyrethroid. Rodenticides can be used in the form of poison baits (rodenticide + attractant) containing warfarin, brodifacoum, bromadiolone, chlorophacinone, and calciferol. The insecticide must be used before rodenticides; otherwise, rodents will be killed before their fleas are killed.

7.7.3 Cat and Dog Flea

1. Vacuuming in homes where pets rest or sleep helps remove immature fleas and food.
2. Steam cleaning of the carpet reduces the number of fleas.
3. In most cases, flea collars or pet collars impregnated with propoxur or bendiocarb, or an insect growth regulator (Methoprene), fenoxycarb, or pyriproxyfen, provide adequate flea control for up to a year.
4. Imidacloprid and Permethrin are formulated as "spot on" and applied on a small skin area, which in turn spreads on the entire body. Fleas come in contact while sucking blood and are killed.
5. Formulations having IGRs such as Methoprene and Pyriproxyfen are popular for flea control.

They are highly safe for mammalian cells to be around. Flea development is inhibited by insect growth regulators (IGR). IGR does not cause death in adults. Instead, they act as larvicides, preventing larvae from hatching from eggs, larvae from successful moulting. Lufenuron, a chitin synthesis inhibitor, is administered orally as pills for dogs or as liquid added to food or injected into the cats. The active ingredient passes into the bloodstream and is picked by the flea during the feeding.

6. Some pulicides are given orally to the host for good flea control. Examples: Henicotinoids (such as nitenpyram) and spinosyns (e.g., Spinosad).
7. Topical application of insecticides is used so that flea acquires the toxicant via its cuticle. Example: pyrethrins, pyrethroids (e.g., Permethrin), neonicotinoids (e.g., imidacloprid, dinotefuran), phenyl pyrazoles (e.g., Fipronil), macrocyclic lactones (e.g., selamectin), Lufenuron (Inhibit the egg development, does not kill the adults), Nitenpyram, Estenvalerate, Pyridin, Novaluron adulticides and IGRs (insect growth regulators) or IDR (Insect development regulator) are used in combinations in most of the formulation for effective flea control. It is necessary to repeat the treatment after two weeks.

SAQ 2

Read the following statements and write true (T) or false (F) against each:

- i) *Tunga penetrans* is commonly called Jiggers or sand flea.
- ii) Larva of *Tunga penetrans* undergoes three mountings, there are three larval instars under favorable conditions.
- iii) Tungiasis is a non-inflammatory skin disease caused by male ectoparasite.
- iv) Chemicals used to kill fleas are called pulicides.
- v) Rodenticides can be used in the form of poison baits
- vi) Steam cleaning of the carpet increases the number of fleas.

7.8 SUMMARY

Let us summarize what we have learnt so far:

- Fleas are blood-feeding insects that are small and wingless.
- During their life cycle, fleas undergo a complete transformation. There are four stages: the egg, the larva, the pupa, and the adult. Mouthparts in both sexes are adapted for piercing and sucking. Several fleas are medically significant.
- The presence or absence of combs on fleas is often taxonomically significant.
- The most medically important flea, *Xenopsylla cheopis*, lacks genal and pronotal combs.
- Both infected males and females inoculate disease-causing agents into the body while taking blood.
- Fleas have favourite hosts but are not host-specific. Flea biting causes allergic reactions and dermatitis.
- *Xenopsylla sp.* carries and transmits plague and murine typhus, by *Yersinia pestis* and *Rickettsia typhi*, respectively. Bubonic, Septicemic and pneumonic plague are the three clinical forms of plague.
- The cestode, *Dipylidium caninum*, can be transmitted by cat and dog flea to pets and humans.
- Cat flea also transmits cat scratch disease-causing agent. Fleas also play a minor role in transmitting the tularaemia causing agents.
- *Tunga penetrans* that burrow into humans' tissues and causes tungiasis.
- Rats (reservoir of pathogens) are killed by rodenticides and control of fleas by maintaining cleanliness in the house and application of pulicides and insect growth regulators.

7.9 TERMINAL QUESTIONS

1. Define the following:
 - (a) Pulicide
 - (b) Tungiasis
 - (c) Tularaemia
2. Match the following:

(i) <i>Xenopsylla cheopis</i>	(a) Cestodes
(ii) <i>Tunga penetrans</i>	(b) Plague
(iii) <i>Dipylidium caninum</i>	(c) Tungiasis
(iv) <i>Bartonella henselae</i>	(d) Cat scratch disease

3. Describe the generalized Life cycle of flea.
4. Write a short note on the following:
 - (a) Prevention /control measures of fleas.
 - (b) Typhus fever
 - (c) *Tunga penetrans*
 - (d) *Yersinia pestis* transmission

7.10 ANSWERS

Self Assessment Questions

1. i) Male, ii) Complete, iii) Adults, iv) Dead, v) Gram-positive, vi) Endemic, vii) Human, viii) Cat-scratch.
2. i) T, ii) F, iii) F, iv) T, v) T, vi) F.

Terminal Questions

1. (i) Refer to section 7.7.2; (ii) Refer to section 7.6.3; (iii) Refer to section 7.4,5.
2. (i) b; (ii) c; (iii) a; (iv) d.
3. Refer to Section 7.3.
4. (i) Refer to section 7.7; (ii) Refer to section 7.5.3; (iii) Refer to section 7.6.; (iv) Refer to section 7.5.2.

Acknowledgment of Figures

Fig. 7.2: Medical Entomology for Students Fourth Edition, Mike Service

Fig. 7.3: Medical Entomology for Students Fourth Edition, Mike Service

Fig. 7.5: Medicine Published in the Hospital 2012 DOI:10.1136/bmj.2.2127.1011

Fig. 7.6: CDC

SIPHUNCULATA (LICE) AS DISEASE VECTORS

Structure

8.1	Introduction	Medical Importance
	Objectives	Control and Prevention
8.2	Body Louse	8.4 Pubic Louse
	External morphology	External morphology
	Life cycle	Life cycle
	Medical Importance	Medical Importance
	Pediculosis	Control and Prevention
	Louse borne Epidemic Typhus	8.5 Summary
	Louse borne Epidemic relapsing fever	8.6 Terminal Questions
	Trench Fever	8.7 Answers
	Control and Prevention	
8.3	Head Louse	
	External morphology	
	Life cycle	

8.1 INTRODUCTION

In the previous unit, you have studied the order Siphonaptera comprising fleas and their different types. In the present unit, you would learn about sucking lice that have around 500 species. The body louse (*Pediculus humanus corporis*), head louse (*Pediculus humanus capitis*), and pubic or crab louse (*Phthirus pubis*) are the three types of sucking lice found in humans. **Sucking lice belong to the order Anoplura, formerly known as Siphunculata.** Anoplurans are all blood-feeding apterous ectoparasites.

Morphologically, all three forms differ significantly. The *corporis* and *capitis* can breed together readily under laboratory conditions. All three species are

distributed more or less widely but are more commonly found in temperate areas. In addition to body louse *Rickettsia prowazekii* (epidemic typhus), *Bartonella quintana* (trench fever), and *Borrelia recurrentis* are the disease-causing agents transmitted by body lice (relapsing fever). So far, *Pthirus pubis* is not known to transmit any kind of disease.

Objectives

After studying this unit, you will be able to:

- ❖ define a hemimetabolous insect,
- ❖ describe the external morphology of adult body louse,
- ❖ distinguish the *Pediculus sp.* from *Pthirus pubis*,
- ❖ describe the life cycle of body louse,
- ❖ define the Vagabond's disease,
- ❖ define the pediculosis,
- ❖ describe the mode of transmission of pathogens into the host body,
- ❖ describe the medical importance of lice,
- ❖ explain the control/prevention of lice.

8.2 BODY LOUSE (*PEDICULUS HUMANUS CORPORIS*)

In this section, you will learn about the body louse's external morphology, life cycle, and medical importance.

8.2.1 External Morphology

Originally the body louse and head louse were a single species. However, there are two races of the human louse, the head louse (*Pediculus humanus capitis*) and the body louse (*Pediculus humanus corporis*). Some scientists say these should be divided into two species.

The body louse is an unavoidable obligate ectoparasite of humans. A small greyish insect lives on the human body and is dorsoventrally flattened. The female is longer than the male, measuring about 2 mm to 3 mm and 3 mm to 4 mm, respectively (Fig. 8.1). The head has a pair of inconspicuous black eyes and short five segmented antennae. The thoracic segments are not distinguishable, whereas the abdomen is distinctly segmented. The legs are well developed and adapted for clinging. On the inner edge of the tibia, there is a small spine called a tibial thumb, and on the outer edge of the tibia, there is a single segmented tarsus bearing a curved claw called the tibial claw. Both claw and thumb oppose each other and grip the fibres of the cloth/hair of the host. Mouthparts consist of a sucking snout-like proboscis called haustellum, which is armed on the inner side with small teeth arranged in a circle. The proboscis is everted to grip the host skin during feeding. Ventral to cibarium is

a well-developed pouch, the trophic sac, accommodating three stylets, lying one above the other. While feeding, these stylets are protruded and thrust into the skin, and saliva is injected into the wound to keep the blood from clotting. As a result of this piercing, blood oozes out on the surface and is sucked in by the suctorial cibarium and pharynx. The abdomen is nine segmented.

The lateral margins of the abdominal segments are thinly sclerotized and darker than the remaining segments. There are dark transverse bands on the dorsal surface of the abdominal segments in males. The male abdomen has a rounded tip, whereas the female abdomen has a bifurcated or bilobed tip that is used to grasp the fibres of the cloth and direct the alignment of the eggs.

