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

— রবীন্দ্রনাথ ঠাকুর

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

— Subhas Chandra Bose

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

— সুভাষচন্দ্র বসু

Price : ₹ 250.00

(NSOU-র ছাত্রছাত্রীদের কাছে
বিক্রয়ের জন্য নয়)

Published by : Netaji Subhas Open University, DD-26, Sector-1, Salt Lake City, Kolkata-700 064 and
Printed at : Royal Hlaftone Co., 4, Sarkar Bye Lane, Kolkata-700 007

CBCS • UG • ZOOLOGY • (HZO) • GE – ZO – 31

NETAJI SUBHAS OPEN UNIVERSITY

Under Graduate Degree Programme
Choice Based Credit System (CBCS)

SELF LEARNING MATERIAL

ZOOLOGY
[HZO]

Insect, Vector and Disease

GE – ZO – 31

PREFACE

In a bid to standardise higher education in the country, the University Grants Commission (UGC) has introduced Choice Based Credit System (CBCS) based on five types of courses viz. *core, discipline specific, generic elective, ability* and *skill enhancement* for graduate students of all programmes at Honours level. This brings in the semester pattern, which finds efficacy in sync with credit system, credit transfer, comprehensive continuous assessments and a graded pattern of evaluation. The objective is to offer learners ample flexibility to choose from a wide gamut of courses, as also to provide them lateral mobility between various educational institutions in the country where they can carry acquired credits. I am happy to note that the University has been accredited by NAAC with grade 'A'.

UGC (Open and Distance Learning Programmes and Online Learning Programmes) Regulations, 2020 have mandated compliance with CBCS for U.G. programmes for all the HEIs in this mode. Welcoming this paradigm shift in higher education, Netaji Subhas Open University (NSOU) has resolved to adopt CBCS from the academic session 2021-22 at the Under Graduate Degree Programme level. The present syllabus, framed in the spirit of syllabi recommended by UGC, lays due stress on all aspects envisaged in the curricular framework of the apex body on higher education. It will be imparted to learners over the *six* semesters of the Programme.

Self Learning Materials (SLMs) are the mainstay of Student Support Services (SSS) of an Open University. From a logistic point of view, NSOU has embarked upon CBCS presently with SLMs in English / Bengali. Eventually, the English version SLMs will be translated into Bengali too, for the benefit of learners. As always, all of our teaching faculties contributed in this process. In addition to this we have also requisitioned the services of best academics in each domain in preparation of the new SLMs. I am sure they will be of commendable academic support. We look forward to proactive feedback from all stakeholders who will participate in the teaching-learning based on these study materials. It has been a very challenging task well executed, and I congratulate all concerned in the preparation of these SLMs.

I wish the venture a grand success.

Professor (Dr.) Subha Sankar Sarkar

Vice-Chancellor

Netaji Subhas Open University

Undergraduate Degree Programme

Choice Based Credit System (CBCS)

Subject : UG Zoology (HZO)

Course : Insect, Vector and Disease

Course Code : GE - ZO - 31

First Print : June, 2022

Printed in accordance with the regulations of the
Distance Education Bureau of the University Grants Commission.

Netaji Subhas Open University

Undergraduate Degree Programme

Choice Based Credit System (CBCS)

Subject : UG Zoology (HZO)

Curse : Insect, Vector and Desease

Course Code : GE - ZO - 31

: Board of Studies :

Members

: Course Writer :

Dr. Kamalesh Kumar Mishra
Rtd. Associate Professor,
Rishi Bankim Chandra College

: Course Editor :

Prof. Samiran Chakraborty
Rtd. Professor,
Kalyani University

: Format Editor :

Dr. Sanjay Mandal and Mr. Ashif Ahamed
NSOU

Notification

Kishore Sengupta
Registrar

Netaji Subhas Open University

UG : Zoology

(HZO)

Curse : Insect, Vector and Desease

Course Code : GE - ZO - 31

GE-ZO-31
Generic Elective
Insect Vector and Diseases
(Theory)

Unit 1 ❑ Introductrion to insects. General features of insects, morphological features, head-eyes, types of antennae, mouthparts with respect to feeding havits.

Structure

1.0 Objectives

After studying this unit, learners will be able to understand the following :

- General features of insects.
- Morphological features of insects and its body parts.
- Different types of mouthparts of insects according to its feeding habits.

1.1 Introduction

Insects or Insecta are hexapod non-chordates and the largest group within the phylum arthropod. Insects have segmented bodies, jointed legs, and external chitinous skeletons (exoskeletons). They are distinguished from other arthropods by their body, which is divided into three major regions: (1) the head, which bears the mouthparts, eyes, and a pair of antennae, (2) the three segmented thorax, which usually had three pairs of legs (hence "Hexapoda") in adults and usually one or two pairs of wings, and (3) the many-segmented abdomen. Insects are the most diverse group of animals; they include more than a million described species and represent more than half of known living organism.

In a popular sense "insect" usually refers to famillíar pests or disease carriers, such as bedbugs, houseflies, clothes moths, Japanese beetles, aphids, mosquitoes, flease, horseflies and hornets, or to conspicuous groups, such as butterflies, moths, and beetles. Many insects, however, are beneficial from a human viewpoint; they pollinate plants, produce useful substances, control pest insects, act as scavengers, and serve as food for other animals (*see below* Importance). Furthermore, insects are valuable objects of study in elucidating many aspects of biology and ecology. Much of the scientific knowledge of genetics has been gained from fruit fly experiments and of population biology from flour beetle studies. Insects are often used in investigations of hormonal action, nerve and sense organ function, and many other physiological processes. Insects are also used as environmental quality indicators to assess water quality and soil contamination and are the basis of many studies of biodiversity. Insects have recently been used the the forensic investigations.

1.2 General features

In numbers of species and individuals and in adaptability and wide distribution, insects are perhaps the most eminently successful group among all animals. They dominate the present- day land fauna with about 1 million described species. This represent about three-fourths of all described animal species. Entomologists estimate the actual number of living insect species could be as high as 5 million to 10 milion. The orders that contain the greastest numbers of species are Coleoptera (beetles), Lepidoptera (butterflies and moths), Hymenoptera (ants, bees, wasps), and Diptera (true flies).

- Insects possess an exoskeleton or a hard, shell-like covering on the outside of its body.
- Insects have three main body parts: head, thorax, and abdomen.
- Insects have a pair of antennae on top of their heads.
- Insects have three pairs of legs.
- Most have 2 pairs of wings (a few insects, such as spring-tails, silver fishes don't usually have wings; some insects, such as flies, only have 1 pair of wings and in some insects wings have secondarity)

1.3 Morphological features, head-eyes, types of antennae

Insect's morphology is the study and description of the physical form of insects, Head-eyes, types of antennae, mouth parts with respect to feeding habits.

The head of an insect is composed of mainly rigid sclerites or sclerotized 6 segments. The insect head contains the compound eyes, simple eyes (ocelli), mouthparts, and antennae.

In most insects there is one pair of large, prominent compound eyes composed of units called ommatidia. There may be up to 30,000 ommatidia in a compound eye. This type of eye gives less resolution than the vertebrate eye, but it gives acute perception of movement. When present, ocelli (either 2 or 3), detect low light or small changes in light intensity.

Mouthparts

The 4 main mouthparts are the labrum, mandibles, maxillage (plural maxilla) and labium. The labrum is a siimple fused sclerite, often called the upper lip, and moves longitudinally. It is hinged to the clypeus. The mandibles, or jaws, are highly sclerotized paired structures that move at right angles to the body. They are used for biting, chewing and severing food. The maxillae are paired structures that can move at right angles to the body and possess segmented palps. The labium (often called the lower lip), is a fused structure that moves longitudinally and possesses a pair of segmented palps. Mouthparts vary greatly among insects of different orders but there are tow main functional groups : mandibulate and haustellate. Show above and below are mandibulate (chewing) mouthparts. Haustellate mouthparts can be further classified as piercing-sucking, sponging, and siphoning.

Mandibulate (chewing) mouthparts are used for biting and grinding solid foods.

Haustellate mouthparts are primarily used for sucking liquids and can be broken down into two subgroups: those that possess stylets and those that do not. Stylets are needle-like projections used to penetrate plant and animal tissue. The modified mandibles and maxilla from the stylets and the labium as feeding tube. After piercing solid tissue, insects use the modified mouthparts to suck liquids from the host. To the left is a diagram of cicada mouthparts. Some haustellate mouthparts lack stylets. Unable to pierce tissues, these insects must rely on easily accessible food sources such as nectar at the base if a flower. One example of nonstylate mouthparts are the long siphoning proboscis of butterflies and moths (Lepidoptera). Although the method of liquid transport differs from that of a lepidopteran proboscis, the rasping-sucking rostrum of some flies are also considered to be haustellate without stylets. Piercing-sucking mouthparts are used to penetrate solid tissue and then suck up liquid food. Example: bugs (order Hemiptera), sucking lice (order Phthiraptera), stable flies and mosquitoes (order Diptera).

Sponging mouthparts are used to sponge and suck liquids. Examples: House flies and blow flies (order Diptera).

Structure	Function
Labrum	A single plate that forms the 'upper lip' of sorts. It's used to protect the other mouthparts and bring food into the mouth.
Mandibles	A set of jaws that move laterally, meaning side-to-side.
Maxillae	A second set of smaller, segmented claws that are used to anipulate food for the insect.
Labium	Afused structure that's essentially the 'lower lip.' This mouth part is used to close the mouth.

Antennae

Antennae function almost exclusively in sensory perception. Some of the information that can be detected by insect antennae includes: motion and orientation, odor, sound, humidity, and a variety of chemical cues. Antennae very greatly among insects, but all follow a basic segments (flagelliomeres) are jointly called the flagellum. In the basis of structure antenned may be of the fllowing types :

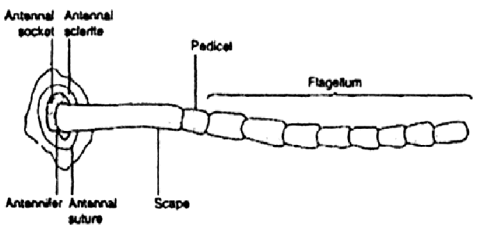

Figure 1.3.1. Structure of a typical antenna

Aristate antennae are pouch-like with a lateralbristle. Examples: House and shore flies (order Diptera).

Capitate atennae are abruptly clubbed at the end. Examples: Butterflies (order Lepidptera).

Clavate Antennae are geradually clubbed at the end. Examples: Carrion beetles (order Coleoptera). Adult carrion beetles feed on decaying animal matter or maggots.

Filiform antennae have a thread-like shape. Examples: Ground and long horned beetles (Coleoptera), cockroaches (order Blattaria).

Geniculate antennae are hinged or bent like an elbow. Examples: Bees and ants (order Hymenoptera).

Lamellate or clubbed antennae end in bested plates. Examples: Scarab beetles (order Coleoptera).

Moniliform have a bead-like shape. Examples : Termites (order Isoptera).

Pectinate antennae have a feather-like shape. Examples: Fire-colored beetles and fireflies (order Coleoptera).

Plumose antennae have a feather-like shape. Examples: Moths (order Lepidoptera) and mosquitoes (Order Diptera).

Serrate antennae have a saw-toothed shape. Examples: Click beetles (order Coleoptera).

Setaceous antennae have a bristle-like shape. Examples: Dragonlfies and dameselflies (order Odonata).

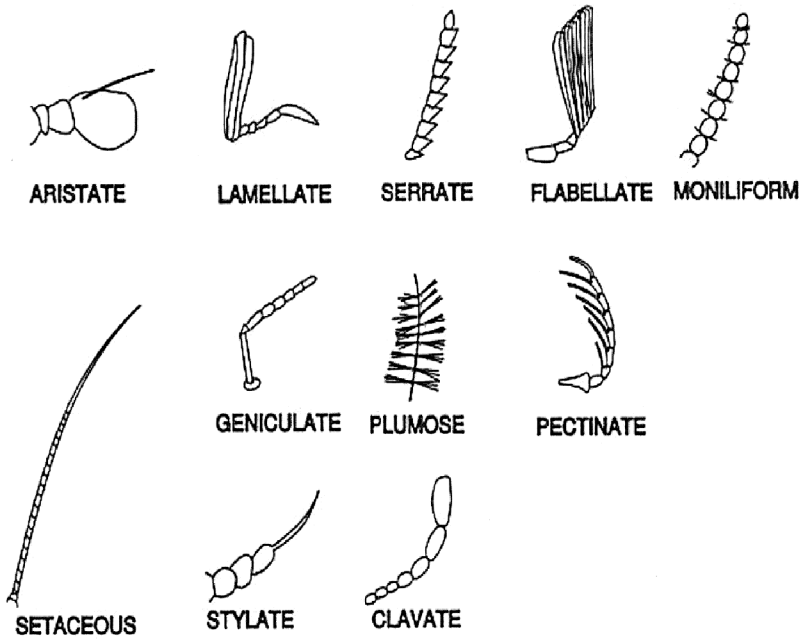

Figure. 1.3.2. Diagram of different types of antennae.

1.4. Mouthparts with respect to feeding habits

A. Biting and Chewing :

This type of mouth parts are supposed to be the most primitive type as the other types are believed to be evolved from biting and chewing type of mouth parts. These consist of the labrum forming upper lip, mandibles, first maxillae, second maxillae forming lower lip, hypo-pharynx and the epipharynx.

The labrum is median, somewhat rectangular flap-like. The mandibles are paired and bear toothed edges at their inner surfaces; they work transversally by two sets of

muscles to masticate the food. The first maxillae are paired and lie one on either side of the head capsule behind the mandibles. Each possesses a five-jointed maxillary palp which is a tactile organ. The first maxillae help in holding the food. The second maxillae are paired but fused to form the lower lip. Its function is to push the masticated food into the mouth. The hypopharynx is single median tongue-like process at whose base the common salivary duct opens. The epipharynx is a single small membranous piece lying under the labrum and bears taste buds.

This type of mouth parts are found in orthoptern insects like cockroaches, grasshoppers, crickets, etc. These are also found in silver fish, termites, earwigs, beetles, some hymenopterans and in caterpillars of Lepidoptera.

B. Chewing and lapping:

This type of mouth parts are modified for collecting the nectar and pollen from flowers and also for moulding the wax, as is found in honeybees, wasps, etc. They consist of the labrum, epipharynx, mandibles first pair of maxillae and second pair of maxillae.

The labrum lies below the clypeus, below the labrum is a fleshy epipharynx which is an organ of taste.

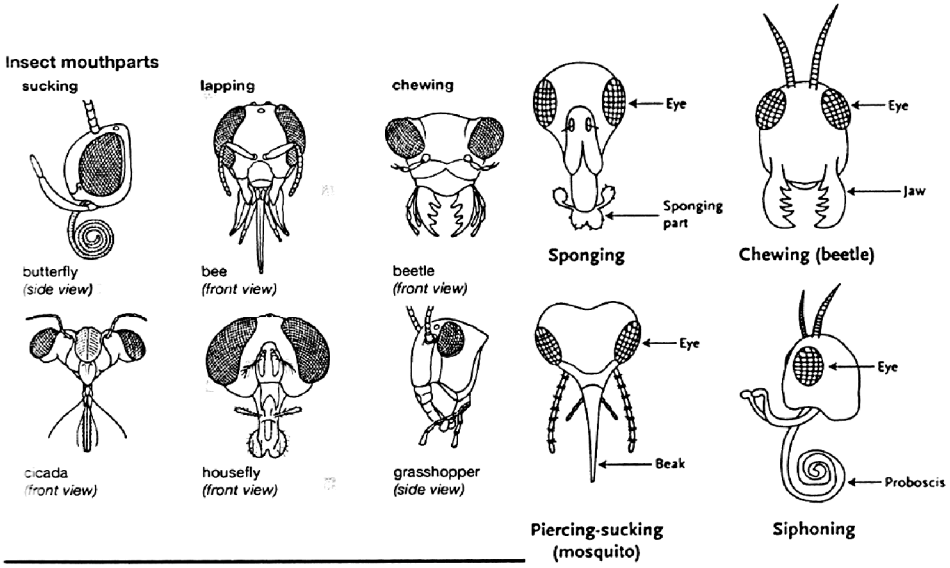

Figure 1.4.1 Diagrammatic view of various types of insect mouthparts.