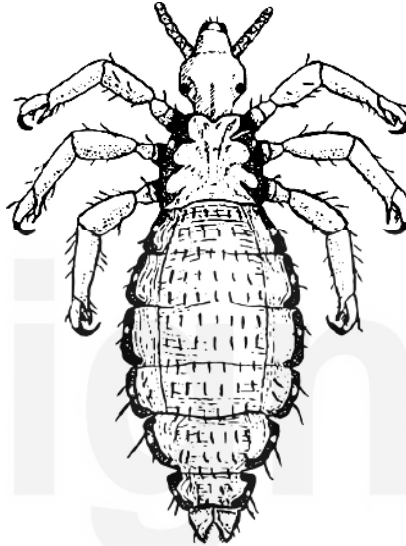


Fig. 8.1: Body Louse (Female)A

8.2.2 Life Cycle

Both adults and nymphal stages feed on the blood and live permanently on humans. Lice cling mainly to the fibres of the clothing and the hair during the feeding. Females cement their eggs firmly primarily to clothing fibres along the seams/creases of underclothes. Human lice develop from an egg to an adult via gradual metamorphosis. It means the last larval stage develops directly into an adult without passing through a non-feeding stage called the pupa. However, occasionally they are glued onto the base of the host's hair. Females require a blood meal to develop eggs, commonly known as nits. The egg is oval and usually yellow to white in color. Eggs have long perforated operculum at the free ends, which gives the eggs the appearance of minuscule pepper pots.

On the top, these perforations/holes are called aerophyles, through which the developing embryo respire. Intake of air through these holes also aids in hatching out of the nymph. Most of the egg is heavily chitinized and helps protect the embryo from mechanical damage and desiccation. Nymph emerges from the egg by cracking a suture of their cuticle, which encircles the base of the operculum and pushes up the operculum. Females lay 4-5 eggs per day on average, hatching after 8 days. The longevity of female lice is 2-4 weeks and may lay 150-300 eggs/per female. On discarded clothing, eggs take a more extended period to hatch, but the eggs do not hatch at all because these eggs do not survive more than four weeks.

The immature stage of the louse is called a nymph. A nymph is morphologically similar to an adult except for the size and development of reproductive organs. There are three nymphal instars, and each nymphal instar requires a blood meal before moulting into the next nymphal stage. The nymphal period is 7-14 days. The duration of the nymphal period depends on many factors, such as whether clothes are worn continuously or discarded at night or temperature. The life cycle is completed in about 2-3 weeks during favorable conditions. The body louse is an obligate parasite; however, they are rarely found in other places because they can only survive for a few days away from their host. Without a blood meal, they die within 2-4 days. The longevity of a blood-fed louse is 5-10 days. Lice survive up to 32 days on the hosts, taking blood meals every 4-6 hours. The young mature female louse lays eggs up to 9 eggs per day for 8-9 days after single insemination.

Lice are most motivated to be transferred to another host. Lice crawl at a speed of 6-30 cm per minute. They cannot jump. Lice do not have dormant stages (pupal stage). A person may have 400-500 lice on their clothing or body during a severe infestation. Body lice infestation occurs when body lice infest clothing. Infestations are generally spread through close contact with other people, and they are most common in areas with poor hygiene and a high population density. For example, lice are commonly found in primitive jails, refugee camps, and trenches during wars and after natural calamities where people are forced to live in overcrowded conditions. The body lice are considerably larger than other types of lice. They lay their eggs on the skin and clothing, leaving behind waste. Lice can only crawl. People wear several layers of clothes that they rarely change and wash in the mountains and often have lice. In most developing countries, body lice may be found in homeless people.

8.2.3 Medical Importance

Pediculosis

Pediculosis is an infestation of lice. Although Pediculosis in humans may adequately refer to lice infestation of any part of the body, the term is sometimes used loosely to refer to *Pediculosis capitis*, the infestation of the head with a specific head louse. A condition of pigmentation and toughness of the skin caused by long-continued exposure, uncleanliness, and especially by scratch marks and other lesions due to the presence of body lice is called Vagabond disease. In addition, repeated injections of saliva into the individual during the blood meals may cause weariness, irritability, and allergies such as dermatitis, intense itching (pruritus), and asthmatic bronchitis.

Louse Borne Epidemic Typhus

Infection caused by the rickettsial pathogen *Rickettsia prowazekii* is the causative agent of epidemic typhus. This disease is known by several names, including jail fever and louse-borne relapsing fever. Epidemic typhus is primarily a disease of a cooler climate. Several people died in previous centuries due to epidemic typhus. The vector of *R. prowazekii* infection is the body louse. When lice consume a blood meal containing *R. prowazekii* from an infected individual, they become infected. *R. prowazekii* invades the

epithelial cell lining of the gut and multiplies enormously, eventually causing the cells to rupture and release the *R. prowazekii* back into the lumen of the intestine. Other louse tissues are not invaded. As a result, there is no transovarial transmission. Humans susceptible to louse infection become infected when rickettsiae are scratched into the wound caused by the louse's biting. *R. prowazekii* can survive in dried faeces for up to 60 days. Infection can also be caused by inhalation of dried louse faeces or crushed lice. The louse is crushed during scratching. As a result, rickettsiae are released from the gut and enter the abrasions on the skin caused by biting. Humans, therefore, are infected not by lice biting. The *R. prowazekii* infection is also fatal to the body louse, as it causes the rupture of an increasing number of epithelial gut cells. Lice usually die due to infection 8-12 days after ingesting an infectious blood meal. Classic epidemic typhus fever is a disease caused by the bacterium *R. prowazekii* and spread by lice on the human body.

Epidemic typhus symptoms include malaise, muscle spasms and headaches, cough, fever, chills, rapid breathing, rash, nausea, vomiting, and confusion. The *R. prowazekii* can be found in lymph nodes or other tissues months or years after a person recovers from epidemic typhus. It gives pathogens the chance to infiltrate other tissues and cause disease later. **Recrudescent Typhus**, also known as **Brill-Zinsser** disease, is a type of Typhus that recurs over a certain period.

Treatment

- (1) It is recommended that the antibiotic Doxycycline be used to treat epidemic typhus.
- (2) There is no vaccine.

Louse-borne Epidemic relapsing fever (LBERF)

Borrelia recurrentis is a spirochete bacterium, that is the cause of LBERF transmission. Fever, headache, muscle ache, anorexia, dizziness, nausea, coughing, and vomiting are clinical signs and symptoms. The blood platelets are also decreasing. Body lice become infected when they feed on a spirochete-infected person.

Most spirochetes have perished in the gut, but few survive and penetrate the gut wall where they multiply in the haemolymph, nerves, and muscle tissues. Therefore, transmission occurs only when infected lice are crushed during scratching. Then, it invades the spirochetes into the body through abrasions, other skin lesions, or mucous membranes. Body lice are killed in the same way that an *R. prowazekii* is killed due to infection with *B. recurrentis*. Therefore, killing lice between the fingers or cracking with the teeth is very dangerous if the lice are positive with spirochetes.

Treatment

- (1) Treatment with antibiotic tetracycline.
- (2) No vaccine is available.

Trench fever

Trench fever is also called a “five-day fever” or “quintan fever”. It is caused by the bacterium *Bartonella quintana*. Clinical symptoms are headache, muscle

ache, fever, nausea, etc. After ingesting an infected person's blood, lice become infected with *Bartonella quintana*. The pathogens multiply on the surface of epithelial cells of the gut wall.

When louse bites are scratched, the pathogen is expelled from the body, and the faeces are introduced into the body. *Bartonella* can survive in dried faeces for up to several months before dying. *Bartonella* does not affect the lice. Trench fever was first recognized during world war-I among the soldiers. The person may also get *Bartonella* by crushing the louse or faeces coming into contact with mucous membranes.

Treatment

- (1) Doxycycline and tetracycline are commonly used.
- (2) Chloramphenicol is an alternative medication recommended under certain circumstances.

8.2.4 Control/Prevention

- (1) Regular washing and changing clothes usually prevent the body louse infestation.
- (2) Washing the cloth in water hotter than 60°C.
- (3) Blowing insecticidal powder between the body and under cloths such as talcum powder mixed with permethrin (0.5%), lindane (1%), carbaryl (5%), and malathion (1%).
- (4) Impregnation of clothing with pyrethroid emulsion provides long-lasting protection. For example, 1% permethrin, 0.3-0.4% phenothrin.
- (5) Oral administration of ivermectin kills body louse and head louse.
- (6) Do not share clothing, beds, bedding, and towels used by an infected person.

SAQ 1

Fill in the blanks

- i) The body louse is an ectoparasite of humans.
- ii) The immature stage of the louse is called.....
- iii) Is an infestation of lice.
- iv) Epidemic typhus is a..... disease caused by *Rickettsia prowazekii*.
- v) Trench fever is also called as fever.

8.3 HEAD LOUSE (*PEDICULUS HUMANUS CAPITIS*)

This section will discuss the morphology and life cycle of the head louse with its medical treatment and prevention.

8.3.1 External Morphology

Head louse *Pediculosis capitis* is also an obligate ectoparasite of humans that causes head lice infestation. Head louse is found on the head. The body louse is *Pediculus humanus corporis*, it is morphologically identical to *Pediculus humanus capitis*, but does not normally interbreed, though they can interbreed under laboratory conditions.

The head louse is generally smaller (2.5mm -3.3mm long) than the body louse, and it is dorsoventrally flattened and wingless. The thoracic segments are joined but distinct from the head and stomach. There are seven visible segments in the abdominal cavity. Head lice are typically greyish in color. Male forelegs are slightly larger than the remaining middle and hind legs, and they are specifically designed to hold the female during copulation, as illustrated. Males and females are distinguished by a pointed end to the abdomen. Males are a little bit smaller than females. The presence of a notch (two gonopods arranged in the shape of a W) at the end of the abdomen distinguishes females (Fig. 8.2).

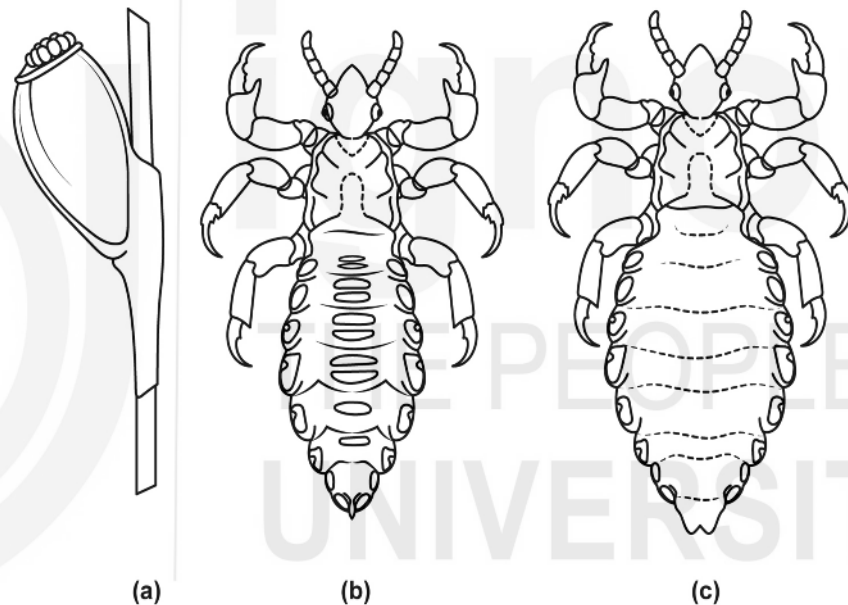


Fig. 8.2: Head Louse: (A) Nit, or Egg (B) Adult male (C) Adult female

8.3.2 Life Cycle

The life cycle of the head louse is very similar to the body louse, except the eggs in the head louse are glued to the hair of the head at their base. As the hair grows, the eggs become further displaced from the scalp. The female usually lays a single egg on each hair. Females lay about 3-4 eggs per day. In order to attach an egg to her cervix, the adult female secretes glue from her reproductive organs. In a short period, this glue hardens into nit. Except for the hair shaft, the operculum is protected by a sheath covering the hair shaft and the more significant parts of the egg.

The egg is oval, 0.8 mm long, bright, transparent, and coffee-colored. The incubation period (the period between the oviposition and hatching of the nymph from the egg) is 6-7 days. After hatching, the eggshell remains attached to the hair shaft. The term nit refers to an egg without an embryo or a dead egg. Most individuals have only 10-20 head lice. However, during the

severe infestation, the hair may be matted with a mixture of nit, nymphs, adults, and exudates from pustules resulting from bites of the lice. In such cases, secondary infection may be established, and an unpleasant crust forms on the parts of the head. The female deposits 50-150 eggs in its longevity. The longevity of females is 2-4 weeks. Nymphs hatch out from the egg. There are also three nymphal instars. The nymphal period is about 7-10 days. The time required for head lice to complete the nymph development to imago (final & fully developed adult stage of an insect, typically winged) depends on the feeding conditions. A minimum of 7-10 days is required for the lice of having continuous access to the human host. If nymphs do not have easy access to blood, they will develop for a more extended period, typically 12 to 24 days. The adults die within 2-3 days if they remain away from the host. A single louse has 30 days of the life cycle.

Transmission occurs by a person to person contact and sharing combs, beds, brushes, headphones, and caps. School-going children are at high risk because they usually use such items. Girls are two or four times more frequently infested than boys.

8.3.3 Medical Importance

Head lice are not significant if we see them from a pathogen transmitting point of view. However, under optimal laboratory conditions, head lice can transmit the causative agent, *R. prowazekii*. Heavy infestation of head lice causes severe irritation. During a severe infestation, occasionally, lice form scabby crusts beneath which the lice tend to aggregate, a condition called Plica polonica or Plica neuropathica.

8.3.4 Control/ Prevention

- 1) The louse comb, which has fine teeth, is one of the most effective tools for preventing and controlling lice. The comb removes the nymphs, adults, and nits (dead eggs and eggshells).
- 2) Contact should be avoided by direct head to head (hair to hair).
- 3) Do not share clothing such as caps, hats, scarves, coats, sports uniforms, hair ribbons, etc.
- 4) Do not share combs, brushes, or towels.
- 5) Do not lie on beds, pillows, carpets, etc., that have recently been in contact with an infected person.
- 6) Vacuum the floor and furniture, paying particular attention to areas where the infested person sits or lies.
- 7) Use of Pyrethrin combined with piperonyl butoxide (PbO) (Brand name: A-200). Pyrethrin can only kill the live lice, not unhatched eggs. Therefore, the second treatment should be given 9-10 days after the first treatment.
- 8) The Food and Drug Administration has approved the use of permethrin lotion (1%) (Brand name: NIX) for the treatment of head lice (FDA).

Plica polonica is an uncommon condition that is characterized by diffuse matting of hair. It is present in Poland since the 19th century, hence the name Plica polonica or polish plait.

Permethrin can only be used to treat lice. On day 9, a second treatment is given to kill any newly hatched lice.

- 9) Benzyl alcohol (5%) (Brand name: Uleseia lotion) has been approved by FDA. The second treatment is given after 7 days of the first treatment.
- 10) The Food and Drug Administration approved ivermectin lotion (0.5%) for head lice treatment in 2012. Unfortunately, it has no ovicidal properties. However, it is effective when given as a tablet and taken orally in most patients.
- 11) Spinosad (0.9%) topical suspension was approved by FDA in 2011. It kills both living lice and an unhatched egg.
- 12) The FDA approves the Lindane shampoo (1%).
- 13) Insecticide formulations for killing lice/eggs are dust, emulsion, and lotion. Dust is most effective but causes a greyish appearance, thereby giving signal that person has lice. Shampoos are not very effective. Other pyrethroids are commercially available in the market in various formulations such as Phenothrin, bio-allethrin, or tetramethrin. Malathion and carbaryl are also used as pediculicides. If the lotions are left on the head overnight, they give better results.
- 14) Most synthetic pyrethroids have been found resistant to lice. However, a novel head Lice lotion called **Hadrian** containing 4% dimeticone is commercially available. This pediculicide is left for 8 hours on the head to kill lice. Newly hatched nymphs from residual eggs could be killed if treatment is given after 7 days.

After studying the body and head louse in detail, let us summarize their differences as given in Table 8.1

Table 8.1: *Pediculus humanus corporis* differs from the *Pediculus humanus capitis*.

Sl. No.	<i>Pediculus humanus capitis</i> (Head louse)	<i>Pediculus humanus corporis</i> (Body louse)
1.	Occurs on the head.	Occurs in the seams of the cloths.
2.	Deeply pigmented body.	Pigmentation absent.
3.	Antennae are short and broad.	Antennae are long and slender, the third segment being relatively broader.
4.	Legs shorter and stouter.	Legs are relatively slender and more extended.
5.	Clearly marked indentations between the successive abdominal segments due to chitinous pleural plates.	Abdominal segments are usually with shallower inter-segmented indentations.

SAQ 2

Choose the correct option given in the parenthesis.

- i) Head louse males are slightly (larger/smaller) than body lice.
- ii) (Girls/Boys) are most frequently infested than (girls/boys)
- iii) (Direct/indirect) head-to-head contact should be avoided.
- iv) A novel head lice lotion is called (lindane/hedrin).

8.4 THE PUBIC LOUSE (*PTHIRUS PUBIS*)

In this section, you will study the external morphology, the life cycle of public louse. Besides, you will also learn its medical importance and prevention.

8.4.1 External Morphology

The crab louse or Pubic louse measures 1.3mm to 2 mm in length and is smaller than *Pediculus* sp. Based on its morphological characteristics, the crab louse can be easily distinguished from *Pediculus* sp. based on its morphological characteristics. Forelegs of crab louse are delicate with slender claws. Middle and hind legs are very stout, with thick massive claws and a short thumb-like process on the inner edge of the tibia called the tibial thumb. Louse body is more or less oval. Thorax and abdomen are not distinguishable. The abdomen is short and broad and has finger-like processes on each lateral side (Fig. 8.3). In the *Pediculus* sp., all legs are stout and have long and slender tibial thumbs bearing solid spines. The abdomen is elongated.

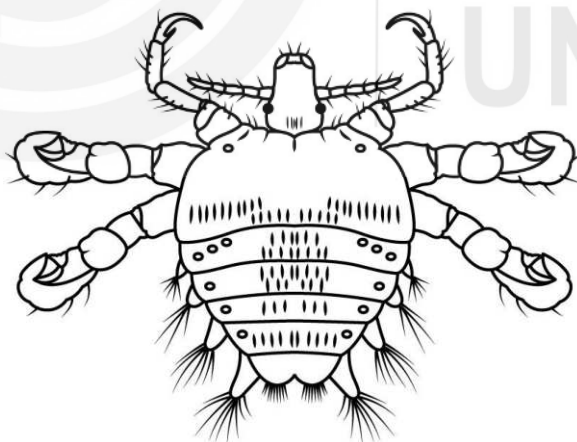


Fig. 8.3: A diagram showing external morphology of female *Pthirus pubis* (modified from Mike Service, Medical entomology for students, 5th edition, 2012, Cambridge).

8.4.2 Life Cycle

The crab louse is most commonly found in pubic and preanal hair, but it can also be found in armpits, beard, and moustache hair. It is uncommon to see it on the eyelids. Crab lice are more commonly found in adults than in children before puberty. Infestation is most common during coitus.

Every day, the female lays 2-3 whitish eggs. Fecundity ranges between 150 and 200 eggs/female. The egg is smaller than the *Pediculus* sp. egg, but it looks similar. *Phthirus* has a larger mass of glue that provides support for the hair. Therefore, several eggs may be cemented on a single hair. Within 6 to 8 days, the nymphs hatch from the eggs. The nymphal period lasts 13 to 17 days. The life cycle takes between 10 and 17 days to complete, and a mature adult has a life expectancy of 15-25 days. Crab louse grasps human hair with at least one of its second or third modified legs while feeding. Neither nymphs nor adults can survive more than 24 hours without feeding.