Mandibles are short, smooth and spatulated, situated one on either side of the labrum; used in moulding wax and making the honeycomb. The labium (second pair

of maxillae) has reduced paraglossae, the glossae are united and elongated to from the so called retractile tongue, at its tip is a small labellum or boney spoon. The labial palps are elengated. The glossa is used for gathering honey and it is an organ of touch and teste. The first pair of maxillae are placed at the sides of labium, they bear small maxillary palps, lacinia is very much reduced but galea are elongated and blade-like. The galea and labial palps form a tube enclosing the glossae which moves up and down to collect nectar from flower nectaries. The nectar is sucked up through the tube, so formed, by the pumping action of the pharynx. The labrum and mandibles help in chewing the food.

C. Piercing and sucking mouth parts of mosquitoes :

The labium is modified to form a long, straight, fleshy tube, called proboscis. It has a deep labial groove on its upper side. The labial palps are modified to form two conical lobes at the tip of the proboscis, called labella which bear tactile bristles. The labrum is long needle like. The epipharynx is fused with the labrum. The labrum-epipharynx, thus, covers the labial groove dorsally from inside.

These structures appear C-shaped in transverse section having a groove, called food channel. Mandibles, maxillae and hypo pharynx are modified to from needle-like stylets which are placed in the labial groove. In male mosquitoes, the mandibles are absent. The mandibles are finer than the maxillae, but both have saw-like edges on their tips. The hypopharynx possesses salivary duct which opens at its tip.

D. Piercing and sucking mouth parts of bugs:

In bedbug, the labium constitutes a three-jointed proboscis. The mandibles and maxillae are modified to form stylets; the mandibular stylets possess blade-like tips, while maxillary stylets possess saw-like tips. The labrum is flap like and covers the labial groove at the base only.

Of the four stylets, mandibles are placed externally in the labial groove, while both the maxillae are placed internally in the labial groove. The maxillae are grooved and placed in such a way that they form a upper food channel and lower salivary canal. The epipharynx and hypo pharynx are absent.

E. Sponging:

This type of mouth parts are adapted for sucking up liquid or semiliquid food and found in houseflies and some other flies. They consist of labrum-epipharynx, maxillae, labium and hypo pharynx; mandibles are entirely absent. In fact, in this type of mouth

parts, the labium, i.e., lower lip is well developed and modified to form a long, fleshey and retractile proboscis. The proboscis is divisible into three distinct parts:

i) **Rostrum or basiproboscis -** It is broad, elongated and cone-shaped basal part of proboscis articulated proximally with the head and bears a pair of un-jointed maxillary palps representing the maxillae.

ii) **Haustellum or mediproboscis -** It is the middle part of proboscis bearing a mid-dorsal oral groove and a ventral weakly chitinised plate-like theca or mentum.

A double-edged blade-like hypo pharynx is located deep inside the oral groove; it bears salivary duct and closes the groove of labrum-epipharynx from below. The labrum-epipharynx is a long, somewhat flattened and grooved structure covering the oral groove. The food canal or channel is, thus, formed by labium-epipharynx and the hypo pharynx.

iii) **Labella or distiproboscis -** It is the distal part of proboscis and consists of two broad, flattened and oval spongy pads having a series of channels called pseudo trachease. These open externally by a double row of tiny holes through which liquid food is taken in. The pseudo tracheae converge into the mouth lying between the two lobes of labella which lead into the food canal.

F. Siphoning:

This type of mouth parts are adapted wonderfully for sucking flower nectar and fruit juice, found in butterflies and moths belonging to the order Lepidoptera. They consist of small labrum, coiled proboscis, reduced mandibles and labium. The hypopharynx and epipharynx are not found.

The labrum is a triangular sclerite attached with the front clypeus of the head. The proboscis is formed by well-developed, greatly elongated and modified galeae of maxillae. It is grooved internally to form the food channel or canal through which food is drawn up to mouth. At rest, when proboscis is not in use, it is tightly coiled beneath the head but it becomes extended in response to food stimulus.

The extension of proboscis is achieved by exerting a fluid pressure by the blood. Mandibles are either absent or greatly reduced, situated on the lateral sides of the labrum. The labium is trangular plate-like bearing labial palps.

1.5 Summary

- Different types of insects vary in their morphological features and the mouthparts are also of different types depending on their food habit.

- Insects belonging to different orders of animal groups also posses different types of antennae.
- "The structure and nature of the mouthparts in different insects varies according to their feeding habit or foods."

1.6 Questions

1. State the general features of class Insecta.
2. Mention the structural components of mouth parts of insects.
3. Classify the mouth parts of insects according the food habit.
4. Illustrate the sucking and mouth parts of mosquitoes.
5. Describe the sucking and poercing mouth parts of bugs.
6. Classify various types of antennae of insects.
7. What are Haustellate and Mandibulate types of mouth parts?
8. What is sponging type of mouth parts of insects? Where is it found?

1.7 Suggested readings

Dasgupta, B. 1986. Parasitology Including Entomology and Acarology. New Central Book Agency, Kolkata.

Hati, A. K. 1979. Medical Entomology. Allied Book Agency, India.

Johnson, N. and Triplehorn, C. A. 2004. Borror and De Long's Introduction to the Study of insects.

Loker, E. S. and Hofkin, B. V. 2015. Parasitology: A Conceptual Approach. Garland Science, New York.

Marcondes, C. B. (ed). 2017. Arthropod Borne Diseases. Springer.

Marquardt. W. 2004. Biology of Disease Vectors. Academic Press, London.

Mullen, G. R. And Durden, L. A. 2018. Medical Veterinary Entomology. Academic Press, London. Brooks/Cole.

Noble, G. A. and Noble, E. R. 1971. Parasitology: The Biology of Animal Parasites, Lea & Febiger, London.

Roberts, L. and Janovy Jr. J. 2008. Foundations of Parasitology. Mc Graw-Hill, London.

Service, M. 2008. Medical Entomology for Students. Cambridge University Press. Cambridge.

Soulsby, E. J. L. 1968. Helminths, Arthropods & Protozoa of Domesticated Animals. 6th edition. Balliere, Tinacell & Cassell, London.

Unit 2 ❑ Concepts of vectors. Brief introduction of carrier and vectors (mechanical and biological vectors), reservoirs, host-vector relationship, vectorial capacity, adaptations as vectors, host specificity.

Structure

2.0 Objectives

After studying this unit, learners will be able to understand the following:

- The similarities and differences between carrier and vectors.
- The reservoirs of different pathogens.
- The relationship between the host and the vector.
- Adaptations of a vector according to the climate and other factors.

2.1 Introduction

In epidemiology, a disease vector is any agent who carries and transmits an infectious pathogen into another living organism. Insect vectors of human and animal

diseases burden health systems and cause millions of deaths yearly, particularly in developing countries in South and Central America and Asia. Millions of dollars are spent each year on research and production of repellent compounds ton prevent insect bites that lead to disease transmission. The insect vectors responsible for the spread of human diiseases include Diptera (mosquitoes and biting flies), Hemiptera (true bugs), Anoplura (lice), and Siphonaptera (fleas). The sense organs of these insects are specifically tuned to detect chemical and physical signals emitted by potential hosts in order to locate an blood meal.

Arthopods form a major group of pathogen vectors with mosquitoes, flies, sand flies, lice, fleas, ticks, and mites transmitting a huge number of pathogens. Many such vectors are haematophagous, which feed on blood at some or all stages of their lives. When the insects feed blood, the pathogen enters the blood stream of the host. This can happen in different ways.

The World Health Organization (WHO) states that control and prevention of vector-borne diseases are emphasizing "Integrated Vector Management (IVM)", which is an approach that looks at the links between health and enviornment, optimizing benefits to both.

In April 2014, WHO launched a campaign called "Small bite, big threat" to educate people about vector-borne illnesses. WHO issued reports indicating that vector-borne illnesses affect poor people, especially people living in areas that do not have adequate levels of sanitation, drinking water and housing.

2.2 Brief introduction of carrier and vectors

Vector and carrier are two types of agents involved in the transmission of diseases between organisms. The main difference between vector and carrier is that a vector does not show any symptoms of the disease in its body whereas a carrier is an infected of ganism capable of transmitting the disease-causing micro organisms to a healthy individual. *Anopheles* mosquito that carries malaria parasites between humans is an example of vector. A human with HIV, who can transmit the virus to another healthy individual is an example of a carrier. Carriers also transmit genetic diseases such as hemophilia, cystic fibrosis, and sickle cell anemia. However, the carriers of the genetic diseases do not show any symptoms of the disease.

• What is a Vector?

Vector refers to an organism that spreads diseases by conveying pathogens from the host to another individual but without causing diseases by itself. Typically, vectors are blood feeding (haematophagous) arthropods such as mosquitoes, sand flies or ticks. Malaria, dengue fever, leishmaniasis, and West Nile virus are some examples of vector-borne disease. The transmission of *Flavivirus* genus develops through a mosquito vector. The disease can be tranmitted through a vector either mechanically or biologically.

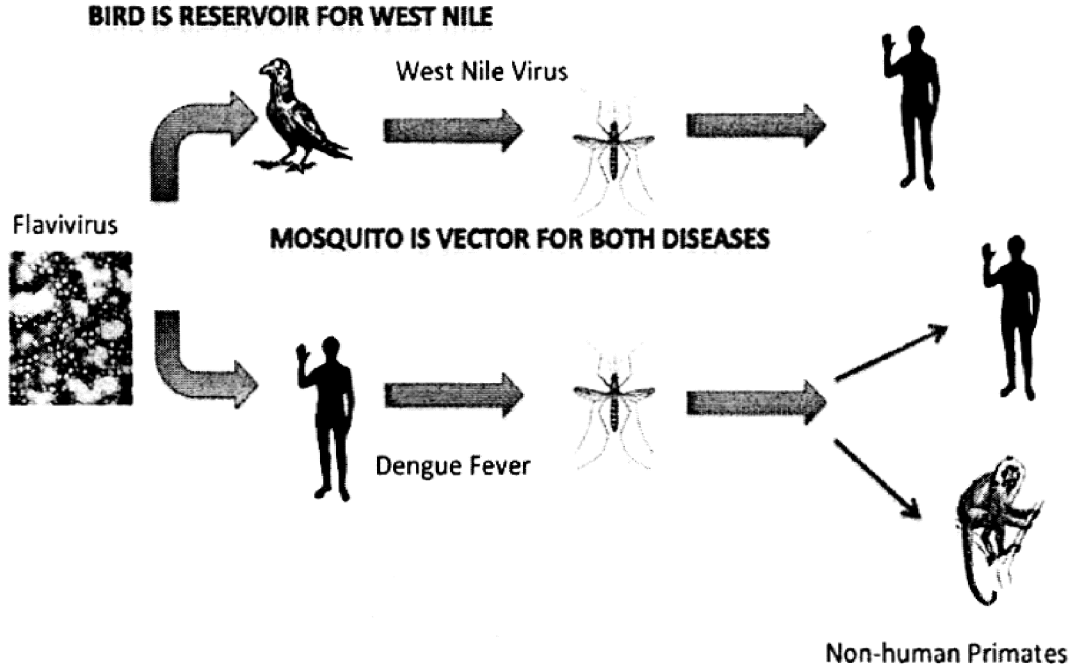

Figure 2.1. Transmission of Flavivirus genus through a misquito vector.

• Mechanicam transmission

Mechanical transmission takes place when the pathogen does not develop or replicate in or on the vector. Thus, only the transport of the pathogen occurs during the mechanical transmission. Insects such as flies are types of vectors involved in the mechanical transmission of diseases.

• Biological transmission

Biological transmission occurs when the pathogen completes a part of its life cycle inside the vector. Thus, the vector serves as the intermediate host of the pathogen.

The vector can be fleas, ticks or mosquitoes that inject the pathogen into or onto another host during their blood meal. The transmission of the disease is characterized by abundance and spatial spread of hosts and the vector, demography, and feeding rate of the vector.

• What is a Carrier

Carrier refers to an organism that harbours a specific infectious agent in the absence of discernible clinical disease and serves as a potential source of infection. A carrier can be divided into three categories based on the type of disease they carry and symptoms they display: asymptomatic carrier, genetic carrier, and symptomatic carrier.

• Asymptomatic Carrier

Asymptomatic carrier refers to an organism infected with an infectious disease but, displays no symptoms. Typhoid fever, HIV, Epstein-Barr virus (EBV), *Clostridium difficile* infection, *Chlamydia* infection, and poliomyelitis are some of the diseases that do not show any symptoms in the carrier.

• Genetic Carrier

Genetic carrier refers to an individual who has inherited a mutated genetic trait of a disease but, show no symptoms. Homophilia is an example of agenetic disease located on the X-linked recessive gene. It does not show any symptoms in the carrier. Cystic fibrosis and sickle cell anemia are such diseases that do not show symptoms in the carrier.

• Symptomatic Carrier

Symptomatic carrier refers to an organism that carries the disease while showing the symptoms of the disease. Hamophilia carriers with gene mutations in the factor VII or IX are typically known as obligate carriers since they do not show any symptoms of the disease. However, some females who carry haemophilia gene may show problems with bleeding. They are considered as symptomatic carriers.

• Similarities between Vector and Carrier

- Vector and carrier are two types of agents that transmit diseases between organisms.
- Both vector and carrier transmit disease-causing microorganisms.
- Both vector and carrier may involved in the biological and mechanical transfer of diseases.

- Disease-causing micro organisms may live on or in the body of both vector and carrier.

• Difference between Vector and Carrier

Definition

Vector: Vector refers to an organism that spreads diseases by conveying pathogens from the host to another individual, but without causing diseases by itself.

Carrier: Carrier refers to an organism that harbors a specific infectious agent in the absence of discernible clinical disease and serves as a potential source of infection.

2.3 Reservoirs

Any person, animal, plant, soil or substance in which an infectious agent normally lives and multiplies is termed as reservoir. The reservoir typically harbours the infectious agent without injury to itself and serves as a source from which other individuals can be infected. The infectious agent primarily depends on the reservoir for its survival. It is from the reservoir that the infectious substance is transmitted to a human or another susceptible host. Many infectious agents, especially those that cause emerging diseases, infect more than one host species. Managing reservoirs of multihost pathogens often plays a crucial role in effective disease control.

Animate or inanimate sources which normally harbour disease-causing organisms, thus serve as potential sources of disease outbreaks. Reservoirs are distinguished from vectors (disease vectors) and carriers, which are agents of disease transmission rather than continuing sources of potential disease outbreaks.

The **Reservoir for Infectious Agents** is the principal habitat where a specific infectious agent lives and multiplies. The reservoir is necessary for the infectious agent either to survive, or to multiply in sufficient amount to be transmitted to a susceptible host. Examples may include **primates** (including human beings), the reservoir of pathogens such as hepatitis A virus, hepatitis B virus, Polio virus (all 3 types), *Bordetella pertussis, Corynebacterium diphtheria,* etc.

Other micro organisms have larger animal reservoirs, e.g. **Salmonella** species can be found in almost every animal. The **environment** contains a large number of reservoirs: **soil,** the reservoir for *Clostridium tetani* or **water**, the reservoir for *Legionella pneumophila.*

It is important to know the reservoir of pathogens, as this may offer opportunities for control. For example, a disease like smallpox (**Variola Major**) could be eradicated from this planet, in part because humans were the main reservoir. By immunizing the majority of the reservoir population, and by rigorously keeping infectious patients isolated and immunizing contacts, the smallpox virus could no longer survive in nature. This is one of public health's great achievements and currently similar attempts are underway to do the same with poliovirus.

2.4 Host-vector relationship

The terms host and vector refer to the route of transmission of some infectious diseases to humans and animals. The host is the living being that the bacteria, virus, protozoan, or other disease-causing organisms normally reside in. Some bird species, for example are normal hosts to arboviruses such as West Nile virus. Typically, the microorganism does little or no harm to the host, which is important if the disease-causing organism is to successfully persist in the host over time. Occasionally, the host population maintains the organism even though some members suffer from infection caused by it. Several species of birds in North America have experienced West Nile infection although they are considered the natural host.

The transmission of many animal and plant diseases relies on the behavior of arthropod vectors. In particular, the choice to feed on either infected or uninfected hosts can dramatically affect the epidemiology of vector-borne diseases. In humans, several deadly vector-borne diseases (e.g. malaria, yellow fever, dengue, West Nile virus) are transmitted by mosquitoes or by other insect species (sand flies, fleas, ticks, tsetse flies etc.).

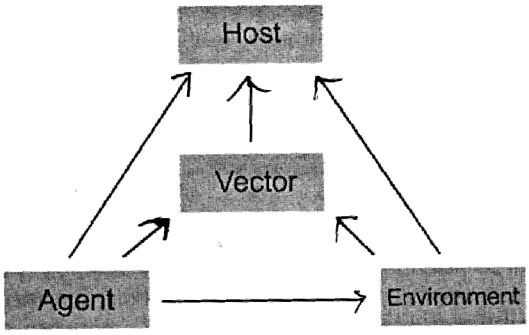

Figure 2.2. Epidemiologic Triad of Disease Causation indicating host-vector relationship.

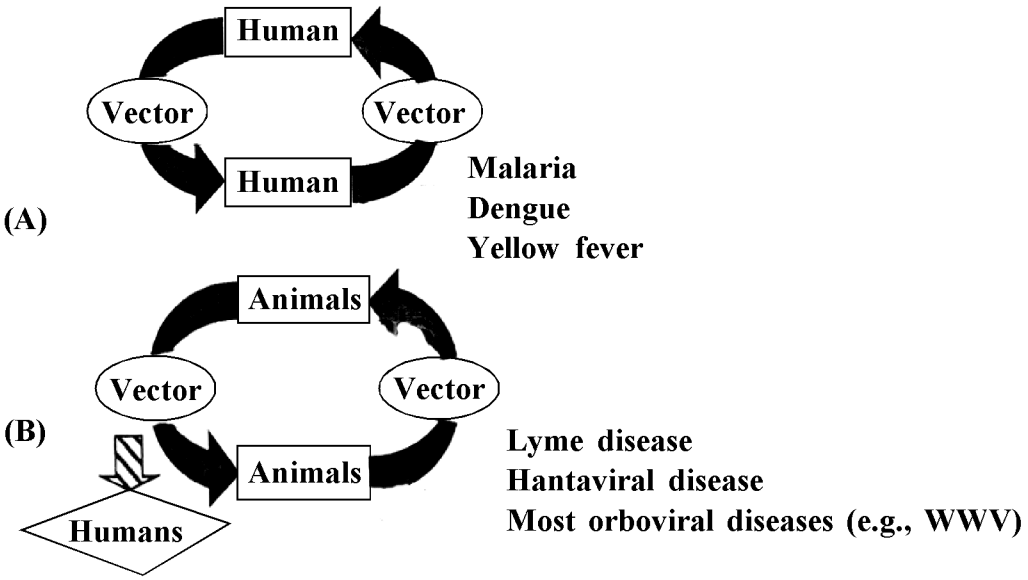

Figure 2.3. A. Human-vector-human (Anthroponotic infection). B. Animal-vector-human (zoonotic infections).

2.5 Vectorial capacity

Vectorial capacity is the capability for disease transmission by a vector to a host, as influenced by behavioral, ecological and environmental factors, such as population density, host preference, feeding habits or frequency, duration of latent period, or longevity.

- Vectorial capacity determines the relative importance of a mosquito as a vector
- Vector competence is one component of vectorial capacity
- Interactions between mosquitoes and viruses are vector-and virus strain-specific
- Microbiota of the mosquito may inpact vector competence
- There are costs to the mosquito with both infection and resistance to a virus

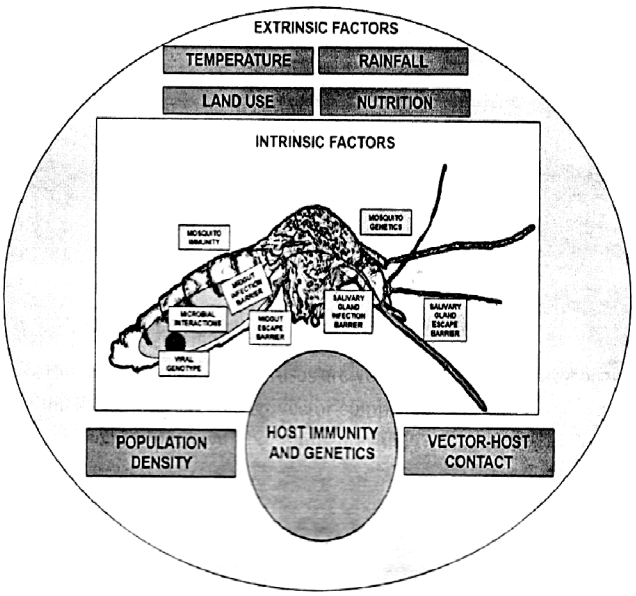

Figure 2.4. Factors affecting vectorial capacity of a mosquito vector.

2.6 Adaptations as vectors

Changes in climate will influence arthropod vectors, their life cycles and life histories, resulting in changes in both vector and pathogen distribution and changes in the ability of arthropods to transmit pathogens. Climate can affect the way pathogens interact with both the arthropod vector and the human or animal host. Predicting and mitigating the effects of future changes in the environment (like climate change on the complex arthropod-pathogen-host epidemiological cycle) requires understanding of a variety of complex mechanisms from the molecular to the populations of a given parasite or vector species respond similarly to temperature, regardless of their source population.

Mosquitoes that carry malaria are constantly adapting. Some develope resistance. others alter their behaviour. Mosquitoes of the genus *Anopheles,* the vectors of malaria, always find a way to foil human attempts to protect themselves from this disease.

Typically, most vectors are located in tropical regions; currently, variations in temperature and different climate patterns could be driving changes in their native range. The increase of annual mean tempratures and the introduction of disturbances in seasonal rhythms in latitudes located above tropics seem to be the major causes

of the spreading of these organisms. Thus, in a few years the number of cases of vector-borne diseases will probably increase greatly in different non-tropical locations around the world (e.g. Dengue, Chikungunya fever or West Nile Fever transmitted by mosquitoes of the genera *Aedes, Anopheles* and *Culex*). Changes in some agricultural practices forced by changes in temperature and precipitations could be influencing on the spreading of vector-borne diseases (mainly due to an inappropriate use of water sources, since many insects go through an aquatic larval phase).

However, climate change is not the only possible cause of their expansion: global transport and commerical exchanges worldwide are an open door the the international transport of vectors. If there is also an climate matching (that is, a correlation or similarity in climatic conditions) between the native and the new range, it is way easier for vectors to settle in the new location.

The conditions necessary for an insect to become a vector are multiple but require an innate vector competence as a genetic basis. Next to the vector competence plenty of entomological, ecological and pathogen-related factors are decisive, given the availability of infection sources. The various modes of pathogen transmission by vectors are connected to the developmental routes of the microorganisms in their vectors.

2.7 Host specificity

Parasites can be very particular about which host species they will use; this can apply to difinitive as well as intermediate hosts. A parasite that is specific for a single host species is said to be **oioxenous (monoxenous),** one that parasitizes closely-related hosts is **stenoxenous,** while one that parasitizes unrelated hosts is **euryxenous.** Host-specificity is determined by a complex of factors, some obvious and others still obscure. The first requirement is that the prospective host shares its environment with the parasite (**ecological** specificity); e,g, parasites of dolphins might not have much luck infecting humans who do not live near the sea (although modern food transport networks have changed this!). Secondly, host behaviour must expose it to the parasites (**ethological** specificity); e.g. if a parasite of dolphins thinks it is in a large fish or a dolphin when it arrives in the human gut, it may then behave accordingly. Obviously, this last determinate of host-specificity is the one we understand least.

Many parasites complete their developmental cycle in a single host species (**monoxenous** life-cycles) while others require multiple host species (**heteroxenous** life cycles). When multiple hosts are involved, the **definitive host** is that species in

which the adult (or sexual) form of the parasite occurs, whereas the **intermediate host** is the species which supports the development and/or multiplication of the non-sexual, or larval (for helminths), stages of the parasite. Intermediate hosts which physically carry the infective stage from one host to another are also termed **vectors;** they are **mechanical** vectors if they simply transmit the parasite (unchanged and non-multiplied), and **cyclical** vectors if they also function as true intermediate hosts that support essential development and/or proliferation of the parasite. Intermediate hosts may be optional in some helminth life-cycles; the parasite might not undergo essential development in them, although it may increase in size. These **paratenic hosts** carry parasites through food chains to the difinitive host, ensuring successful transmission even when the hosts are thinly dispersed through the environment. The successive fish hosts that carry the plerocercoid of *Diphyllobothrium latum,* to larger food fish that eventually eaten by humans or other final hosts. Some parasites exhibit low specificity for their definitive and/or intermediate hosts and so can develop in a range of animal species.

Note:

Vector and carrier are two types of agents involved in the transmission of diseases from one individual to another. Generally, a vector does not show the symptoms of the disease. Some disease-causing organisms complete their life cycle within the vector. The main difference between vector and carrier is the appearance of the symptoms of the diseases in each type of transmitting agent.

2.8 Summary

- Different disease vectors carry and transmit pathogens into another living organism.
- Vectors do not cause disease by itself, but by infecting the pathogen it carried.
- Carriers also serve as potential source of infection.
- Identifying and controlling the reservoirs of pathogen is important.

2.9 Questions

1. Distinguish between biological and mechanical vectors with examples.
2. Define asymptomatic and genetic carrier.

3. What are the differences between vector and carrier?
4. State the similarities between vector and carrier.
5. Difine vectorial capacity.
6. What are monoxenous and heteroxenous parasites?
7. State the role of reservoir in disease transmission.
8. Explain host-vector relationship.
9. What is host specificity?
10. Define paratenic host with example.

2.10 Suggested readings

Dasgupta, B. 1986. Parasitology Including Entomology and Acarology. New Central Book Agency, Kolkata.

Hati, A. K. 1979. Medical Entomology. Allied Book Agency, India.

Johnson, N. and Triplehorn, C.A. 2004. Borror and De Long's Introduction to the Study of insects.

Loker, E. S. and Hofkin, B. V. 2015. Parasitology: A Conceptual Approach. Garland Science, New York.

Marcondes, C. B. (ed). 2017. Arthropod Borne Diseases. Springer. Marquardt, W. 2004. Biology of Disease Vectors. Academic Press, London. Mullen, G. R. And Durden, L. A. 2018. Medical Veterinary Entomology. Academic Press, London. Brooks/Cole.

Noble, G. A. and Noble, E. R. 1971. Parasitology: The Biology of Animal Parasites. Lea & Febiger, London,

Roberts, L. and Janovy Jr. J. 2008. Foundations of Parasitology. Me Graw-Hill, London.

Service, M. 2008. Medical Entomology for Students. Cambridge University Press. Cambridge.

Soulsby, E. J. L. 1968. Helminths. Arthropods & Protozoa of Domesticated Animals. 6th edition. Balliere, Tinacell & Cassell, London.

Unit 3 ❑ Insects as vectors. Classification of insects up to orders, detailed features of Orders with insects as vectors-Deptera, Siphonaptera, Siphunculata, Hemiptera.

Structure

3.0 Objectives

After studying this unit, learners will be able to understand the following:

- Classification of the insects up to orders based on their detailed features.
- Different types of insects vectors involved in spreading pathogens in human and in other organisms.

3.1 Introduction

Insects and arthropods vector many human, animals, and plant diseases. The insect vectors responsible for the spread of human diseases include Diptera (mosquitoes and biting flies), Hemiptera (true bugs), Anoplura (lice), and Siphonaptera (fleas). The sense organs of these insects are specifically tuned to detect chemical and physical singals emitted bypotential hosts in order to locate a blood meal. Among the many

complex relationships between insects and microogranisms 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. Most common insects acting as a biological vector for infectious agents are: Anoplura (lice), Siphonaptera (fleas), Heteroptera (bugs: Cimicidae, Triatoma, Belostomatidae), Psychodidae (Sandflies), Simuliidae (black flies), Caratopogonidae (biting midges), Culicidae (mosquitoes), Tabanidae (horseflies) and Muscidae (testse flies, stable flies and pupipara).

Disease*	Parasite	Insect (vector)
African trypanosomiasis (sleeping sickness)	*Trypanosoma burcei gambiense, Trypanosoma burcei rhodesiense*	Testse flies
Babesiosis	*Babesia microti* and other species	*Babesia microti: Ixodes* (hard-bodied) ticks
Chagas disease	*Trypanosoma cruzi*	Triatomine ("kissing") bugs
Leishmaniasis	*Leishmania*	Phlebotomine sand flies
Malaria	*Plasmodium*	*Anopheles* mosquitoes

3.2 Classification of insects up to orders

Insects have three main body segments: the head, thorax and abdomen. They have six legs and specialized mouth parts. Most insects have one or two pairs of wings.

Characters of Class Insecta

1. Body is divided into three regions
2. Head is formal of six fused sgments a pair of atenna and a pair of maxilla.
3. Usually a pair of compound ears on the head are principal usual organ.
4. Thorax segment bears one pairs of five jointed legs.
5. Paired wings when present are either on mesothorax and metathorax or sometimes only one pair.
6. Excretion is mainly through Malpighian tubules.
7. Tracheal system of respiration well developed.

Outline classification of Class Insecta

The class Insecta has 29 order (4 in Apterygota and 25 in Pterygota).

The class Insecta has two subclasses *viz.*,**Apterygota** and **Pterygota.**

The subclass **Apterygota** has 4 orders namely

1. Thysanura - Silverfish (Thysan-fringed, Ura-tali)
2. Collembola-Springtail or snowflea (coll-glue; embol-peg)
3. Protura-Proturans or Telsontial (Pro-first, Ura-tail)
4. Diplura-Diplurans or Japygids (Di-two; Ura-tail)

The sub-class **Paterygota** has two divisions, namely Exopterygota and Endopterygota based on the wing development

Exopterygota	**Groups**
01. Ephemeroptera–Mayflies	Group I. Paleopteran orders (1,2)
02. Odonata-Dragonfly, Dameslfly	
03. Plecoptera-Stonefly	Group II. Orthopteroid order (3-11)
04. Grylloblatodia- Rock crawlers	
05. Orthoptera-Grasshopper, locust, cricket, mole cricket	
06. Phasmida-stick insect, leaf insect	
07. Dermaptera-Earwigs	
08. Embioptera-Webspinners/Embids	
09. Dictyoptera-cockroach, praying mantis	
10. Isoptera-Termites	
11. Zoraptera-Zorapterans	
12. Posocoptera-Book lice	Group III. Hemipteroid orders (12-16)
13. Mallophaga-Bird lice	
14. Siphunculata-Head and body louse	
15. Hemiptera-Bugs	
16. Thysanoptera-Trip	

Endopterygota

01. Neuroptera- Antilions, aphidlion, owl flies, mantispid flies.
02. Mecoptera- Butterflies and moths. Group IV. Panorpoid complex (1-6)
03. Lepidoptera-Butterflies and moths.
04. Trichoptera-Caddisfly.
05. Diptera-True fly.
06. Siphonaoptera-Fleas.
07. Hymenoptera-Bees, wasps, ants.
08. Coleoptera-Beetles and weevils.
09. Strepsiptera-Stylopids.