8.4.3 Medical Importance

There is no evidence that pubic lice transmit any causative agents for any disease under natural conditions, but can transmit louse-borne Typhus causing agents. The crab louse causes minor irritation than the body lice, but some experience severe pruritus (severe allergic reaction) in response to lice biting due to saliva infection. **Blue spots/maculae caeruleae**, which may result from the biting, is 0.2cm to 0.3 cm in diameter. They appear some hours after biting..

8.4.4 Control/Prevention

The application of insecticides has replaced the original shaving method of pubic-infested areas. In addition to being effective against head and body lice, most methods used to control them are also effective against crab lice. A liquid or powder (insecticide formulations) must be applied to the body's pubic and preanal regions, underarms, and hairy areas, as well as the body's general appearance. If the person is hairy, the whole body must be treated. Usually, two applications are required over a week. It is because the incubation period is 6-8 days. So, this ensures complete control from nymphs and adults both.

Adults and nymphs killing lotions containing 1% permethrin, 0.5% malathion, pyrethrins with piperonyl butoxide (synergist) are used. Lindane shampoo is recommended that can kill both lice and eggs. Both topical lotions containing ivermectin have been used to treat the lice as recommended by US FDA. Due to the sensitivity of the genital region, an insecticidal solution should be applied. Vaseline containing pyrethrins should be used daily for several days to treat the eyelashes, but it may irritate the eyes in some patients. These chemicals can be decontaminated through sanitation, including frequent clothing changes and laundering of clothing and bedding in hot water or dry cleaning.

SAQ 3

Discuss the medical importance of pubic louse with its control.

8.5 SUMMARY

Let us summarize, what we have learn so far in this unit:

- Lice are common ectoparasites that infest the heads and bodies of humans. They can continue to exist by consuming human blood.

- Each area of the body has its lice. Humans have three types of lice: head lice, body lice (or clothing lice), and pubic lice (also called crab lice).
- The life cycle is completed in three stages: egg, nymph, and adult. Except for the size and development of reproductive organs, the lice exhibit hemimetabolism, which means that the immature stage (nymph) and adults are structurally and morphologically similar. The lice exhibit hemimetabolism, i.e., immature stage (nymph), and adults are morphologically similar in structure and shape except for the size and development of reproductive organs.
- Symptoms of lice may include intense itching, rash, visible nits or crawling irritability, sores that develop from scratching itches, pigmentation, and toughness of the skin. Lice spread most commonly by close person-to-person contact.
- Lice move by crawling. Only the body louse is known to transmit disease-causing agents. The other two, head and crab lice, can also transmit disease-causing agents under laboratory conditions.
- The lice management could be done by maintaining the sanitation and application of pediculicides.

8.6 TERMINAL QUESTIONS

1. Define the following:
 - (a) Nit
 - (b) Hemimetabolous
 - (c) Obligate parasite
 - (d) Incubation period
 - (e) Vagabond's disease
2. Distinguish between the following:
 - (a) *Pediculus humanus corporis* and *Pediculus humanus capitis*
 - (b) Male and Female body louse
3. Name the causative agents of the following disease:
 - (a) Relapsing fever
 - (b) Typhus fever
 - (c) Trench fever
4. Describe the biology and control measures of *Pediculus humanus corporis*.
5. Write a short note on the following:
 - (a) Medical importance of lice
 - (b) Control measures of head and body lice.

8.7 ANSWERS

Self Assessment Questions

1. i) Obligate, ii) Nymph, iii) Pediculosis, iv) Rickettsial, v) 5-day.
2. i) Smaller; ii) girls, boys; iii) direct; iv) Hadrian.
3. There is no evidence that public lice transmit any causative agents for any disease under natural conditions. Therefore, most of the control measures that are used against body/head louse are also effective against pubic louse. Refer to Sub-Sections 8.4.3 and 8.4.4

Terminal Questions

1. a) Female requires a blood meal for the development of eggs that are known as nits.
b) In hemimetabolans, immature nymphs hatch out from the eggs and there is no other larval stage.
c) Refer to Sub-Section 8.2.1.
d) Period required for hatching out of nymphs from eggs.
e) Vagabond's disease. A person who has no home or travels from place to place suffers from a disease transmitted by body/hair louse.
2. a) Refer to Table 8.1.
b) Refer to Subsection 8.2.1.
3. a) *Borrelia recurrentis*
b) *R. prowazekii*
c) *Bartonella quintana*
4. Refer to Sub-Section 8.2.4.
5. a) Refer to Subsection 8.2.3.
b) Refer to Subsection 8.2.4 and 8.3.4.

SUGGESTED READINGS

1. **Mike Service**, Medical entomology for students, 5th edition 2012, Cambridge.
2. **John Hall Grundy**, Arthropods of medical importance, 1st edition 1981, UK.
3. **Gary R. Mullen and Lance A. Durden**, Medical and Veterinary Entomology, 2nd edition, 2009, Academic press USA.

UNIT 9

HEMIPTERA (BUGS) AS DISEASE VECTORS

Structure

9.1 Introduction	9.5 Summary
Objectives	9.6 Terminal Questions
9.2 General description of Bugs	9.7 Answers
9.3 Types of Bugs	
Bed bug	
Reduviid bug	
9.4 Prevention and Control of Bugs	

9.1 INTRODUCTION

Bugs belong to the order Hemiptera (hemi means half and pteron: wing). It is a large group of insects of different sizes. Bugs for example scale insects, aphids, leafhoppers, cicadas etc. are very important as pests to the agriculturist. However, some of the bugs have medical importance for example Reduviid bug (family: Reduviidae) and bed bug (family: Cimicidae). Bugs belong to the superorder Hemipteroidea which is divided into two orders: order Hemiptera and order Homoptera (Refer to Unit 4: General classification of insects).

Bugs of medical importance can act both as mechanical vectors and biological vectors, for example, Reduviid bug is a biological vector for Chagas disease, the causative agent of which is *Trypanosoma cruzi*. The bed bug is a mechanical vector for diseases like typhus fever, plague, leprosy etc. (You have studied in detail about mechanical and biological vectors in Unit 5 of this course).

Objectives

After reading this unit you should be able to:

- ❖ classify and identify bugs,

- ❖ appreciate the role of bugs as mechanical and biological vectors in the transmission of diseases,
- ❖ identify bed bugs and Reduviid bugs,
- ❖ explain the life cycle of bed bug and Reduviid bug,
- ❖ apprehend Reduviid bug as biological vector, and
- ❖ discuss the prevention and control of bugs.

9.2 GENERAL DESCRIPTION OF BUGS

Classification:

Phylum : Arthropoda

Subphylum : Uniramia

Class : Insecta

Subclass : Pterygota

Division : Endopterygota

Order : Hemiptera

- There are about 50,000 to 80,000 species of true bugs that belong to the order Hemiptera for example cicadas, aphids, leafhoppers, bed bugs etc.
- True bugs have the general characteristics of insects i.e., the body of the bug consists of head, thorax and abdomen.
- The head bears a pair of antennae, a pair of compound eyes and mouthparts.
- Mouthparts of bugs are of piercing and sucking type (Refer to Unit 2). They feed on liquid food, mostly of vegetable origin. However, some like bed bugs and Reduviid bugs are parasites feeding on animal and human blood. Bugs have needle-like mouthparts to suck the blood or the liquid food of plant origin.
- Bugs have a characteristic proboscis. It is segmented and is folded backward under the head.
- Thorax is three-segmented. While feeding, the thorax is partially or fully extended. Thorax bears the wings and legs.
- Wings may or may not be present. When present, there may be two pairs of wings or one pair of wings. The wings are membranous. In the order Hemiptera, the basal part of the forewings when present, is hardened to form wing cover or elytra and the back is reflexed.
- The bugs of the family Reduviidae and Cimicidae and other Hemipterans emit an unpleasant odour which is because of the secretion of a volatile oily fluid by special scent glands.

- Bugs have incomplete metamorphosis. They are hemimetabolous insects.
- Bugs are oviparous, however, some like aphids are parthenogenetic.
- The majority of bugs are terrestrial, some are aquatic like *Belostoma* (giant water bug). The water bugs feed on aquatic insects, mosquito larvae and other dipterous larvae (Fig. 9.1).

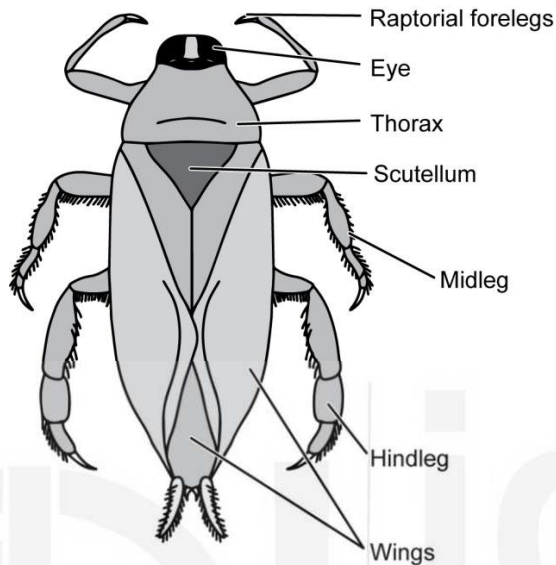


Fig. 9.1: Giant water bug (*Belostoma*)

9.3 TYPES OF BUGS

In this Section you will study about two medically important bugs viz. bed bugs and Reduviid bugs. You will study about their distribution, life cycle and identifying features in this Section. In the next Section, you will study about their prevention and control methods

9.3.1 Bed Bug

Insects are hexapods having three pairs of jointed legs, articulated to the pleura of the thorax. Each leg has 6 components. In sequence from the body, they are coxa, trochanter, femur, tibia, tarsus and pretarsus. Each is single-segmented except tarsus which usually consists of 3 to 7 segments called tarsomeres.