Characters of different orders of class Insecta

3.2.1. Order Diptera

General characteristics :

- Soft body
- One pair of membranous wings prescat or methothorax.
- Second pair of wings on metathorax present as a haltere.
- Halteres are tiny dumbbell structures serve as a balancing organ.
- Body is often covered with short bristles.
- Depending on the species of fly, the mouthparts may be of sucking, lapping up fluids or prercing types.
- Thorax that is enlarged in the middle to give it a rather hunch-backed look.
- Those are holometabolous metamorphosis representing egg, larva, pupa and adult in their left cycle.

Examples : Mosquitoes, house flies, black flies, blow flies, sand flies, testse flies, etc.

3.2.2. Order Siphonaptera

General characteristics:

- Small, wingless.
- Laterally side to side compressed bodies

- Piercing-sucking mouthparts
- Enlarged hind legs adapted for jumping
- strong tarsal claws adapted for holding onto their hosts
- Backward pointing hairs and birstles for ease of movement through the hair of a host
- Without typical compond eyes
- Small antennae which tuck away into special groves in the head
- Holometabalous insect warthapodous larval stage.

Examples : Fleas, rat flea, cat flea etc.

3.2.3. Order Siphunculata (now termed as Anoplura)

General characteristics:

- Small, wingless parasites in both adult and nymphal stages
- Head narrow and eyes reduced or absent
- Antennae short
- Piercing/sucking or chewings nouthparts, retracted into head when not feeding
- Each leg ends in a strong claw well-developed for clinging to the host
- Hemimetabolous insects moving egg nymphal and adult stages
- Eggs are usually stuck on to the host's hair and hatch when the temperature is sufficiently high
- Feeds solely on blood of mammals
- The Anoplura are now combined with the Mallophaga into one order called the Phthiraptera

Examples : Head louse, body louse, all sucking lice

3.2.4. Order Hemiptera

General characteristics:

- Two pairs of wings usually present; the anterior pair most often of harder consistency than the posterior pair or with the apical portion more membranous than the remainder (Heteroptera) or uniformly so (Homoptera)

- Head position Opisthognathous with mouth parts piercing and sucking type.
- Labium (2 to 4 segmented forming a dorsally grooved sheath (beak), in which lie two pairs of bristle like styles viz, mandibular & maxillary can be placed during feeding.
- Thorax well developed in some cases pronotum triangular.
- Abdomen soft, tapering at the end or bulging. Carei totally absent.
- Metamorphosis usually incomplete (hemimetabolous)

Examples : Bugs, Aphids, Whiteflies, Leaf hoppers, plant hoppers, Mealy bugs, Scales insects, Cicados.

3.3 Summary

- Insect vectors, responsible for the spread of human diseases, belong to different orders.
- Insect of different orders have difference in morphological characters, like the difference in their mouth parts, antennae, developmental stages in life cycle etc.
- Insects can be boradly classified into 29 different orders.

3.4 Questions

1. Name the orders of Apterygota.
2. State the general characters of Diptera.
3. How many orders are there in exopterygota and endopterygota?
4. State the characters of Hemiptera.
5. List the characters of Anoplura (Siphunculata)
6. State the general characteristics of Siphonaptera.
7. Name the vectors of sleeping sickness, Chagas disease and Babesiousis.

3.5 Suggested readings

Dasgupta, B. 1986, Parasitology Including Entomology and Acarology. New Central Book Agency, Kolkata.

Hati, A. K. 1979. Medical Entomology. Allied Book Agency, India.

Johnson, N. and Triplehorn, C.A. 2004. Borror and De Long's Introduction to the Study of insects.

Loker, E. S. and Hofkin, B. V. 2015. Parasitology: A Conceptual Approach. Garland Science, New York.

Marcondes, C. B. (ed). 2017. Arthropod Borne Diseases. Springer. Marquardt, W. 2004. Biology of Disease Vectors. Academic Press, London. Mullen, G. R. And Durden, L. A. 2018. Medical Veterinary Entomology. Academic Press, London. Brooks/Cole.

Noble, G. A. and Noble, E. R. 1971. Parasitology: The Biology of Animal Parasites. Lea & Febiger, London.

Roberts, L. and Janovy Jr. J. 2008. Foundations of Parasitology. Me Graw-Hill, London.

Service, M. 2008. Medical Entomology for Students. Cambridge University Press. Cambridge.

Soulsby, E. J. L. 1968. Helminths, Arthropods & Protozoa of Domesticated Animals. 6^{lh} edition. Balliere, Tinacell & Cassell, London.

Unit 4 ❑ Dipteran as disease vectors. Dipteran as important insect vectors – mosquitoes, sand fly, houseflies; study of mosquito borne diseases – malaria, dengue, chikungunya, viral encephalitis, filariasis; control of mosquitoes; study of sand fly borne diseases – visceral leishmaniasis, cutaneous leishmaniasis, phlebotomus fever; control of sand fly, study of house fly as important mechanical vector, myiasis, control of house fly.

Structure

4.0 Objectives

After studying this unit, learners will be able to understand the following:

- Different types of dipteran insects, responsible for the various types of diseases.
- Disease conditions caused by the different vectors like mosquitoes, sand fly and houseflies.
- Control measures of these vectors.

4.1 Introduction

Insects that transmit infective organisms from one host to another or from an inanimate reservoir to an animate host are termed as vector, the biting diptera are two-winged flying insects that suck blood from humans and other animals. In many parts of the world their biting is a considerable nuisance. More importantly, they are carriers of a number of diseases, mostly in the tropics, causing illness and death on a large scale. The most important group of biting diptera is the mosquitoes, which have a long, slender body and long, needle-shaped, piercing mouthparts. Others include the black flies, phlebotomine sand flies, tsetse flies, biting midges, horseflies

(tananids) and stable flies, which generally have shorter biting mouthparts and more robust bodies. The last three groups are of limited importance as vectors of human disease.

Many parasites and pathogens responsible for some of the most important diseases in humans, agriculture and nature are routinely described as 'vector-borne'. Many important and rapidly emerging pathogens of humans, livestock and wildlife are 'vector-borne'. However, the term 'vector' has been applied to diverse agent in a broad range of epidemiological systems.

Most common insects acting as a biological vector for infectious agents are: Anoplura (lice), Siphonaptera (fleas), Heteroptera (bugs: Cimicidae, Triatoma, Belostomatidae), Psychodidae (sandflies), Simuliidae (black flies), Ceratopogonidae (biting midges), Culidicae (mosquitoes), Tabanidae (horseflies) and Muscidae (tsetse flies, stable flies and pupipara).

- Vector-borne diseases account for more than 17% of all infectious diseases, causing more than 700 000 death annually.

4.2 Diptera as important insect vectors

Diptera is an order of winged insects commonly known as flies. The bitting Diptera are two-winged flying insects that suck blood from humans and animals. Incase of malaria, dengue, trypanosomiasis, chikungunya, leishmaniasis and schistomiasis dipteran organisms act as vector.

More than 3.9 billion people in over 128 countries are at risk of contracting dengue, with 96 million cases estimated per year.

Malaria causes more than 400 000 deaths every year globally, most of them children under 5 years of age.

Other diseases such as Chagas disease, leishmaniasis and schistosomiasis affect hundreds of millions of people worldwide.

4.2.1. Mosquitoes

Mosquitoes are a large arthropod group with approximately 3,100, species occurring in the world. Only about a hundred of them are vectors of human diseases. Mosquitoes can be divided into two subfamily groups;

1. The anopheline subfamily including the most important mosquito genus

Anopheles which is responsible for transmitting malaria. *Anopheles* is also involved in transmission of filariasis in West Africa.

2. The culicine subfamily where the important genera *Aedes, Culex,* and *Mansonia* belong. Several disease are transmitted by them such as yellow fever, dengue and chikungunya by aedes, encephalitis virus by *Culex.* All of these mosquitoes are also involved in the transmission of filariasis.

Both male and female mosquitoes feed on sugary secretions such as nectar from plants. In all species, only the female mosquito takes blood-meals from animals and/ or humans. The female mosquitoes are attracted by the odour, the carbon dioxide and the heat from animals and humans. The blood sucked is used to provide proteins to mature batches of eggs. The life cycle of the mosquito consist of four stages: the immature stages of egg. The females are able to lay between 30 and 300 eggs at a time, according to species. The anopheline mosquitoes lay their eggs seprately over the surface of any kind of unpolluted water. The culicine mosquitoes, *Culex* and *Mansonia,* lay their eggs on water as an egg-raft form. The eggs of *Aedes* mosquitoes are laid just above the water line or in wet mud. Provided that they are kept dry they can survive for 3 to 4 years and hatch only when flooded by rising water levels or heavy rain.

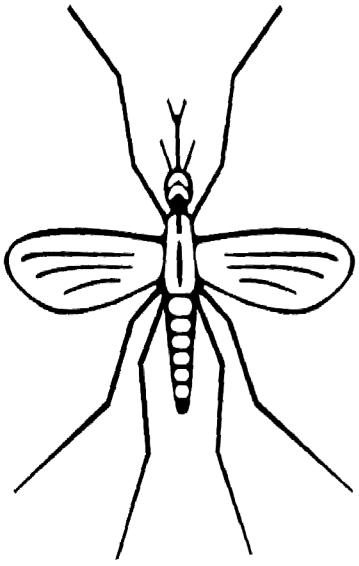

Figure 4.2.1. Drawing of a typical Mosquito

Mosquitoes as vector of most common diseases:

Aedes	*Anopheles*	*Culex*
Chikungunya	Malaria	Japanese encephalitis
Dengue fever	Lymphatic filariasis	Lymphatic filariasis
Lymphatic filariasis'		West Nile fever
Rift Valley fever		
Yellow fever		
Zika		

4.2.2. Sand flies

Sand fly (Phlebotominae) adults are small flies–only about 3 mm long – and are golden, brownish or gray colored. They have long, piercing mouthparts that are well adapted for sucking blood from their selected host. Sand flies hold their hairy-looking wings in a vertical V-shape when at rest, a characteristic that distinguishes them from some other small flies. Also, the legs of the adults are extremely long, being longer than the insect's body. Phlebotomus argentipes is the main vector species of kalaazor in India.

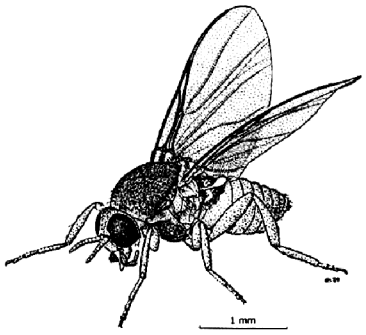

Figure 4.2.2. Drawing of a typical female sand fly.

Sand fly diseases are transmitted by the bite of infected female sand flies in many parts of the world. Some of more important sand fly transmitted diseases include:

- Cutaneous leishmaniasis
- Visceral leishmaniasis
- Sand fly fever

- Carrion's disease
- Pappataci fever
- Vesicular stomatitis virus

4.2.3. House flies

Adult house flies are grey to black, with four dark, longitudinal lines on the thorax, slightly hairy bodies, and a single pair of membrabous wings. They have red eyes, set farther apart in the slightly larger female. Adult houseflies are usually 6 to 7 mm (0.24 to 0.28 in) long with a wingspan of 13 to 15 mm (0.5 tp 0.6 in). The females tend to be larger winged than males, while males have relatively longer individuals in higher latitudes. The house fly, *Musca domestica* Linnaeus, is a well-known cosmopolitan pest of both farm and home. This species is always found in association with humans or the activities of humans. Adult house flies typically live 15-25 days. House flies are usually only active during the daytime when they will congregate indoors on floors, walls and ceilings. Outside, house flies opt for hanging around plants, fence wires, garbage cans and the ground.

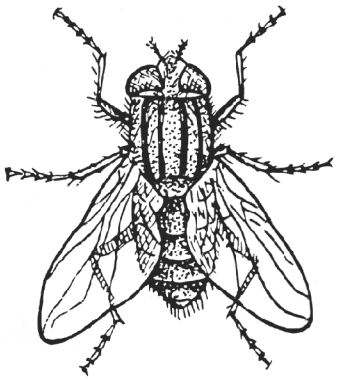

Figure 4.2.3 Drawing of a house fly.

House flies are strongly suspected of transmitting at least **65 diseases** to humans, including

- typhoid fever
- dysentry
- cholera
- poliomyelitis
- yaws

- anthrax
- tularaemia
- leprosy
- tuberculosis

4.3 Study of mosquito borne diseases

4.3.1. Malaria

Malaria is a life-threatening disease. It's typically transmitted through the bite of an infected *Anopheles* mosquito. Infected mosquitoes carry the *Plasmodium* parasite. When this mosquito bites a person, the parasite is released into his/her boodstream.

Once the parasites are inside the body, they travel to the liver, where they mature. After several days, the mature parasites enter the bloodstream and begin to infect red blood cells. Within 48 to 72 hours, the parsites inside the red blood cells multiply, causing the infected cells to burst open. The parasites continue to infect red blood cells, resulting in symptoms that occur in cycles that last two to three days at a time.

Malaria is typically found in tropical and subtropical climates where the parasites can live. According to the World Health Organisation (WHO) in 2016, there were an estimated 216 million cases of malaria in 91 countries. There are four species of malaria in 91 countries.

There are four species of malaria parasites that can infected humans: *Plasmodium vivax, P. ovale, P. Malariea,* and *P. falciparum.*

There are three necessary aspects to the malaria life cycle:

1. The *Anopheles* **mosquito** carries the parasite where the parasite starts its life cycle. The sexual cycle of **plasmodium** resides in the body of mosquitos.
2. The **parasite** (*Plasmodium*) has multiple species and their local races, each causing a different severity of symptoms and responding to different treatments.
3. The parasite first travels to a **human's** liver to grow and multiply (asexual cycle). It then travels in the bloodstream and infects and destroys red blood cells.

The symptoms of malaria typically develop within 10 days to 4 weaks following the infection. In some cases, symptoms may not develop for several months. Some malarial parasites can enter the body but will be dormant for long periods of time.

Common symptoms of malaria include :

- shaking chills that can range from moderate to severe
- high fever
- profuse sweating
- headache
- nausia
- vomiting
- abdominal pain
- diarrhea
- anemia
- muscle pain
- convulsions
- coma
- bloody stools

4.3.2. Dengue

Dengue fever, also known as breakbone fever, is a mosquito-borne infection that can lead to a severe flu-like illness. It is caused by four different dengue viruses and spread by *Aedes* mosquitoes. Dengue fever is a mosquito-borne viral disease that causes high fevers with headaches and severe muscle and joint pains; a rash may develop. This may include a high fever, headache, vomiting, muscle and joint pains, and a characteristic skin rash. Recovery generally takes two to seven days. In a small proportion of cases, the disease develops into **severe dengue,** also know as **dengue hemorrhagic fever,** resulting in bleeding, low levels of blood platelets and blood plasma leakage, or into **Dengue shock syndrome,** where dangerously low blood pressure occurs.

Dengue is fast emerging pandemic-prone viral disease in many parts of the world. Dengue flourishes in urban poor areas, suburbs and the countryside but also affected affluent neighbourhoods in tropical and subtropical countries. The incidence of dengue has increased 30-fold over the last 50 years. Up to 50-100 million infections are now estimated to occur annually in over 100 endemic countries, putting almost half of the world's population at risk.

The dengue virus (DEN) comprises four distinct serotypes (DEN-1, Den-2, Den-3 and DEN-4) which belong to the genus **Flavivirus,** family Flaviviridae. Distinct genotypes have been identified within each serotype, highlighting the extensive genetic variability of the dengue serotypes. Among them, "Asian" genotypes of DEN-2 and Den-3 are frequently associated with severe disease accompanying secondary dengue infections.

- Dengue is transmitted by the mosquitoes *Aedes aegypti* and *Aedes albopictus*, which are found throughout the world.
- Around 2.5 billion people, or 40 percent of the world's population, live in areas where there is a risk of dengue transmission.
- Dengue is endemic in at least 100 countries in Asia, the Pacific, the Americas, Africa, and the Caribbean.
- Symptoms usually begin 4 to 7 days after the mosquito bite and typically last 3 to 10 days.
- Effective treatment is possible if a clinical diagnosis is made early.