Cimex: Common name is bed bug

The species most commonly found in temperate regions are *Cimex lectularius* and *Cimex hemipterus*. The two species are indistinguishable by the naked eye. Physiologically also the two species resemble each other. The two can be distinguished by the close examination of the prothorax. The prothorax in the case of *C. lectularius* is semi-lunar in shape, its anterior margin has a rounded lobe on each side of the head. The lateral margins of the prothorax are thin and flat. Anterior margin of the prothorax projects lateral to the eyes. However, in the case of *C. hemipterus*, the prothorax is narrower and shorter, margins are rounded. The anterolateral margins of the prothorax only reach up to the level of the eye margins.

i. Distribution

C. lectularis is found in America, Europe, Northern India, Siberia, Northern China and Australia.

C. hemipterus is the **Indian bed bug** and is found in the tropical and sub-tropical regions. It is found in India, Burma, Sri Lanka, Malaya, South Sudan, Mauritius, West Africa and South America (Fig. 9.2).



Fig. 9.2: Distribution of Bed bugs across the world.

ii. Habit and Habitat

Bed bugs are found around human dwellings such as old buildings, hotels, beddings etc. They are attracted by the warmth and odour of humans. Although they cannot fly, they can go from one house to the other along the walls, pipes, or drains. They can climb up the ceiling and drop down on our beds. Their preferred host is humans, but they can feed on other warm-blooded animals like rodents, rabbits, bats etc. They can also feed on birds. During the day both nymphs and adults are inactive and hide in cracks and crevices, furniture, ceilings, walls, between mattresses and beds, in dark and dry places (Figs 9.3 and 9.4).



Fig. 9.3: Bed bug infestation on the mattress.



Fig. 9.4: Bed bug infestation on the wooden furniture.

iii. Identifying Features

- Dorsoventrally flattened, oval body, 5 mm long and 3 mm broad (Figs. 9.5 and 9.6).
- Chestnut brown or pale yellow in colour. After the insect has taken a blood meal, colour changes to red.
- The small, broad head is closely surrounded by the prothorax and appears as if sunk in the thorax. It bears a pair of compound eyes, two short four segmented antennae. Piercing and sucking mouthparts are present on the ventral side of the head (Refer to Unit 2).
- The proboscis (also called rostrum) lies bent beneath the thorax.
- Thorax is three-segmented—prothorax, mesothorax and metathorax. The prothorax is large and semi-lunar in shape. Metathorax is inconspicuous.
- A pair of forewings (vestigial forewings) in the form of hemielytra are present on either side of the dorsal surface of the metathorax. Hindwings are absent. These parasitic bugs are thus unable to fly (Fig. 9.5).
- There are three pairs of clawed legs, tarsi are three-segmented. Although the bugs cannot fly, they can run rapidly, especially during the warm summer months.
- The abdomen consists of 9-10 segments. Sexual organs are present on the last three segments. The aedeagus, the male copulatory organ is present on the left side of the 8th segment in the case of males.
- The last segment of the abdomen bears some hairs, is extremely small and inconspicuous.
- The tip of the abdomen is broad and round in the case of females but narrower and pointed in males.



Fig. 9.5: Dorsal view of an adult Bed bug.

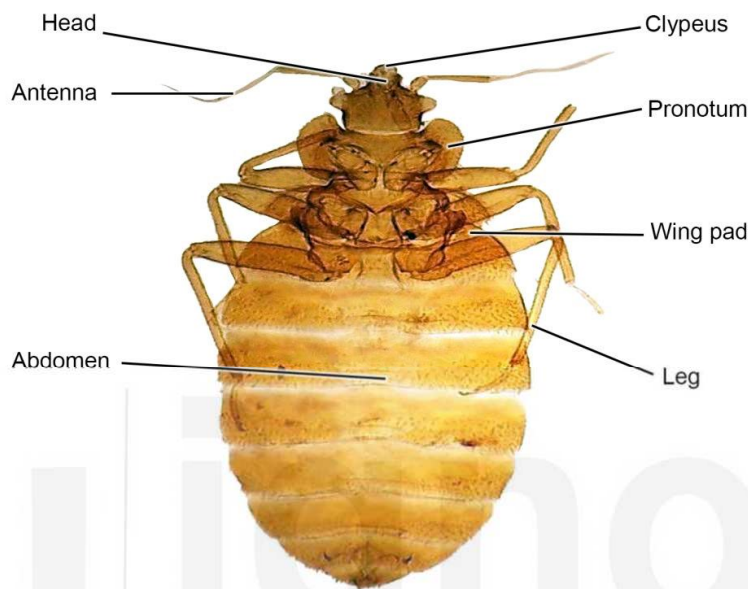


Fig. 9.6: Ventral view of the Bed Bug.

SAQ 1

State whether following statements are 'True' or 'False':

- i) Bed bugs can fly long distances when disturbed.
- ii) The organ of Berlese is present in the female bed bug to receive the spermatozoa from the male.
- iii) The aedeagus is a male copulatory organ present in the 4th segment.
- iv) Vestigial forewings in the form of hemielytra are present on the metathorax.
- v) Both the male and female bed bugs have piercing and sucking types of mouthparts.

iv. Life Cycle of Bed Bug (Fig. 9.7 a)

Bed bugs have incomplete metamorphosis. The life cycle includes the egg stage, nymph stage and adult. A female bug must take a blood meal before laying eggs. The number of eggs laid depends on the amount of blood taken by the female and the state of the male. It has been found that the female impregnated by unfed males do not produce as many eggs as females that are impregnated by males which are well nourished (Fig. 9.7b). The females can lay eggs indefinitely after one impregnation only.

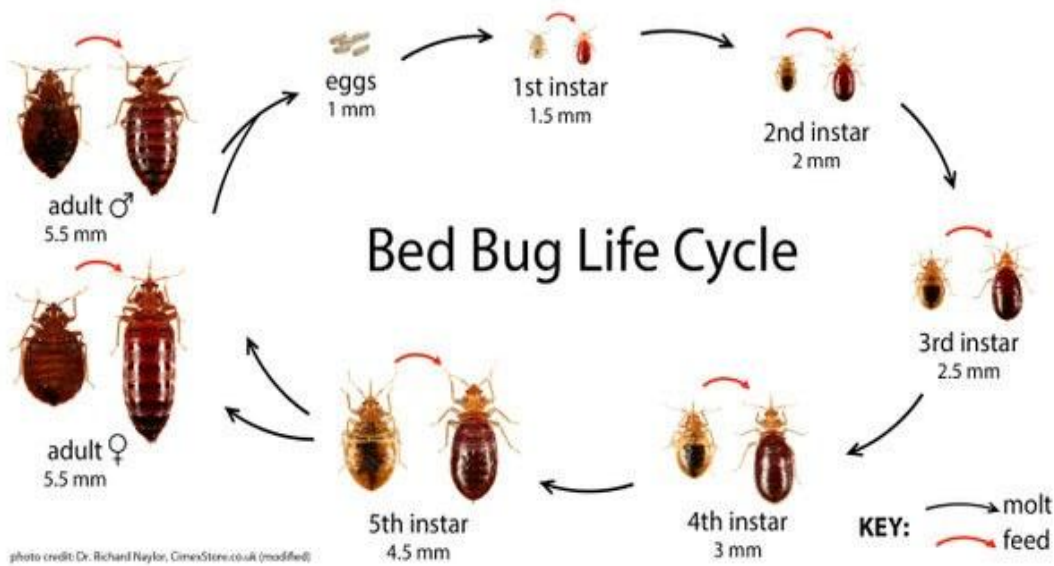


Fig. 9.7 a: Life cycle of a Bed bug.

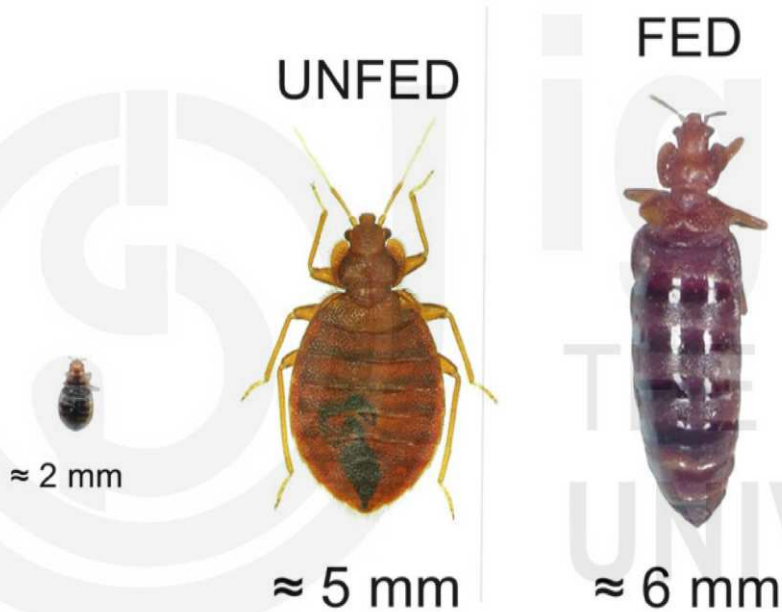


Fig. 9.7 b: View of a Fed and Unfed Bed bug.

EGGS

- Eggs are white in color and flask-shaped.
- They are laid singly in cracks and crevices, furniture, under mattress, pillows, in places well sheltered from light.
- A cap-like lid or operculum perforated by minute holes is present at one end of the egg. The other end of the egg is round.
- Eggs are laid in a mass. A single female lays about 200 eggs, 2-3 eggs per day.
- In the tropics, the incubation period is 4 to 5 days but in winters it is extended to 10 days. Temperatures between 15.5°C to 30°C are favorable for hatching. Although the eggs can survive at low temperature up to three months, hatching will not take place below 14°C .

NYMPH

- The nymphs come out by pushing off the operculum. The empty eggs with the partially attached operculum usually remain adhered in their place after hatching.
- The newly emerged eggs are semi-transparent of the size of the all-pin's head.
- Nymphs resemble adults in all respects except that they are smaller in size, paler, possess thicker antennae, stouter legs and are not sexually mature.
- Within an hour or two after emergence from the eggs, the nymph starts feeding on the human blood.
- The nymphs molt five times to become an adult. Each nymph stage lasts from 5 to 7 days. After each molt, the nymph becomes darker and larger.
- The nymph development takes 6-8 weeks but may be prolonged at low temperatures or if regular feeding is interrupted because of lack of hosts.