Most cases occur in tropical areas of the world, with the greatest risk occurring in : The Indian subcontinent

- Southeast Asia
- Southern China
- Taiwan
- The Pacific Islands
- The Carbbean (except Cuba and the Cayman Islands)
- Mexico
- Africa
- Central and South America (except Chile, Paraguay, and Argentina)

Symptoms, which usually begin four to six days after infection and last for up to 10 days, may include

- Sudden, high fever
- Severe headaches
- Pain behind the eyes
- Severe joint and muscle pain

- Fatigue
- Nausea
- Vomiting
- Skin rash, which appears two to five days after the onest of fever
- Mild bleeding (such a nose bleed, bleeding gums, or easy bruising)

4.3.3. Chikungunya

Chikungunya is a viral disease (genus *Alphavirus*) which is transmitted to humans by infected mosquitoes-including *Aedes aegypti* and *Aedes albopictus*. The name chikungunya originates from a verb in the Kimakonde language, meaning 'to become contorted'. This refers to the 'stooped' appearance of those suffering with joint pain. Chikungunya is rarely fatal. Symptoms are generally self-limiting and last for 2-3 days. The virus remains in the human system for 5-7 days and mosquitoes feeding on an infected person during this period can also become infected. Chikungunya shares some clinical signs with dengue and can be misdiagnosed in areas where dengue is common.

Human chikungunya virus infection has been documented in Cambodia, East Timor, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Pakistan, Philippines, Reunion, Seychelles, Singapore, Taiwan, Thailand and Vietnam. Outbreaks also occur in Africa, Europe and Americas.

- is a viral disease transmitted to humans by infected mosquitoes. It causes fever and severe joint pain. Other symptoms include muscle pain, headache, nausea, fatigue and rash.
- Joint pain is often debilitating and can vary in duration.
- The disease shares some clinical signs with dengue and zika, and can be misdiagnosed in areas where they are common.
- There is no cure for the disease. Treatment is focused on relieving the symptoms.
- The proximity of mosquito breeding sites to human habitation is a significant risk factor for chikungunya.
- The disease mostly occurs in Africa, Asia and the India subcontinent. However a major outbreak in 2015 affected several countries of the Region of the Americas.

Symptoms

Symptoms appear between 4 and 7 days after the patient has been bitten by the infected mosquito and these include:

- High fever (40°C/104°F)
- Joint pain (lower back, ankle, knees, wrists or phalanges)
- Joint swelling
- Rash
- Headache
- Muscle pain
- Nausea
- Fatigue

4.3.4. Viral encephalitis

Viral encephalitis is inflammation of the brain, caused by any one of a number of viruses. There are several causes, but the most common is viral infection. Encephalitis often causes only mild flu-like signs and symptoms-such as a fever or headache-or no symptoms at all. Sometimes the flu-like symptoms are more severe. Encephalitis can also cause confused thinking, seizures, or these viruses include:

- West Nile encephalitis (WNV)
- Eastern equine encephalitis (EEE)
- Western equine encephalitis (WEE)
- St. Louis encelhalitis (SLE)
- La Crosse encephalitis (LCE)
- Jamanese encephalitis (JEV or JE)
- Venezuelan equine encephalitis (VEE)

Mosquito-borne encephalitis/encephalomyelitis is viral diseases that are transmitted to humans and animals by mosquitoes. Encephalitis refers to an inflammation of the brain, and encephalomyelitis refers to an inflammation of the brain and spinal cord. In California, West Nile Virus (WNV), Western Equine encephalitis (WEE) and St. Louis encephalitis (SLE) are the three most important viruses that can cause mosquito-

borne encephalitis/encephal omyelitis. These viruses are maintained in nature through a bird-mosquito-bird cycle. Birds that are common in California such as the American crow, English house sparrow and the house finch are important hosts or reservoirs of these viruses. The mosquitoes that transmit WEE and SLE perfer to bite birds, but sometimes these encephalitis viruses cannot be transmitted from person to person. Humans are not carriers, hosts or reservoirs for these diseases. Occasionally, breast fed infants, unborn fetuses and blood and organ donor recipients can contract these viruses, but the incidence of this happening is very or must be euthanized. St. Louis encephalitis does not cause disease in horses. Vaccines to protect horses from WNV and WEE are in use, but unfortunately none are available for humans. In addition, there are no vaccines to protect humans. In addition, there are no vaccines to protect humans from SLE.

Japanese encephlitis is a mosquito-borne viral infection. It is the leading cause of viral encephalitis in Asia. Humans can get the disease from mosquito that carries the virus. Japanese encephalitis virus (JEV) cannot transmit from one person to another. Japanese encephalitis is a virus in the flaviviridal family. The *Culex* mosquito passes it on. Wild birds are likely to be the natural hosts of JEV, and humans. This can lead to encephalitis in horses and miscarriage in pigs. A host is the source of a virus, and the vector passes it on. Wild birds are likely to be the natural hosts of JEV, and mosquitoes are the vectors. When mosquitoes infect an animal, the animal might become a carrier of the virus. When othe mosquitoes feed on this animals that have newly acquired the virus, they take it on board and infect other animals. People are at the highest risk in rural areas where the virus is common. Japanese encephalitis is common around towns and cities.

Japanese encephalitis is most common throughout Southeast Asia, China, Korea, Japan, Taiwan, and Thailand have had outbreaks in the past, but they have mainly controlled the disease through vaccination, Vietnam, Cambodia, Mayanmar, India, Nepal, and Malayasis still experience occasional epidemic.

Possible Symptoms include :

- a headache
- high fever
- tremors
- nausea
- vomiting

- stiff neck
- spastic paralysis

A person might also undergo changes to brain function, including:

- stupor
- disorientation
- coma
- convulsions in children

The testicles can also swell.

The brain symptoms of Japanese encephalitis can cause lifelong complications, such as deafness, uncontrollable emotions, and weakness on one side of the body.

4.3.5. Filariasis

Filariasis is a parasitic disease caused by several round , coiled and thread-wise parasitic nematode worm belonging to the Family Filaridea. These are spread by blood-feeding diptera as black flies and mosquitoes. This disease belongs to the group of diseases called helminthiases. Eight known filarial nematodes use humans as their difinitive hosts.

A wide range of mosquitoes can transmit the parasite, depending on the geographic area. In Africa, the most common vector is *Anopheles* and in the Americas, it is *Culex quinquefasciatus. Aedes* and *Mansonia* can transmit the infection in the Pacific and in Asia.

In mainland India, *Wuchereria bancrofti* transmitted by the ubiquitous vector, *Culex quinquefasciatus*, has been the most predominant infection contributing to 99.4% of the problem in the country. The infection is prevalent in both urban and rural areas. *Brugia malayi* infection is mainly restricted to rural areas due to peculiar breeding habits of the vector associated with floating vegetation. *Mansonia (Mansonioides) annulifera* is the principal vector whil *M(M) uniformis* is the secondary vector. The vectorial role of *M.(M.) indiana* is very limited due to its low density. Both *W. bancrofti* and *B. malayi* infection in mainland India exibit nocturnal periodicity of microfilaraemia. In 1974-75 diurnal subperiodic *W.bancrofit* infection was discovered among aborigines, inhabiting nicobar group of Andaman & Nicobar Islands. *Aedes (Finlaya) niveus* group of mosquitoes were incriminated as the vectors for this infection.

These parasites penetrate the skin either their own or through the opening created by mosquito bites to reach the lymphatic system. The disease generally presents with the symptoms like swelling of legs, and can cause a raft of societal stigma.

Lymphatic Filariasis (LF) is commonly known as elephantiasis. It is a disfiguring and disabling disease, which is generally acquired in childhood. In the early stages, though there are either no symptoms or non-specific symptoms, the lymphatic system is damaged. This stage can last for several years. Infected persons sustain the transmission of the disease. The long term physical consequences are painful swolen limbs (lymphoedema or elephantiasis). Hydrocele in males is also common in endemic areas.

Adult male and female worms lodge in the lymphatics. Fecund females release larvae (microfilaria) which periodically circulate in the blood. Microfilaria circulating in the blood can be ingested by feeding mosquito vectors. Micrifilaria must mature in the vector before becoming infective. The mosquitoes can then spread infective larae to new hosts when feeding. Transmission in a community is influenced by the number of infected persons (prevalence), the density of microfilaria in the blood of infected persons, the density of vector mosquitoes, characteristics of the vector that affect development of infective larvae and frequency of human-vector contact.

Lymphatic filariasis (LF) is one of the neglected tropical diseases (NDT) which is still a public helth problem in India and is endemic in 17 states and 6 union territories. *Brugia malayi* is prevalent in the states of Kerala, Tamil Nadu, Andhra Pradesh, Odisha, Madhya Pradesh, Assam and West Bengal.

An estimated 120 million people in tropical and subtropical areas of the world are infected with lymphatic filariasis; of these, almost 25 million men have genital disease (most commonly hydrocoele) and almost 15 million, mostly women, have lymphoedema or elephantiasis of the leg. A recent estimation of the impact of mass drug administration (MDA) during the past 13 years suggests 96.71 mission cases were prevented or cured, yet as many as 36 million cases of hydrocoele and lymphoedema remain. Of the total population requiring preventative chemotherapy, 57% live in the South-East Asia Region (9 countries) adn 37% live in the African Region (35 countries).

Signs and symptoms

Lymphatic filariasis infection involves asymptomatic, acute, and chronic conditions. The majority of infections are asymptomatic, showing no external signs

of infection, although their blood is positive for microfilaria. This stage may lasts for months.

- Fever.
- Inguinal or axillary lymphadenopathty.
- Testicular and/or inguinal pain.
- Skin exfoliation.
- Limb or genital swelling-repeated episodes of inflammation and lymphedema lead to lymphatic damage, chronic swelling, and elephantiasis of the legs, arms, scrotum, vulva, and breasts.

4.3.6. Control of mosquitoes

Depending on the situation, source reduction, biocontrol, larviciding (killing of larvae), of adulticiding (killing of adults) may be used to manage mosquito populations. These techniques are accomplished using habitat modification, pesticide, biological control agents, and trapping.

Mosquito (vector) control is an important component of malaria control strategy, although elimination of malaria in an area does not require the elimination of all *Anopheles* mosquitoes.

Mosquito prevention and control involves a basic understanding of their life cycle. A mosquito life cycle has 4 stages: egg, larva, pupa, and adult.

1. The best way to control mosquitoes is to remove potential egg laying sites
2. Remove any sources of standing water
   - Add drainage holes to stuctures or containers that may trap water (barrles, old tires)
   - change or circulate the water in pet bowls and birdbaths at least once a week.
   - Fill tree holes with sand, mortar or place drainage holes to prevent standing water.
   - Clean roof gutters to prevent them from becoming clogged and holding water.
   - properly dispose of all trash especially anything that could hold water.
3. Keep weeds and other vegetation mowed and trimmed to minimize shelter for adult mosquitoes.

4. For areas with ponds, consider stocking mosquito larvae eating fish,

5. **Control of Adult Mosquitoes –**

- This is the least efficient way to control mosquitoes
- Special equipment is needed to apply pesticides to kill adult mosquitoes (adulticides); small droplets are produced that drift through the air and contact adult mosquitoes to kill them
- Check with your local extension office or department of pest management ot determine which pesticides are approved for use in your area
- The use of pesticides should only be supplemental to controlling mosquitoes through the reduction and management of mosquito egg laying sites.
- Pyrethrin or 5% malathion can be fogged outdoors; Follow all lable directions
- Contact nearrby local extension agent for assistance in developing a mosquito management plan.

6. **Control of mosquito larvae**

- The use of larvacides is a consideration, but should only be used as a supplemental measure
- Use only larvicides approved for use in your area; Check with your local extension office of department of pest management for a list of approved pesticides
- Do not apply pesticide to moving water (i.e. streams)
- Always read and follow all label directions
- Non-chemical pesticides (e.g., *Bacillus thuringiensis israelensis*) may be an option

• Methoprene products can be used to treat areas that collect water, such as bird baths, urns, old tires, flower pots, abandoned swimming pools, etc.

- There are several types of **biological control** including the direct introduction of parasites, pathogens and predators to target mosquitoes. Effective biocontrol agents include predatory fish that feed on mosquito larvae such as mosquito fish (*Gambusia affinis*) and some cyprinids (carps and minnows) and killifish.

7. **Personal Protection**

- Avoid being outdoors during prime mosquito biting times (dusk, dawn)
- Use insect repellant containing DEET, Picaridin or Oil of lemon
- eucalyptus [NOTE: DEET can be toxic to companion animals, so should not be used on pets]
- Keep windows, doors and porches tightly screened

4.4 Study of sand fly borne diseses

Sand fly is a colloquial name for any species or genus of flying, biting, blood-sucking dipteran encountered in sandy areas. Phlebotomines are the sole or principal vectors of *Leishmania, Bartonella bacilliformis,* and some arboviruses. The coevolution of sand flies with *Leishmanis* species of mammals and lizards is considered in relation to the landscape epidemiology of leishmaniasis, a neglected tropical disease. In the various sorts of sand.

Fly only the female is responsible for biting and sucking the blood of mammals, reptiles and birds; the protein in the blood is necessary for the production of eggs, making the sandfly an autogenous reproducer.

There is only one sand fly vector of Kala-Azar in India i.e. *Phlebotomus argentipes.* Sand flies are small insects, 1.5 to 3.5 mm long about on fourth of the size of a mosquito.

Both female and male sand fly adult obtain carbohydrate nutrition from plant juices; however, most females also require at least one blood meal in order to complete development of egg batches. Some are autogenous (able to produce viable eggs withour a blood meal). Acquisition of disease agents is therefore incidental to blood meals.

Leishmaniasis is broadly classified based upon its location in the Western or Eastern hemispheres. In the Western Hemisphere the disease is known as New World leishmaniasis, and is found in some areas of Mexico, Central America and South America. In the Eastern Hemisphere, the disease is known as Old World leishmaniasis, and is found in certain parts of Asia, the Middle East, southern Europe (particularly the Mediterranean area), North Africa and tropical regions of Africa. New World and Old World leishmaniasis are caused by different *Leishmania* species.

Leishmaniasis is a tropical/sub-tropical disease, spread by the bite of infected sand flies. There are several different forms of leishmaniasis in people: cutaneous leishmaniasis and mucocutaneous leishmaniasis causing ulcers in nose, throat and mouth causes skin sores, viscreral leishmaniasis causes systemic disease Without treatment, most patients with the visceral disease will die and those with diffuse cutaneous disease can suffer long infections associated with secondary life-threatening infections. The sand flies that carry the parasite typically reside in tropical and subtropical environments. Fatal epidemics have occurred in areas of Asia, East Africa, and South America.

Leishmaniasis is due to protozoan parasites from the *Lishmania* species. The parasite lives and multiplies inside the female sand fly. This insect is most active in humid environments during the warmer months and at night, from dusk to dawn. Domestic animals, such as dogs, can serve as reservoirs for the parasite. Transmission may occur from animal to sand fly to human. Humans can also transmit the parasite between each other through a blood transfusion or shared needles. In some parts of the world, transmission may also occur from human to sand fly to human. Different species of the *Leishmania* parasite are associated with each from. Experts believe that there are about 20 *Leishmania* species that can transmit the disease to humans.

4.4.1. Visceral leshmaniasis

Visceral leishmaniasis is sometimes known as systemic leishmaniasis or kala azar. It usually occurs two to eight months after being bitten by a sand fly. It damages internal organs, such as your spleen and liver. It also affects your bone marrow, as well as your immune system through damage to these organs. The condition is almost always fatal if it's not treated.