ADULT

- The eggs are laid six days after the last nymphal stage.
- The bed bugs are nocturnal. They hide during the daytime in holes and crevices. Although nocturnal, bed bugs can come out during the day if they are hungry.
- The bed bug can live for 5-6 months.
- Breeding occurs throughout the year.

Some Important Facts about Bed Bug

- The bed bug feeds intermittently in all stages of its life. Both the male and female bugs are biters.
- Bed bugs visit the humans only to take their blood meal. They return to their resting site after taking the blood meal to digest it.
- They may remain alive and active for months (3-4 months) in an uninhabited house without food. The bug does not moult during the starving period.
- Sometimes the starving bugs may become cannibalistic.
- Bed bugs are gregarious and found in large numbers.
- Bed bugs can be detected in the houses by the presence of live bed bugs, the castoff skin of the nymphs, empty eggshells in beddings, mattresses, cracks and crevices, furniture and their other hiding places. They can also be detected by brown or black marks on walls, bed sheets, mattresses etc. These black and brown marks are their excreta and consist of excess blood ingested during feeding. The bugs can also be detected by the unpleasant odour, but that is only in case of heavy infestation.

Feeding: When at rest, the proboscis lies bent beneath the thorax but while feeding it is pointed downwards or forward. The stylets of the mandibles make a puncture in the host's skin. Maxillary stylets then penetrate the wound. The saliva which contains an anticoagulant is poured over through a punctured wound and the blood is finally sucked up from the host's body. It takes from four to twelve minutes for the bed bug to suck the blood.

v. Dissemination

As bed bugs do not have wings, they have limited power of dispersal. Bed bugs are disseminated through personal clothing, beddings, luggage and furniture.

The medical importance of bed bugs

1. **Bite:** All persons are bitten indiscriminately on the exposed area of the skin and the bite is extremely painful and irritating to the skin (Fig. 9.8a). No sensation is felt when the bed bug is biting but immediately afterwards there is itching. Although bed bug can feed on any warm-blooded animal but it prefers to bite human beings. The bite causes redness, inflammation and irritation. The other health effects include psychological effects and allergic symptoms. This may cause a loss of sleep. Their bite may lead to secondary infection by micro-organisms.



Fig. 9.8 (a): View of the Bed bugs biting.



Fig. 9.8 (b): View of the signs of Bed bug bites.

2. The stinking odour of bugs becomes unbearable and irritating (Fig. 9.8b).
3. **Diseases:** Bed bugs are not known to cause any disease but act as a mechanical vector of many diseases such as kala azar, relapsing fever, plague and typhoid. It has been suggested that the bed bug allergens may be responsible for asthmatic reactions. Experiments have suggested that bed bugs could be vectors of hepatitis B. DNA of hepatitis B has been detected in bed bugs and their excrement up to six weeks after their infected blood meal. However, it has not been accepted by many scientists and more research is needed to establish the fact.

vi. Prevention and Control

- Heat treatment of houses. A temperature of 50°C for an hour can kill the bed bugs. The low temperature of -17°C for two hours can also kill the bugs.
- A sprinkling of boiled water kills them.
- Fumigation of infested houses, furniture etc. with sulphur can reduce bed bug infestation.
- Spraying petrol or an emulsion of kerosene, benzene and petrol helps in reducing the infestation or exterminating bed bugs.
- Regularly wash and dry the mattresses, beddings etc. at high temperatures.

SAQ 2

Fill in the blanks:

- i) The life cycle of hemimetabolous insects includes the egg stage, _____ stage, and the adult.
 - ii) Bed bugs are _____ vectors.
 - iii) The stylets of the _____ make a puncture in the host's skin.
 - iv) Fumigation of infested houses, furniture etc. with _____ can reduce the bed bug infestation.
 - v) Bed bugs bite during the _____ time.
-

9.3.2 Reduviid Bug

Reduviid bug, Genus *Triatoma*

Commonly called cone-nose bugs, assassin bugs or kissing bugs.

Reduviid bugs belong to the Family: Reduviidae; Sub-family: Triatominae.

The sub-family Triatominae includes all those Reduviid bugs that are parasites, feeding on vertebrates. *Rhodnius*, *Neotriatoma*, *Triatoma*, *Panstrongylus*, *Paratriatoma* are some of the important genera of medical importance. All these genera are inhabitants of Central and North America and West Indies. However, *Rhodnius prolixus*, *Triatoma infestans*, *T. maculata* and *T. dimidiata* occur more widely. These bugs act as biological vectors for the transmission of Chagas disease. You will study about Chagas disease later in this Unit.

Chagas endemic countries are shown in Fig. 9.9.

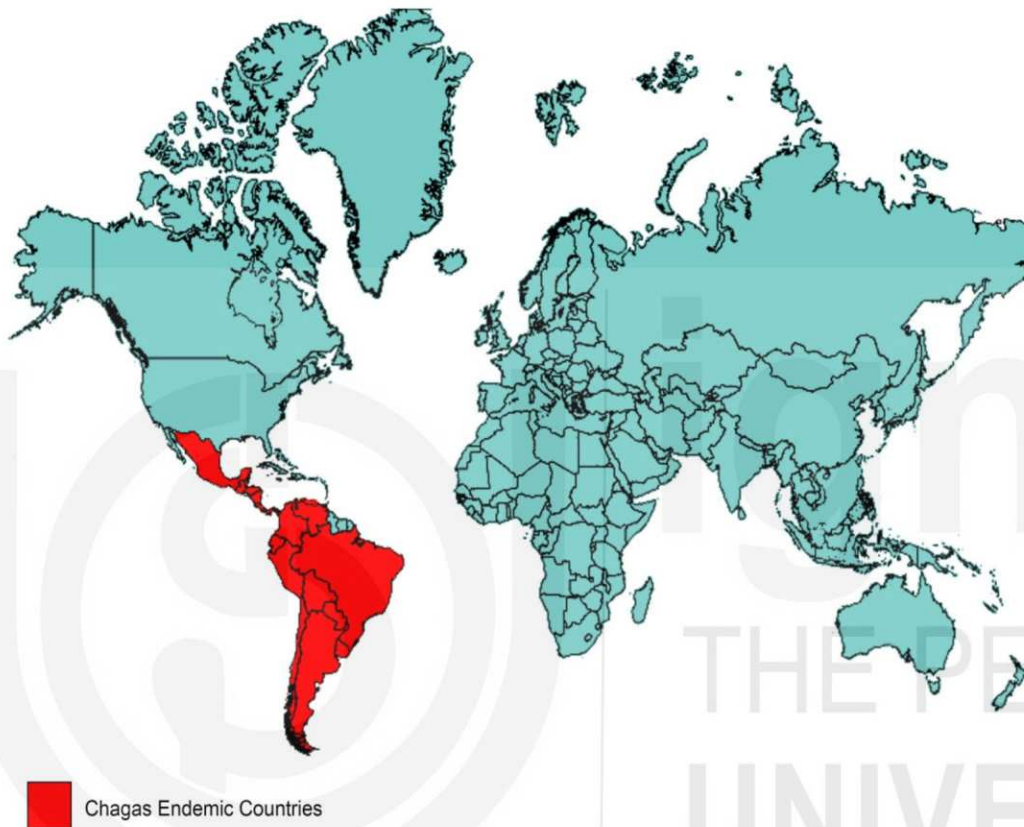


Fig. 9.9: Chagas endemic countries of the world.

They are terrestrial insects, larger than bed bugs found in almost all parts of the world. During day time, these bugs have a habit of hiding in tree holes, tree nests, crevices and other places where warm-blooded animals live. In human habitations, they prefer dark and sheltered places, cracks and holes in walls, crevices, mud walls and thatched roofs etc. They are often attracted by light to human habitations and enter houses at night. The Reduviid bugs come out during the night to feed.

i. Identifying features of Triatominae bugs

- Large bugs about 25 mm or more in length, dull brownish-black in color although some species are more colorful having yellow or red bands on the pronotum, basal part of the forewings or margins of the abdomen.
- They have elongated bodies. The head is elongated, protruded in the form of a snout. Head bears a pair of prominent dark-colored eyes.
- The Head is blackish-brown in color.

Do you know how the three medically important genera can be differentiated?

Triatoma: Short head, antennae situated half way along the head.

Rhodnius: Head relatively long, antennae situated near the end of the head.

Panstrongylus: Relatively short head, antennae present close to the eyes.

Interesting Fact:

Some of the bugs of Reduviidae family feed on plants and some are predators of small insects.

- Antennae are 4 segmented, larger than the bed bug antennae. The antennae are present on the side of the head, inserted midway between the eyes and the tip of the snout.
- Proboscis (also called rostrum) is short, 3 segmented, distal end lies on the prosternum. The proboscis lies closely appressed to the ventral surface of the head.
- Thorax is three-segmented (prothorax, mesothorax and metathorax). The pronotum is conspicuous and triangular while the mesothorax and metathorax are hidden dorsally by the folded forewings (hemelytra). The distal part of the hemelytra is membranous while the basal part is hard and thick. The hindwings are membranous and remain hidden beneath the hemelytra at rest.
- Thorax has three pairs of long and slender legs, tarsus is 3 segmented.
- The abdomen is oval. Except for the lateral margins, the abdomen is covered by the wings. The lateral edges of the abdomen are flattened.
- The tip of the abdomen of the female is broader than the males. Males have a slight bulge on the undersurface near the tip of the abdomen.
- Although insects have wings, they cannot fly far (Fig. 9.10).