Symptoms often don't appear for months after the bite with this type of leishmaniasis. Most cases are apparent two to six months after the infection occurred. People who develop clinical evidence of infection usually have fever, weight loss, enlargement (swelling) of the spleen and liver, and abnormal blood tests. People may have low blood counts, including a low platelet count (thrombocytopenia). Common signs and symptoms include:

- weight loss
- weakness
- fever that lasts for weeks or months
- enlarged liver

- decreased production of blood cells
- bleeding
- other infection
- swollen lymph nodes

4.4.2. Post Kala-Azar Dermal Leishmaniasis (PKDL)

Kala-Azar is a slow progressing indigenous disease caused by a protozoan parasite of the genus *Leishmania.* The parasite primarily infects the reticulio-endothelial system and may be found in abundance in bone marrow, spleen and liver. Post Kala-Azar Dermal Leishmaniasis is a condition in which *Leishmania donovani* parasites invade in skin cells. The parasite resides and develops there and manifests as dermal lesions. Recently it is believed that PKDL may appear without passing through visceral stage. However, adequate data is yet to be generated on the common sighs and symptoms course of PKDL manifestation.

- Recurrent fever, intermittent, or remittent develop with often double rise of temperature.
- Loss of appetite, pallor and weight loss with progressive emaciation
- Weakness
- Skin – Dry, thin and scaly and hair may be lost. Light coloured person show grayish discoloration of the skin of hands, feet, abdomen and face which gives the Indian name Kala - Azar meaning "Black fever".
- Anemia - develops rapidly
- Splenomegaly - spleen enlarges rapidly to massive enlargement, usually soft and non - tender.
- Liver - enlargement not to the extent of spleen, soft, smooth surface, sharp edge.

4.4.3. Cutaneous leishmaniasis

Cutaneous leishmaniasis causes ulcers on human skin. It's the most common form of leishmaniasis. Treatment may not always be necessary depending on the person, but it can speed healing and prevent complications.

Some people have a silent infection, without any symptoms or signs. People who develop clinical evidence of infection have one or more sores on their skin. The sores

can change in size and appearance over time. The sores may start out as papules (bumps) or nodules (lumps) and may end up as ulcers (like a volcano, with a raised edge and central crater); skin ulcers may be covered by scab or crust. The sores usually are painless but can be painful. Some people have swollen glands near the sores for example, under the arm, if the sores are on the arm or hand).

The main symptom of this condition is painless skin ulcers. Cutaneous symptoms may appear a few weeks after being bitten by an infected sand fly. However, sometimes simptoms won't appear for months or years.

4.4.4. Mucocutaneous leishmaniasis

A rare form of the disease, mucocutaneous leishmaniasis is caused by the cutaneous form of the parasite and can occur several months after skin ulcers heal. With this type of leishmaniasis, the parasites spread to your nose, throat, and mouth. This can lead to partial or complete destruction of the mucous membranes in those areas. Although mucocutaneous leishmaniasis is usually considered a subset of cutaneous leishmaniasis, it's more serious. It doesn't heal on its own and always requires treatment.

In people with the mucocutaneous form of the the disease, symptoms usually appear one to five years after the skin lesions. These are primarily ulcers in their mouth and nose or on their lips.

Other symptoms may include:

- runny or stuffy nose
- nosebleeds
- difficulty in breathing

4.4.5. Phlebotomas fever

Sand fly fever is a vector-borne viral infection and is endemic in many parts of the world, particularly in areas that are infected with different types of leishmaniasis. Clinical spectrum ranges from asymptomatic infection to very high fever and photophobia in patients.

Sand fly fever, also called 3-day fever, phlebotomus fever, pappataci fever is well known previously. Now a days the disease becames an inportant infection not for mortality (because no cases has been reported so far) but for very hard morbidity. In addition, the disease is more prevalent in conflict and wars. Sand fly fever is arboviruses and belongs to Bunyaviridea family and genus of Narioviurses, and more than six

serotypes of viruses including Karimabad, Salehabad, Sicilian, Naples, Tehran virus, and Toscana were introduced at present time. Rodents may be the main source of infection and the virus could come from these animals and infected patients. Transmission occurs via blood feeding either from rodents to human or from patients to susceptible populations and vertical transmission in sand flies. It is transmitted to humans by the bloodsucking female sand fly (notably *Phlebotomus papatasi, P. perniciousus*, and *P. perfiliewsi*).

Patients mostly experience high fever (>39^{0}C) with back pain, muscle pain, and photophobis during acute period of the disease. During the febrile period, fatigue and weakness and a low blood pressure and pulse may also be seen.

4.4.6. Control of sand fly

Sand flies breed in high relative humidity, warm temperature, high subsoil water and abundance of vegetation. Sand flies breed in favourable micro-climatic conditions mostly in the holes of soils in places with high organic matter that serve as food for larvae. These are ecologically sesitive insects, fragile and cannot withstand desiccation. Cleaning of cattle sheds and ther organic matter and closing of pot holes reduce the breathing space of sand flies.

4.5 Study of house fly as important mechanical vector, myiasis, and control of house fly.

4.5.1. Study of house fly as important mechanical vector

The flies of the superfamily Muscoidea, family Muscidae belongs to order diptera. Some of these are commonly known as house flies or stable flies due to their synanthropy. The house fly (*Musca domestica*) is a fly of the suborder Cyclorrhapha. Adults are grey to black, with four dark, longitudinal lines on the thorax, slightly hair bodies, and a single pair of membranous wings. They have red eyes, set farther apart in the slightly larger female. The female housefly usually mates only once and stores the sperm for later use. She lays batches of about 100 eggs on decaying organic matter such as food waste, carrion, or faeces. These soon hatch into legless white larvae, known as maggots. After 2 to 5 days of development, these metamorphose into reddish-brown pupae, about 8 mm (0.3 in) long. Adult flies normally live for 2 to 4 weeks, but can hibernate during the winter. The adults feed on a variety of liquid or semiliquid substances, as well as solid materials which have been softened by their

saliva. They can carry pathogens on their bodies and in their faeces, contaminate food, and contribute to the transfar of food-borne illnesses, while, in numbers, they can be physically annoying.

The Muscidae include approximately 5,000 species in 200 genera. Several species of these genera are of medical or veterinary concern, From the medical and veterinary point of view, the most important are species causing irritation to people and animal due to their numerous occurrence, vectors of pathogenic microorganisms, biting species feeding on blood, and those that reveal parasitic behavior in immature stages. However, in larval stages, muscids can be often found in an variety of decomposing organic matter of animal and plant origin. They can reveal saprophagous or either facultative or obligatory predatory behavior. Adults of many species are passive vectors of pathogens for diseases such as typhoid fever, dysentery, anthrax, and African sleeping sickness.

4.5.2. Myiasis

Myiasis is the parasitic infestation of the body of live vertebrates (humans and/ or animals) by fly larvae (maggots) that grow inside the host while feeding on its tissue. Myiasis is infection with a fly larva, usually occurring in tropical and subtropical areas. There are several ways for flies to transmit their larvae to people. Some flies attach their eggs to mosquitoes and wait for mosquitoes to bite people. their larvae then enter throug these bites. Other flies larvae burrow into skin. Although flies are most commonly attracted to open wounds and urine- or feces-soaked fur, some species (including the most common myiatic flies–the botfly, blowfly, and screwfly) can create an infestation even on unbroken skin and have been known to use moist soil and non-myiatic flies (such as the common housefly) as vector agents for their parasitic larvae.

How myiasis affects the human body depends on where the larvae are located. Larvae may infect dead, necrotic or living tissue in various sites: the skin, eyes, ears, stomach and intestinal tract, or in genitourinary sites. They may invade open wounds and lesions or unbroken skin. Some enter the body through the nose or ears. Larvae of eggs can reach the stomach or intestines if they are swallowed with food and cause gastric or intestinal myiasis.

Worldwide, the most common flies that cause the human infestation are *Dermatobia hominis* (human botfly) and *Cordylobia anthripophaga* (tumbu fly).

Because some animals (particularly domestic animals) cannot react as effectively

as humans to the causes and effects of myiasis, such infestations present a severe and continuing problem for livestock industries worldwide, causing severe economic losses where they are not mitigated by human action.

Several different presentations of myiasis and their symptoms:

Syndrome	Symptoms
Cutaneous myiasis	Painful, slow-developing ulcers or furuncle-(boil-) like sores than can last for a prolonged period
Nasal myiasis	Obstruction of nasal passages and severe irritation. In some cases facial edema and fever can develop. Death is not uncommon.
Aural myiasis	Crawling sensations and buzzing noises. Smelly discharge is sometimes present. If located in the middle ear, larvae may get to the brain.
Ophthalmomyiasis	Fairly common, this causes severe irritation, edema, and pain.

Furuncular myiasis: itching, a sensation of movement and sometimes sharp, stabbing pain. At first, people have a small red bump that may resemble a common insect bite or the beginning of a pimple (furuncle). Later, the bump enlarges, and a small opening may be visible at the center.

Occasionally there are three main fly families causing economically important myiasis in livestock and also in humans:

- Calliphoridae (blowflies)
- Oestridae (botlfies)
- Sarcophagidae (fleshflies)
- Other families occasionally involved are:
- Anisopodidae
- Piophilidae
- Stratiomyidae
- Syrphidae

4.5.3. Control of house fly

Flies can be killed directly by insecticides or physical means such as traps, sticky tapes, fly swats and electrocuting girds. However, they should preferably be controlled

by improving environmental sanitation and hygiene. This approach provides longer-lasting results, is more cost-effective and usually has other benefits.

1. Control of breeding of houseflies:

(a) Flies breed in stable manure, human faeces and garbage, these should be kept in closed cisterns, then removed by municipalities and be either buried underground or incinerated, as is done in many cantonment areas.

(b) City and village garbage may be spread out in fields so that it dries quickly to prevent egg-laying. If lime is added to manure it also prevents egg-laying. In China sodium cyanide solution is put into human faeces containers and it prevents eggs-lying successfully.

(c) Garbage and refuse may ne treated with insecticides, such as calcium borate which kills the larvae.

2. Protection of food:

If kitchens are screened and food is kept covered the flies cannot transmit disease, but this should be done on a large scale in public restaurants, in shops which sell sweets, and especially in keeping a city's milk supply free from files.

3. Killing adult housefly:

Many divices can be used for killing flies in a home:

(a) Fly swatters are used on dining tables, fly paper is put on windows and tables to which the flies get stuck and die.

(b) Hang wires smeared with a boiled mixture of four parts of resin and one part of castor oil, the flies sit on these wires and die.

(c) A few drops of 3% solution of formalin in a saucer of sweetened milk is kept in homes and restaurants, flies suck up this milks and die, but the milk should be rendered slightly alkaline to make it palatable to flies.

(d) Spray of pyrethroid based insecticides are effective against houseflies. Sometime attract housefly and hitimately killed.

(e) Some passite wasps are used as biocontrpagers for controling houseflies.

4.6 Summary

- Many dipteran insects acts as disease vectors.
- Dipterans like mosquitoes, sand fly, house fly etc. carries a range of

pathogens inside their body and also supports several life cycle stayes of these pathogens inside them.

- These vector borne diseases have several symptoms and mode of infection in human and other organisms.
- By approprite control of the vectors, these dipterans can be controlled in numbers as well.

4.7 Questions

1. State the symptoms of cutaneous myiasis.
2. What is aural myiasis?
3. Name four important diseases where *Aedes* act as vector.
4. What diseases are transmitted by *Culex?*
5. Write a note on sand fly as vector.
6. Name at least four diseases those are carried by house flies.
7. State some common symptoms of malaria.
8. Name the causative agent of Dengue hemorrhagic fever.
9. What is dengue shock syndrome?
10. State the symptoms of Chikungunya.
11. State the types of viral encephalitis.
12. Mention the possible symptoms of viral encephalitis.
13. What is lymphatic filariasis?
14. State the sign and symptoms of lymphatic filariasis.
15. State some measures of control of adult mosquitoes.
16. State the measures to control the larva of mosquitoes.
17. What is phlebotomus fever? Name the vector of the disease.
18. What is visceral leishmaniasis? State the symptoms of the disease.
19. What is PKDL?

4.8 Suggested readings

Dasgupta, B, 1986. Parasitology Including Entomology and Acarology. New Central Book Agency, Kolkata.

Hati, A. K. 1979. Medical Entomology. Allied Book Agency, India.

Johnson, N. and Triplehorn. C.A, 2004. Borror and De Long's Introduction to the Study of insects.

Loker, E. S. and Hofkin, B. V. 2015. Parasitology; A Conceptual Approach. Garland Science, New York.

Marcondes, C. B. (ed). 2017. Arthropod Borne Diseases. Springer. Marquardt, W. 2004. Biology of Disease Vectors. Academic Press, London. Mullen, G. R. And Durden, L. A. 2018. Medical Veterinary Entomology. Academic Press, London. Brooks/Cole.

Noble, G. A. and Noble, E. R. 1971. Parasitology: The Biology of Animal Parasites. Lea & Febiger, London.

Roberts, L. and Janovy Jr. J. 2008. Foundations of Parasitology. Me Graw-Hill, London.

Service, M. 2008. Medical Entomology for Students. Cambridge University Press. Cambridge.

Soulsby, E. J. L. 1968. Helminths, Arthropods & Protozoa of Domesticated Animals. 6th edition. Balliere, Tinacell & Cassell, London.

Unit 5 ❑ Siphonaptera as disease vectors. Fleas as important insect vectors; host-specificity, study of flea-borne diseases, plague, typhus fever; control of fleas.

Structure

5.0 Objectives

After studying this unit, learners will be able to understand the following:

- The different insect vectors belonging to Order Siphonaptera.
- Diseases caused by the vectors like fleas and the symptoms of these diseases.
- Controlling measures of fleas.

5.1 Introduction

Siphonaptera, the true fleas, are laterally compressed, wingless obligate ectoparasites. Adults are small, 1-10mm long, wingless, flattened from side to side, and have jumping hind legs. Spines on the body point to the rear of the insect, which allows them to move through the hair of an animal easily. The immature or larval stage is worm-like, quite different from the adults. They feed exclusively on the blood of mammals (94%) and birds (6%).

5.2 Siphonptera as disease vectors

Fleas are common especially those with cats or dogs. Fleas can be recognised by the following features:

General characteristics:

- Small, laterally flattened body (they look narrow when viewed from above)
- dark-colored
- wingless
- antennae short and clubbed
- bristles usually present on legs and body
- Piercing-sucking mouthparts
- Enlarged hind legs adapted for jumping
- Strong tarsal claws adapted for holding onto their hosts
- Backward pointing hairs and bristles for ease of movement through the hair of a host
- holometabolous metamorphosis (egg – larva – pula – adult)

5.3 Fleas as important insect vectors

All species are parasitic in the adult stage and possess mouthparts modified for piercing and sucking, highly modified combs and setae on their body and legs, and legs that are modified for jumping. Some species are vectors of disease.

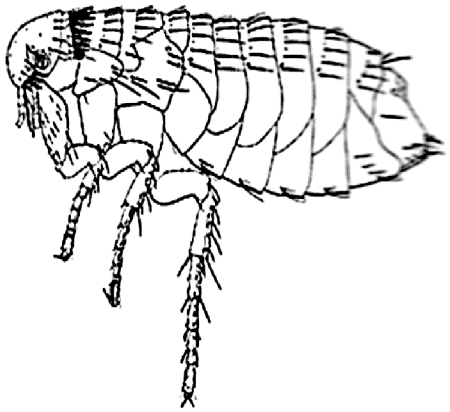

Figure 5.1 Diagram of *Ctenocephalides felis* (PULICIDAE)

Fleas are mainly vessel feeders, thus damaging blood vessels directly. Another, more concerning effect of this dietary preference is that fleas themselves are hosts to pathogens, and thus provide a natural avenue for pathogen dispersal. The two commonly known ways of pathogen transmission by fleas are by oral route through regurgitation of blood meals, or by fecal route, by contaminated fecal pellets. Specific examples of this will be given in the following sections.