Fig. 9.10: A view of a Reduviid bug (*Triatominae* bug).

ii. Life Cycle

The life cycle extends over several weeks. Both the sexes are bloodsuckers and all the stages of the bug feed on the blood of warm-blooded animals including humans. The females take more blood than the males. When the *Triatominae* takes a blood meal, the proboscis is pressed forward and downwards. Bugs are hemimetabolous insects. Their life cycle includes the egg stage, the nymphs and the adult stage.

Adults that appear in spring, lay eggs during the summer months. These bugs pass the winter as developing nymphs and become adults in the following spring. A female can lay 50 to 800 eggs during its lifetime depending on the species in dark and sheltered places, cracks and holes in walls, crevices, mud walls and thatched roofs etc., in or near the habitations of its hosts. A female Reduviid bug requires a good blood meal to lay eggs. The number of eggs laid thus depends on the number of blood meals that a female takes. Eggs are laid 2 to 4 weeks after the emergence of the adult.

EGGS

- The eggs are oval, elongate and whitish in color when laid. As they mature, the color changes to yellow, pink and finally red depending on the species.
- The mature eggs are smooth and shiny.
- Eggs are about 1.5 mm - 2.5 mm long.
- One end of the eggs has an operculum through which the first instar nymphs emerge.
- The eggs may be laid in small batches which may be glued to the substrate or they may be laid singly either free or adhered to the substrate. This would vary from species to species.
- The incubation period of the eggs is 7 to 15 days and may extend to 60 days depending on the temperature.

NYMPHS

- Nymphs resemble adults in all respects except that they are smaller in size, without wings and are not sexually mature.
- Like adults, they too feed on the blood of warm-blooded animals. The newly emerged nymphs remain hidden for a few days in cracks and crevices before they start feeding on the blood of animals.
- Nymphs are pale in colour.
- Nymphs molt four times before they become adults. Thus, they have five nymphal instars. The nymphs must take a good blood meal before molting.
- Rudimentary wing pads appear in the fourth and the fifth nymphal instars but fully developed functional wings appear only in the adults.
- The young nymphs are voracious feeders and can ingest blood ten times their weight. The fourth and fifth instars, however, ingest only three to four times their weight of blood. The adults feed even less. They ingest only two to three times of their weight of blood. Sometimes, if the nymphs and adults do not find a suitable host to ingest blood, they pierce the swollen abdomen of engorged nymphs and take a blood meal without harming the nymph.
- Both nymphs and adults are nocturnal and feed during the night. They feed on any exposed part of the body.

The life cycle is completed in one to two years or may be a little more and during this period the bug feeds 20 times. At 37°C however, the life cycle is completed in 90 to 120 days (3 to 6 months) (Fig. 9.11).

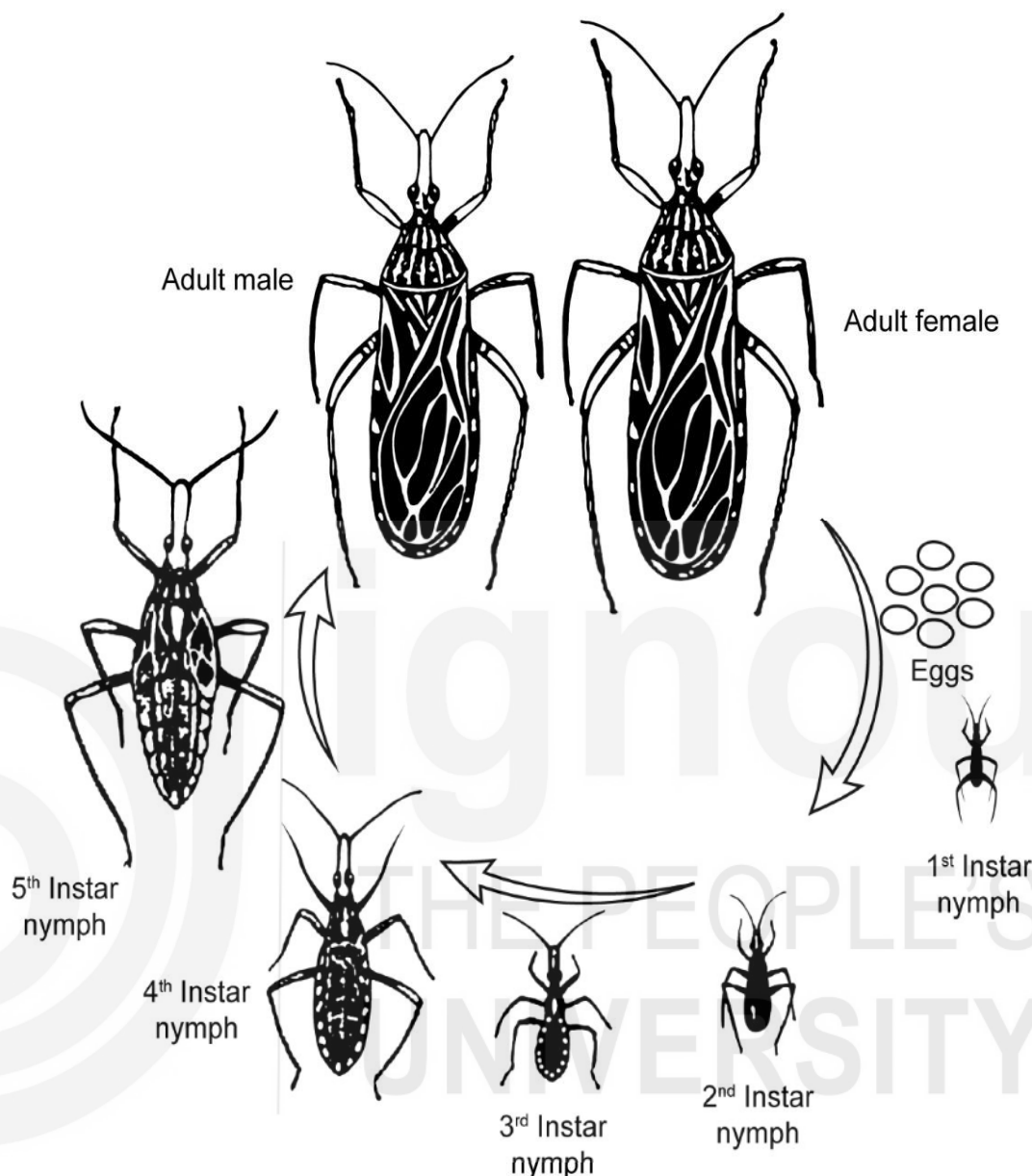


Fig. 9.11: The life cycle of a Reduviid bug (Triatominae bug).

iii. Importance of Reduviid Bugs

Bite: Bite is painless. One feels the discomfort only after some time. They are known as kissing bugs as they bite the soft tissues around the lips and eyes of sleeping humans. The parasite enters the human body through the mucus membrane or open wound caused by its bite.

iv. Reduviid bugs as biological vectors

Reduviid bugs are responsible for transmitting *Trypanosoma cruzi*, the causative agent of Chagas disease sometimes referred to as American trypanosomiasis. This is a zoonotic disease. Chagas disease is commonly found in Central and South America and Southern United States. However, now it can be found in other parts of the world also because of the relocation of the people of endemic areas.

Trypanosoma is ingested by the bug during its blood meal from an infected host. Further development of the parasite takes place in the intestine of the bug. In about 8-20 days the trypanosomes change their form and multiply by binary fission to form the infective metacyclic trypomastigotes. These infective metacyclic trypomastigotes are present in the lumen of the large intestine. A large number of infective forms of trypanosomes (metacyclic trypomastigotes) soon reach the rectum and are voided out along with the feces of the bugs. The Trypanosomes continue to appear in the feces of the bugs more than two months after their feeding on infected monkeys. Sometimes the bugs may remain infected for two years. It is interesting to note here that the excreta is voided out by the bug while feeding or soon after feeding.

Humans and other animals get the infection by crushing the infected feces of the bug on the open wound or when these infected feces accidentally get rubbed on mucus membranes of the mouth, nose or eyes. Infection may also be acquired by eating infected bugs.

It may be emphasized here that the transmission of the parasite is not by the bite of the bug but is through the infected feces of the bug.

Animals acquire the infection in the same manner as human beings.

Rhodnius, *Neotriatoma*, *Triatoma*, *Panstrongylus*, *Paratriatoma* are some of the important genera that can transmit Chagas disease. In general, species that live in close association with humans, regularly feed on them are important vectors of *Trypanosoma cruzi*.

The efficacy of any species of the Reduviid bug as a vector of Chagas disease will depend upon:

- The rapidity with which the bug defecates after feeding.
- Length of the time the bug spends feeding.
- Exposed to the risk of being crushed by the host.

Chagas disease is zoonotic. *Trypanosoma cruzi* is a parasite of wild warm-blooded animals, like rats, mice, monkeys, squirrels, bats, opossums etc. These animals thus act as a reservoir of infection for man. Bug too acts as a reservoir of infection and in some areas, humans too are the reservoir for infection (Fig. 9.12). There is currently no vaccine for Chagas disease.

v. Symptoms of Chagas disease

Symptoms of Chagas disease includes both acute and chronic conditions. The acute phase of the Chagas disease is often symptoms free but mild symptoms may include Swelling at the infection site, Fever, Fatigue, Body aches, Rash, Eyelid swelling, Headache, Nausea, diarrhea or vomiting, Swollen glands whereas Chronic Phase may include Irregular heartbeat, Heart failure, Sudden cardiac arrest, Difficulty swallowing due to enlarged esophagus, Stomach pain or constipation due to enlarged colon.