5.4 Host-specificity

Host specificity is one of the most fundamental properties of parasitic organisms. In simple terms, host specificity can be defined as the number and identity of host species that are used by a parasite population. Host specificity varies among specialists that can parasitize one or only a few hosts to generalists that can use a wide variety of species.

Depending on host specificity parasites can be classified into following types:

Oioxenous parasite: A parasite that is specific for a single host species is call **Oioxenous parasite.** Example-HIV for human; *Eimeria tenella* (Intracellular protozoa) which infects only chickens.

Stenoxenous parasite: A parasite that parasitizes closely-related hosts is called **Stenoxenous parasite.** Example - Trichinellosis (trichinosis) is caused by nematodes (roundworms) of the genus *Trichinella* in many carnivorous and omnivorous **mammals.**

Euryxenous parasite: A parasite that parasitizes unrelated hosts is called **euryxenous parasite.** Exampel - *Toxoplasma gondi* for birds and mammals.

Host-specificity is determined by a complex of factors, some obvious and others still obscure.

Ecological specificity: The first requirement is that the prospective host shares its environment with the parasite; e.g. parasites of dolphins might not have much luck infecting humans who do not live near the sea (although modern food transport networks have changed this!).

Ethological specificity: Second requirement is that host behavior must expose it to the parasite; e.g. people who eat pork may acquire parasites intended for pig such as pork tape worm *Taenia solium.*

Physiological specificity: The final requirement is that once the parasite comes into contact with the host, it must recognize appropriate cues and feel comfortable within its new surroundings.

5.5 Study of flea-borne diseases

5.5.1. Flea-borne diseases

Despite continued efforts, we still lack much knowledge regarding the vectorial role of wild fleas. The most severe infection spread by fleas is plague, caused by the bacteria *Yersinia pestis.* Fleas are also known as vectors of murine typhus (endemic typhus, *Rickettsia typhi*), and Paly a role in the transmission of rural epidemic thyphus (*Rickettsia prowazekii*) in the USA. In recent years, the flea-borne spotted fever agent, *Rickettsia felis* has emerged and can be found throughout the world. Fleas have also been proven to harbor and sometimes transmit *Bartonella* spp, including *Bartonella henselae*, the agent of cat-scratch disease (CSD).

Additionally, fleas are hosting helminths: *Dipylidium caninum* and *Hymenolepis diminuta*, respectively parasites of carnivores and rats. Finally, in tropical areas, tungiasis caused by *Tunga penetrans* is a human disease directly linked to the parasitism of humans by fleas. However, to many of the general population, the insidious attacks by fleas on people and domestic animals causing irritation, blood loss, and severe discomfort are equally important as disease threat.

5.5.2. Plague

Plague, caused by *Yersinia pestis* is a zoonotic disease primarily affecting rodents, but that can affect human beings. Small outbreaks continue to occur throughout the

world; around 2000 cases are reported annually. Plague has recently been recognized as a re-emerging disease and remains a serious problem for international public health, especially in Africa. If used by the aerosol route of exposure as a bioterrorism agent, it could cause mass casualties. *Y. pestis* has been the cause of three recorded pandemics. At present, its circulations has been detected within populations of more than 200 species of wild rodents inhabiting natural plauge foci on all continents,except for Europe, Austrialia and Antarctica. The presistence of zoonotic foci is worrying, since persons living in these arease remain in close contact with rodents and fleas.

Morbidity in humans is noted, as a rule, when rodent epizootics are spreading, and is a conseqence of mainly flea bites, but also direct contact with infected animal tissues, the consumption of insufficiently cooked meat products, or the inhalation of aerosolized respiratory excreta of animals or patients with the pneumonic form of infection.

Important flea vectors include *Xenopsylla cheopts* (nearly worldwide in moderate climates), *Xenopsylla brasilliensis* (Africa, India, and South America), *Xenopsylla astia* (Indonesia and Southeast Asia), *Xenopsylla vexabilis* (pacific islands), and *N. fasciatus* (nearly worldwide in cool, temperate climates).

Plague can have several clinical manifestations; bubonic plague is the most common. Other manifestations include septicemic plague without bubo, pneumonic plague (primary or secondary to bacteremia), meningitis and pharyngitis. Following an incubation period of two to five days, plague has a sudden onset of fever, chills, headache, myalgia and nausea. Pneumonic plague is rapidly fatal if untreated.

5.5.3. Typhus fever

Typhus, also known as typhus fever, is a group of infectious diseases that include epidemic typhus, scrub typhus, and murine typhus. Common symptoms include fever, headache and a rash. Typically these begin one to two weeks after exposure. Typhus fevers are group of diseases caused by bacteria that are spread to humans by fleas, lice, and chiggers. Typhis fevers include scrub typhus, murine typhus, and epidemic typhus. Chiggers spread scrub typhus, fleas spread murine typhus and body lice spread epidemic typhus. The most common symptoms are fever, headaches and sometimes rash.

Murine typhus is a worldwide zoonosis, also known as flea-borne, rat, urban and endemic typhus. The etiologic agent *Rickettsia typhi* (formerly *mooseri*) is transferred from a rodent reservoir by an arthropod (often X. cheopis) to humans. Many recent

reports stress this as a re-emerging disease, which spreads through travelers returning from endemic regions.

R. typhi infects endothelial cells in mammalian hosts and midgut epithelial cells in the fleas host. It is passed in the flea's feces, and transmission to humans is by fecal contamination.

Incubation periods range from 6 to 14 days. Many of its symptoms are shared with other infectious diseases and thus cases may be overlooked without a laboratory confirmed diagonosis. The most common clinical manifestations are high fever, severe headache chills, myalgia, weakness, and nausea. The pathognomonic rash is described as mucular (49%), maculopapular (29%), papular (14%), petechial (6%) and morbiliform (3%), usually centrally distributed on the trunk, but also found on the extremities.

Patients respond rapidly to treatment with tetracycline, doxycycline or fluoroquinolone. Untreated patients show signs for two to three weeks and a significant number are hospitalized, with up to 10% requiring intensive care.

Symptoms of epidemic typhus begin within 2 weeks after contact with infected vector.

Signs and symptoms may include:

- Fever and chills
- Headache
- Rapid breathing
- Body and muscle aches
- Rash
- Cough
- Nausea
- Vomiting
- Confusion

5.6 Control of fleas

The best flea control approach for home and pet is to interrupt the flea life cycle. Low impact methods for controlling abult fleas, eggs and larvae include regular

vacuuming and laundering, along with pet bathing or grooming. If the situation requires a pesticide, opt for low toxicity options. such as boric acid and cu IGR (Insect Growth Regulartor) spray.

5.7 Summary

- Fleas belonging to order Siphonaptera, are responsible for causing a number of diseases in humans and other organisms.
- Plague, typhus fever etc. are major disease conditions, caused caused by the fleas.
- The feas can be controlled by interrupting their life cycle or by approprite use use fo pesticides.

5.8 Questions

1. Write a not on Siphonaptera as disease vector.
2. State the characteristics of Siphonaptera.
3. Define euryxenous parasite with example.
4. what is ethological specificity of a disease?
5. Write a note on plague.
6. What is typhus fever? Mention the symptoms of the disease.
7. State the measures of control of fleas.
8. Name the causative agents of plague and typhus fever.
9. Name some flea species those act as vectors of various diseases.

5.9 Suggested readings

Dasgupta, B. 1986. Parasitology Including Entomology and Acarology. New Central Book Agency, Kolkata.

Hati, A. K. 1979. Medical Entomology. Allied Book Agency, India.

Johnson, N. and Triplehorn, C.A. 2004, Borror and De Long's Introduction to the Study of insects.

Loker. E. S. and Hofkin, B. V. 2015. Parasitology: A Conceptual Approach. Garland Science, New York.

Marcondes, C. B, (ed). 2017. Arthropod Borne Diseases. Springer.

Marquardt, W. 2004. Biology of Disease Vectors. Academic Press, London.

Mullen, G. R. And Durden. L. A. 2018. Medical Veterinary Entomoloev. Academic Press, London. Brooks/Cole.

Noble, G. A. and Noble, E. R. 1971. Parasitology: The Biology of Animal Parasites. Lea & Febiger, London.

Roberts. L. and Janovy Jr. J. 2008. Foundations of Parasitology. Me Graw-Hill, London.

Service, M. 2008. Medical Entomology for Students. Cambridge University Press. Cambridge.

Soulsby, E. J. L. 1968. Helminths, Arthropods & Protozoa of Domesticated Animals. 6th edition, BaJliere, Tinacell & Cassell, London.

Unit 6 ❑ Siphunculata as disease vectors. Human louse (head, body and pubic louse) as important vectors; study of louse-borne diseases- typhus fever, relapsing fever, trench fever, vagabond's disease, pthiriasis; control of human louse.

Structure

6.0 Objectives

After studying this unit, learners will be able to understand the following:

- The different insect vectors belonging to Order Siphunculate.
- Diseases caused by the vectors like louse and the symptoms of these diseases.
- Controlling measures of human louse.

6.1 Introduction

Siphunculate (Anoplura) : (row Phthiraptera), an order of secondarily wingless insects comprising the sucking lice: blood-sucking ectoparasites of mammals, with piercing and sucking mouthparts forming a snout like proboscis. They constitute an irritating pest to humans and domestic animals and can transmit diseases, including typhoid.

Lice are parasitic insects which spend their entire life cycle on the host, never voluntarily leaving it except to transfer to a new host; both sexes of the adult and all nymphal stages suck blood. They are highly host specific, so if an animal louse transfers to a human it will be unble to establish an infection.

They are characterized as follows:

- Small, wingless parasites of mammals
- Head narrow and eyes reduced or absent
- Antennae short (3-5 jonted)
- Piercing/sucking mouthparts, retracted into head when not feeding
- Feeds solely on blood injecting an anticoagulant to allow free flow for feeding
- Each leg ends in a strong claw well-developed for clinging to the host
- Eggs are usually stuck on to the host's hair and hatch when the temperature is sufficiently high
- Nearly all species of mammals are infected including seals and whales
- The Anoplura are sometimes combined with the Mallophaga into one order called the Phthiraptera.

6.2 Human louse (head, body and pubic louse) as important vectors

There are three types of lice that infest humans:

- head louse (*Pediculus humanus capitis*)
- body louse (*Pediculus humanus corporis*)
- Pubic louse (*Pthirus pubis*)

All three insects are obligate human parasites. Contrary to popular belief, these

insects do not hop, jump or fly. Rather, the are transmitted by person-to person contact.

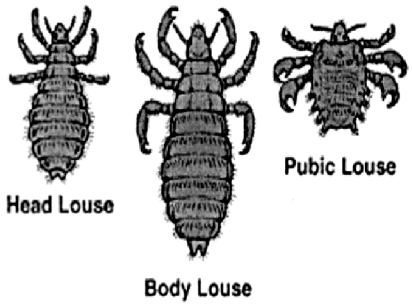

Figure 6.1 Three types of human louse

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

The **head louse** is an obligate ectoparasite of humans that causes head lice infestation. Head lice are wingless insects spending their entire lives on the human scalp and feeding exclusively on human blood. Head lice are tiny, wingless, parasitic insects that live in human hair. They are a common problems and highly contagious. They can also be hard to get rid of. The eggs are known as nits. Human head and body lice attach their eggs respectively to human hair or clothing by female lice secreted glue that hardens into a nit sheath that protects the egg.

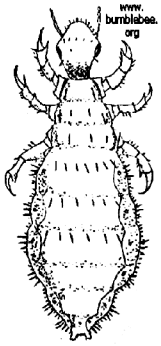

Figure 6.2 *Pendiculus humanus, the human louse*

- Head lice are tiny insects that live on the scalp,
- They can move easily between hairs, at a rate of 9 inches a minute, but they cannot fly or jump.
- The lice need human blood to survive, and they starve within 2 days if they are removed from their host.

- Head lice are usually caught directly from another person through direct head-to-head contact. Pets do not play a role.
- Treatment involves over-the-counter (OTC) or prescription medication, but resistance to these treatments is growing.

Itching is the most common symptom of an infestation. This is due to an allergic reaction to louse saliva. Some people are extremely sensitive to louse bites and have severe itching. Others are not allergic to the saliva, or they build up a tolerance and have little or no itching even with repeated infestations.

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

Body lice resemble head lice, but prefer to live in clothing except when they crawl on to the body to feed. Outbreaks of body lice are usually associated with large numbers of people living in close quarters under poor sanitation. Transfer of body lice can occur from shared bedding or clothing.

The body louse is a hematophagic louse that infests humans. The condition of being infested with head lice body lice, or pubic lice is known as pediculosis. Body lice are vectors for the transmission of the human diseases epidemic typhus, trench fever, and relapsing fever.

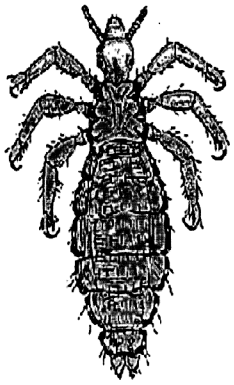

Figure 6.3 body louse (*Pediculus humanus corporis*)

The body louse is the vector of three human diseases – epidemic or louse-borne typhus, caused by *Rickettsia prowazeki* trench fever, caused by *Rochalimaea quintana* (long known as *Rickettsia quintana*); and louse-borne relapsing fever, caused by *Borrellia recurrentis*. These diseases are not presently being reported from the United States, but their intrduction at some future time is not impossible if body louse

infestations should become sufficiently prevalent. Although head lice have been experimentally infected with *Rickettsia prowazeki*, neither head lice nor public lice have been implicated directly in active disease transmission. Although body lice may pose the most serious health threat in many countries, head lice appear to be the greatest nuisance, particularly anong school children in highly developed countries where their presence is considered intolerable.

- **Pubic louse (*Pthirus pubis*)**

Pthirus is a genus of lice. There are only two extant species. *Pthirus gorillae* infests gorillas, and *Pthirus pubis* afflicts humans, and is commonly known as the carb louse or public louse.

Pubic lice, also known as carb lice or crabs, are tiny, parasitic insects that feed on blood. They spread easily and affect the human genitals, causing itching and red spots. Pubic (crab) lice usually infest the pubic area, but also may be found on other hairy areas of the body. Transfer of carb lice between individuals usually requires intimate personal contact because the lice cannot survive longer than 24 hours off the host. Pubic lice (*Pthirus pubis*) maintain a worldwide parasitic population infesting two to over 10 percent of human populations, continuing a presence that has been constant since early evidence 10,000 years ago. Pubic lice are adapted to a sedentary life style on pubic hair, and sometimes on eyelashes and body hair, not often leaving the infested body.

- Having pubic lice does not necessarily reflect poor hygiene.
- The most common symptom of crabs is itching.
- Pubic lice can spread to other parts of the body that are covered in hair, including chests, beards and eyelashes.
- Clothes and bedding should be washed in hot water to remove pubic lice.

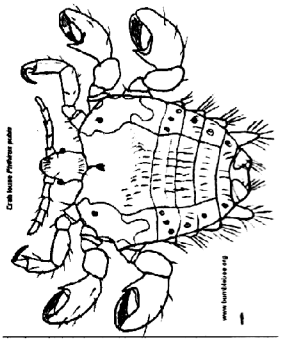

Figure 6.4 Crab louse *Phthirus pubis*

Pubic lice are not known to transmit disease. Adult pubic lice are 1.1-1.8 mm in length. The pubic hair can typically host up to a dozen on average. Pubic lice typically are found attached to hair in the pubic area but sometimes are found on coarse hair elsewhere on the body (for example, eyebrows, eyelashes, beard, mustache, chest, armpits etc.). Crab lice attach to pubic hair that thicker than other body hair because their claws are adapted to the specific diameter of pubic hair. Pubic lice infestations (pthiriasis) are usually spread through sexual contact.

6.3. Study of louse-borne diseases-typhus fever, relapsing fever, trench fever, vagabond's disease, phthiriasis; control of human louse.