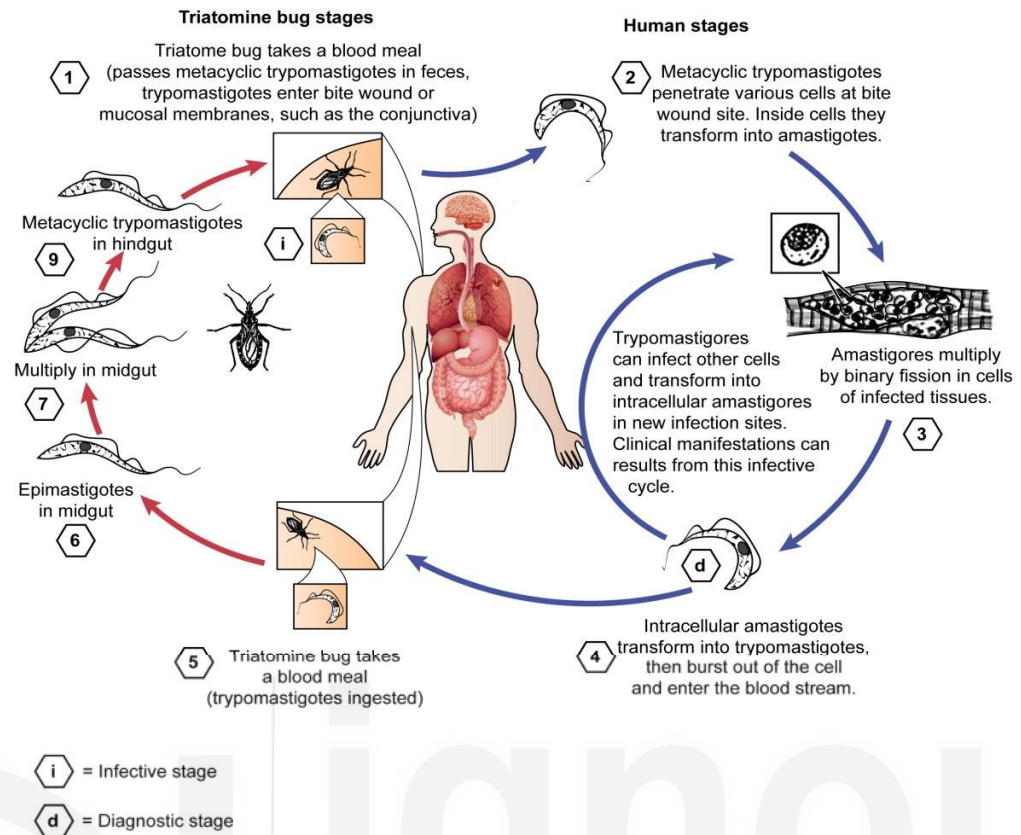


Fig. 9.12: The life cycle of protozoan parasite, *Trypanosoma cruzi* that causes Chagas disease that can be transmitted to humans by blood-sucking triatomine bugs.

vi. Method of transmission

- Feces of the bug carry the largest number of trypomastigote forms of *Trypanosoma*. Humans get the infection by crushing the infected feces onto the open wounds or when these infected feces accidentally get rubbed on mucus membranes of the mouth, nose or eyes.
- By eating infected bugs.
- Transplacentally.
- Organ transplantation from infected persons.
- Blood transfusion from infected persons.
- Infected food and drinks.

vii. Prevention of Reduviid Bugs

- By maintaining good hygiene and sanitation.
- Sealing all cracks and crevices around windows, in walls, roofs and other entry places to the house. Improved housing infrastructure by replacing the thatched and mud houses with bricks and cement.
- If there are pets in the house then their proper hygiene should be maintained. Their sleeping area should be kept neat and clean.
- Educating the people about the parasite and maintaining hygiene.

viii. Control of Reduviid Bugs

Applying residual insecticides to the walls and roofs of the house. A formulation of water-dispersible powder of 1.25% Lindane applied at the rate of 0.5g/m² is very effective. Dieldrin (2.5%) at a dosage of 1.0g/m² is also effective. Other insecticides that can also be used are propoxur and malathion.

However, house spraying will only keep a check on bugs present indoors. Bugs resting in natural outdoor habitats and shelters will not be killed. It is these outdoor populations of bugs that are important in the transmission of *T. cruzi* and thus causing Chagas disease.

SAQ 3

State whether the following statements are 'True' or 'False':

- i) Triatominae bugs are also known as kissing bugs as they bite on the face and lips.
- ii) Reduviid bugs are nocturnal.
- iii) Wings are absent in Reduviid bugs.
- iv) Proboscis lies closely appressed to the dorsal surface of the head.
- v) Both the nymphs and the adult Triatominae bugs are bitters.
- vi) The causative agent of Chagas disease is Reduviid bug.

9.4 PREVENTION AND CONTROL OF BUGS

- Bugs are strong and tough (resilient) insects that are difficult to control.
- Pyrethroids, dichlorvos and malathion are found to be effective insecticides in controlling bugs.
- By maintaining good hygiene and sanitation.
- Sealing all cracks and crevices around windows, in walls, roofs and other entry places to the house.
- Heat treatment of houses.
- Fumigation of houses with an effective fumigant. Hydrogen Cyanide (HCN) is found to be a good fumigant for controlling bugs. Care should be taken to keep the doors and windows of the house open for at least 48 hours so that the fumes of the poisonous gas are not there in the house.
- If there are pets in the house, then their proper hygiene should be maintained. Their sleeping area should be kept neat and clean.
- Educating the people about the hygiene and management of the pests is important to keep the bugs under control.

9.5 SUMMARY

After studying this Unit, you have learnt that:

- Bugs belong to the order Hemiptera.
- Mouthparts are of piercing and sucking type. They feed on liquid food, mostly of vegetable origin. However, some like bed bugs and Reduviid bugs are parasites feeding on animal and human blood.
- Bed bug and Reduviid bug are two medically important bugs that live in close association with human habitation. Reduviid bug is a biological vector for Chagas disease, the causative agent of which is *Trypanosoma cruzi*. The bed bug is a mechanical vector for diseases like Kala azar, Relapsing fever, Typhoid, Plague etc. Its allergens may be responsible for asthmatic reactions. It may be a mechanical vector for Hepatitis B.
- The species of bed bug most commonly found in temperate regions are *Cimex lectularius* and *Cimex hemipterus*.
- Vestigial forewings in the form of hemielytra are present one on either side of the dorsal surface of the metathorax of bed bugs. Hindwings are absent.
- These parasitic bugs cannot fly. Although the bugs cannot fly, they can run rapidly, especially during the warm summer months.
- Organ of Berlese, a blind copulatory pouch is a characteristic feature of the female bed bugs. Its function is to transfer the spermatozoa into the female body.
- The bed bugs possess three pairs of clawed legs.
- The bed bug feeds intermittently in all stages of its life. Both the male and female bugs are biters.
- Bed bugs do not stay on the human body. They visit them only to suck their blood. They may remain alive and active for months in an uninhabited house without food. Sometimes the starving bed bugs may become cannibalistic.
- The bed bug does not molt during the starving period.
- Bed bugs are gregarious and found in large numbers.
- Reduviid bugs are commonly known as cone-nose bugs, assassin bugs or kissing bugs.
- The Reduviid bugs have folded forewings in the form of hemielytra. The hindwings are membranous and remain hidden beneath the hemielytra at rest.
- Except for the lateral margins, the abdomen of the Reduviid bug is covered by the wings. Although winged bugs, they cannot fly far.
- Reduviid bugs are responsible for transmitting *Trypanosoma cruzi*, the causative agent of Chagas disease sometimes referred to as American trypanosomiasis.

- Chagas disease is a zoonotic disease.
- Incomplete metamorphosis is found in all the hemipterans. The life cycle includes the egg stage, nymph stage and adult stage. Both nymphs and adults are nocturnal. They feed on any exposed part of the body.
- Bugs are oviparous.
- The bed bugs and Reduviid bugs emit an unpleasant odour which is because of the secretion of a volatile oily fluid by special scent glands.
- Bugs are resilient insects that are difficult to control.
- Pyrethroids, dichlorvos and malathion are found to be effective insecticides in controlling the bugs.
- Sealing all cracks and holes at all entry places to the house. Heat treatment of houses and fumigation of houses with an effective fumigant are the thermal and chemical methods for controlling the bugs.

9.6 TERMINAL QUESTIONS

1. Explain the life cycle of a bed bug only with the help of diagrams.
2. How can the bed bugs be disseminated?
3. Give the salient/identifying features of Triatominae bugs.
4. Explain the role of Reduviid bug as a biological vector in the transmission of Chagas disease.
5. What preventive measures will you take for controlling the bed bugs from entering your house.

9.7 ANSWERS

Self Assessment Questions

1. i) False ii) True iii) False iv) True v) True.
2. i) Nymph ii) Mechanical iii) Mandibles iv) Sulphur v) Night.
3. i) True ii) True iii) False iv) False v) True v) False.

Terminal Questions

1. Refer to Section 9.3.1.
2. Refer to Section 9.3.1.
3. Refer to Section 9.3.2.
4. Refer to Section 9.3.2.
5. Refer to Section 9.3.2.

Acknowledgements of Figures

Fig. 9.3: <https://www.health.ny.gov/environmental/pests/bedbugs.htm>

Fig. 9.4: <https://upload.wikimedia.org/wikipedia/commons/5/56/Bedbugs1.jpg>

Fig. 9.5: https://en.wikipedia.org/wiki/Bed_bug

Fig. 9.6: <https://www.bedbugs.org/the-history-of-bed-bugs>

Fig. 9.7a: <https://ppld.org/bed-bug-faq-and-guidelines>

Fig. 9.7b: <https://samedaypestaway.com/same-day-pest-away/ny-exterminators/bed-bug-exterminators-nyc/>

Fig. 9.8a: <http://www.cuyahogabedbugs.org/>

Fig. 9.8b: https://en.wikipedia.org/wiki/Bed_bug

Fig. 9.9: <http://www.infectionlandscapes.org/2011/04/trypanosomiasis-part-2-chagas-disease.html>

Fig. 9.10: <http://rdparasites.blogspot.com/2017/02/reduviid-bug-bug-that-transmits.html>

Fig. 9.11: <http://www.kelmacmedical.us/infectious-diseases/vector-life-cycle-strategies.html>

Fig. 9.12: <https://www.cdc.gov/parasites/chagas/biology.html>