6.3.1. Typhus fever

Typhus is a disease caused by infection with one or more rickettsial bacteria. Fleas, mites (chiggers), lice or ticks transmit it when they bite you. When the above arthropods carrying around rickettsial bacteria bite someone, they transmit the bacteria that cause typhus. Scratching the bite further opens the skin and allows the bacteria greater access to the bloodstream. Once in the bloodstream, the bacteria continue to reproduce and grow.

There are three different typhus:

- Epidemic (murine) typhus
- Endemic (murine) typhus
- Scrub typhus

Typhus is not transmitted from person to person like a cold or the flu. There are three different types of typhus, and each type is caused by a different type of bacterium and transmitted by a different type of arthropod.

• Epidemic /louse-borne typhus

This type is caused by *Rickettsia prowazekii* and carried by the body louse, and possibly by ticks as well. It can be found around the world, including in the United States, but is typically found in areas of high population and poor sanitation, where conditions promote lice infestation.

• **Endemic typhus**

Alternatively known as murine typhus, this type is caused by *Rickettsia typhi* and is carried by the rat flea. Endemic typhus can be found worldwide. It may be found among people in close contact with rats.

• **Scrub typhus**

This type is caused by *Orientia tsutsugamushi* and carried by mites in their larval stage when they are chiggers. This type of typhus is more commonly found in Asia, Australia, Papua New Guinea, and the Pacific Islands. It's also called tsutsugamushi disease. The louse, flea, tick or mite becomes a arrier of the bacteria when they feed of the blood of an infected person (epidemic typhus) or an infected rodent (any of the three typhus forms mentioned above).

Symptoms vary slightly by the type of typhus, but there are symptoms that are associated with all three types of typhus, such as:

- headache
- fever
- chills
- rash

Symptoms of epidemic typhus usually appear suddenly and include:

- severe headache
- highfever (above 102.2^{0}F)
- rash that begins on the back or chest and spread
- confusion
- stupor and seeming out of touch with reality
- low blood pressure (hypotension)
- eye sensitiviey to bright lights
- severe muscle pain

The symptoms of endemic typhus last for 10 to 12 days and are very similar to the symptoms of epidemic typhus but are usually less severe. They include:

- dry cough
- nausea and vomiting
- diarrhea

6.3.2. Relapsing fever

Relapsing fever is a type of fever caused by various spirochete bacteria where the infection results in recurrent episodes of fever with an intermittent period of remission. **Relapsing fever** is a vector-borne disease caused by infection with certain bacteria in the genus *Borrelia,* which is transmitted through the bites of lice or soft-bodies ticks

Relapsing fever is of two types depending on the vector of tranmission involved. Even the infectious agents are different in both types.

- Tick-borne
- Louse-borne

Tick-borne fever is reported worldwide, except Antarctica, Australia and the Pacific Southwest.

Louse-borne fever occurs in areas of war, famine, mass migrations, or overcrowding like refugee camps. Louse-borne relapsing fever epidemics were common in Europe during the 20th century. Now, these are found in Ethopia and Sudan, especially during the rainy season. The louse-borne relapsing fever is more lethal and mortality rate reported is 30-70% without treatment during epidemics and about 5% with treatment.

Along with *Rickettsia prowazekii* and *Bartomella quintana, Borrelia recurrentis* is one of three pathogens of which the body louse (*Pediculus humanus humanus*) is a vector. Louse-borne relapsing fever is more severe than the tick-borne variety.

Relapsing fever has no racial or gender predilection. However, Tick-borne occurs more often in males [probably due to greater exposure to ticks] whereas louse-borne has slight female preponderance. Both relapsing fevers are more common in children. Louse-borne relapsing fever occurs in epidemics amid poor living conditions, famine and war in the developing world. It is currently prevalent in Ethiopia and Sudan.

Most people who are infected develop sickness between 5 and 15 days after they are bitten. The symptoms may include a sudden fever, chills, headaches, muscle or joint aches, and nausea. A rash may also occur. These symptoms usually continue for 2 to 9 days, and then disappear. This cycle may continue for several weeks if the person is not treated.

6.3.3. Trench fever

A highly contagious rickettsial disease transmitted by lice that infested soldiers in the trenches in the First World War. Trench fever (also known as "five-day fever",

"quintan fever" (*fevris quintana* in Latin), and "urban trench fever") is a moderately serious disease transmitted by body lice. The disease is caused by the Gram-negative bacterium, *Bartonella quintana* (older names: *Rochalimea quintana, Rickettsia quintana*), found in the stomach walls of the body louse. *B. quintana* is closely related to *Bartonella henselae,* the agent of cat scratch fever and bacillary angiomatosis.

The disease is classically a five-day fever of the relapsing type, rarely exhibiting a continuous course. The incubation period is relatively long, at about two weeks. The onset of symptoms is usually sudden, with high fever, severe headache, pain on moving the eyeballs, soreness of the muscles of the legs and back, and frequently hyperaesthesia of the shins. The initial fever is usually followed in a few days by a single, short rise but there may be many relapses between periods without fever. The most constant symptom is pain in the legs. Recovery takes a month or more. Lethal cases are rare, but in a few cases "the persistent fever might lead to heart failure". The after effects of the disease include neurasthenis, cardiac disturbances and myalgia.

6.3.4. Vagabond's disease

A conditions of pigmentation of the skin caused by long continued exposure, uncleanliness, and especially by scratch marks and other lesions due to the presence of body lice. The topic Vagabond's Disease is a synonym, or alternative name, or is closely related to the medical condition **Pediculosis.** Body louse infestation is also known as vagabond disease, and individuals who have an infestation for many years can develop a condition termed vagabond skin. The skin becomes thickened and darkened after years of bites and subsequent rubbing and excoriations. Pediculosis corporis is a cutaneous condition caused by body lice (specifically *Pediculus corporis*) that lay their egg in the seams of clothing.

Vagabond's leukomelanoderma is a skin disorder found in the elderly with a combination of dietary dificiency and lack of hygiene, resulting in an infestation of *Pediculus humans.* It presents with hypomelanosis related to scratching superimposed on background of diffuse hypermelanosis especially of the ankles, axillae, groin, inner thighs and the back of the neck.

The main symptom is intense itching in the affected areas. This itching is not caused by the louse bite but by the insect's saliva that irritates the skin. The itching becomes more intense after 3-4 weeks of lice infestation. The continuous scratching may cause skin abrasion or excoriations.

6.3.5. Phthiriasis

Phthiriasis palpebrarum is a rare type of eyelid infestation caused by *Phthirus pubis*, commonly known as carb lice. Although their primary habitat is pubic hair, these lice are often found on the hair of the abdomen, things and the axilla, and occasionally they may invade the eyebrows and eyelashes. More extensive infestations usually occur in males with more body hair-bearing regions than females.

Infestation of lid margins by the carb louse (*Phthirus pubis*), a blood feeding obligate ectoparasite affecting only humans.

- Carb lice infest coarsely spaced hair, predominantly pubic hair
- lashes also provide ideal spacing
- genital-to eye transmission, possibly on bedding and towels
- carb lice survive no more than two days if separated from human host
- this insect is not a vector for other diseases
- in severe cases, lice faeces can cause keratoconjunctivitis

6.3.6. Control of human louse

Of the three lice (head, body, and pubic louse) that infest humans, the body louse is the species involved in epidemics of louse-borne typhus, trench fever, and relapsing fever, but all the three cause pediculosis. Removing lice by hand or with a lice comb, heating infested clothing and shaving the scalp were some of the oldest methods of controlling human lice. Despite the introduction of other resources including cresol, naphthalene, sulpher, mercury, vinegar, petroleum and insecticides, the numbers of lice infestation cases and resistance have increased. Today, the development of new treatment strategies such as symbiotic treatment and synergistic treatment (antibiotics+invermectin) *in vitro* has proved effective and is promising.

To get rid of lice, take the following important steps:

1. Bathe regularly to get rid of lice and their eggs.
2. Change your clothes often.
3. Wash clothes in hot water (at least 130^{0}F/54^{0}C) and machine dry using the hot cycle.
4. Don't share items that touch the head like combs or towels.
5. Avoid activities that lead to head-to-head contact.
6. Keep belongings, especially upper body clothing, aways from shared areas like coat closets.

6.4 Summary

- Insect organisms, belonging to Order Siphunculata, are secondarily wingless, comprising the sucking lice. These are blood-sucking ectoparasites of mammals.
- Louse can live in different parts of human body like the head, other parts of body or in public region.
- The different luse-borne diseases are typhus fever, relapsing fever, trench fever, vagabond's disease, pthiriasis etc.

6.5 Questions

1. State the features of Siphunculata.
2. Write the scientific names of louse those infest human.
3. State the characters of head lice.
4. What dieases are transmitted by body louse?
5. Mention the types of typhus fever.
6. What is scrub typhus?
7. State the symptoms of epidemic typhus.
8. What is relapsing fever?
9. What is trench fever?
10. What is Vegabond's leukomelanoderma?
11. How to get rid of human louse?

6.6 Suggested readings

Dasgupta, B. 1986. Parasitology Including Entomology and Acarology. New Central Book Agency, Kolkata.

Hati, A. K. 1979. Medical Entomology. Allied Book Agency, India.

Johnson, N. and Triplehorn, C.A. 2004, Borror and De Long's Introduction to the Study of insects.

Loker. E. S. and Hofkin, B. V. 2015. Parasitology: A Conceptual Approach. Garland Science, New York.

Marcondes, C. B, (ed). 2017. Arthropod Borne Diseases. Springer.

Marquardt, W. 2004. Biology of Disease Vectors. Academic Press, London.

Mullen, G. R. And Durden. L. A. 2018. Medical Veterinary Entomoloev. Academic Press, London. Brooks/Cole.

Noble, G. A. and Noble, E. R. 1971. Parasitology: The Biology of Animal Parasites. Lea & Febiger, London.

Roberts. L. and Janovy Jr. J. 2008. Foundations of Parasitology. Me Graw-Hill, London.

Service, M. 2008. Medical Entomology for Students. Cambridge University Press. Cambridge.

Soulsby, E. J. L. 1968. Helminths, Arthropods & Protozoa of Domesticated Animals. 6th edition, BaJliere, Tinacell & Cassell, London.

Unit 7 ❑ Hemiptera as disease vectors. Bugs as insect vectors; blood-sucking bugs; Chages disease, bed bugs as mechanical vectors, control and prevention measures.

Structure

7.0 Objectives

After studying this unit, learners will be able to understand the following:

- The different insect vectors belonging to Order Hemiptera.
- Diseases caused by the vectors like different types of bugs and the symptoms of these diseases.
- Controlling measures of different types of bugs.

7.1 Hemiptera as disease vectors

Hemiptera is the insect order with the common name of bugs. The family Reduviidae has predacious, plant-feeding and blood-feeding insects. All are hemimetabolous, developing through five nymphal instars. Nymphs and adults live associated with nests, burrows, or habitations of their hosts. Kissing bugs can be very selective for their hosts; some are associated exclusively with birds, others with bats,

and so on. Kissing bugs are vectors of *Trypanosoma cruzi,* the causative agent of Chagas' cisease. This disease has zoonotic cycle, as well as an endemic cycle. Thus, vectors maintaining the zoonotic cycle are associated with wildlife or domesticated animals, and vectors associated with human disease are found in the domestic environment.

Other species may be found within the peridomestic environment, particularly in chicken pens, stables, woodpiles that harbor rodents and so forth. Some species of the genera *Triatoma, Panstronglus* and *Rhobnius* became highly adapted to the human environment.

7.2 Bugs as insect vectors

There are a wide variety of bugs that exist in nature. Some bugs are helpful, other bugs are harmful, and some are just plain nuisances. Humans have interacted with the Hemiptera for millennia. The bed bug is a persistent parasite of humans. A few hemipterans are heamatophagic (often described as "parasites"), feeding on the blood of larger animals. These include bedbugs and the triatomine kissing bugs of the assassin bug family Reduviidae, which can transmit the dangerous *Chagas disease.*

7.3 Blood-sucking bugs

Blood-sucking bugs are parasites that feed on human and other mammal hosts and have the potential to transmit disease.

7.4 Chagas disease

Exotic vector-borne disease have emerged as public health threats due to increasing globalization and transfer fo goods, along with travel and immigration. Chagas is a protozoan disease of particular importance in the United States, because ~300,000 Latin American immigrants may be infected. The risk of infection by transfusion was of such great concern that screening for Chagas was instituted for the US blood supply in 2007.

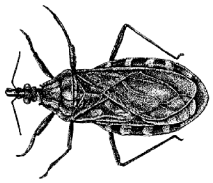

Figure 7.1. Drawing of a triatomine bug, the vector of Chagas disease.

Chagas disease is one of the most important yet neglacted parasitic diseases in Mexico and is transmitted by Triatomina. Nineteen of the 31 Mexican triatomine species have been consistently found to invade human houses and all have been found to be naturally infected with *Trypanosoma Cruzi*. Chagas disease in an inflammatory skin changes (chagomas) and may eventually cause infection and inflammation of many other body tissues, especially those of the heart and intestinal tract.

Signs and symptoms

Chagas disease presents itself in 2 phases. The initial acute phase lasts for about 2 months after infection. During the acute phase, a high number of parasites circulate in the blood but in most cases symptoms are absent or mild and unspecific. In less than 50% of people bitten by a triatomine bug, characteristic first visible signs can be a skin lesion or a purplish swelling of the lids of one eye. Additionally, they can present fever, headache, enlarged lymph glands, pallor, muscle pain, difficulty in breathing, swelling, and abdominal or chest pain.

During the chronic phase, the parasites are hidden mainly in the heart and digestive muscles. Up to 30% of patients suffer from cardiac disorder and up to 10% suffer from digestive (typically enlargement of the oesophagus or colon), neurological or mixed alterations. In later years the infection can lead to sudden death due to cardiac arrhythmias or prograssive heart failure caused by the destruction of the heart muscle and its nervous system.

Transmission

In Latin America, *T. cruzi* parasites are mainly transmitted by contact with faeces/ urine of infected blood-sucking triatomine bugs. These bugs vectors that carry the parasites, typically live in the wall or roof cracks of poorly-constructed homes in rural or suburban areas. Normally they hide during the day and become active at night when they feed on mammalian blood, including human blood. They usually bite an exposed area of skin such as the face (hence its common name 'kissing bug') and the bug defecates or urinates close to the bite. The parasites enter the body when the person instinctively smears the bug faeces or urine into the bite, the eyes, the mouth, or into any skin break.

T. cruzi can also be transmitted by:

- Consumption of food contaminated with *T. cruzi*.
- Blood or blood product transfusion from infected donors;

- Passage from an infected mother to her newborn during pregenancy or childbirth;
- Organ transplants using organs from infected donors; and
- Laboratory accidents.

7.5. Bed bugs as mechanical vectors

Bed bugs are parasites in the cimicidae family. They get their name from their preferred abode: beds, bedding, or other similar areas where humans sleep. Bed bugs are parasitic insects that feed on the blood of humans and other warm-blooded organisms. Bed bugs are resilient. They can enter a hibernation type state where they can go for approximately a year without feeding. This resiliency can make them very hard to eradicate. The 2 cosmopolite species, *Cimex lectualarius* and *Cimex hemipterus,* feed on humans and/or domestic animals, and recent outbreaks have been reported in western countries. Numerous authors have postulated that these species could transmit pathogens to humans.

Bed Bugs are one of the most important pests in the world. They live in furniture and matteresses, popping out of hiding to feast on human blood for 5 minutes each night. People with a bed bug problem often have multiple bites, particularly around the chest, neck, and upper arms. Bed bugs like Carbon Dioxide, which we exhale, so they generally stay near our upper bodies.

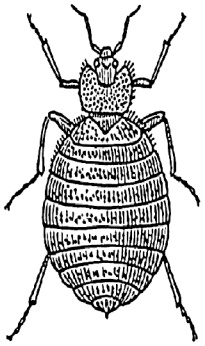

Figure 7.2 Drawing of a bed bug.

Bedbugs have been suspected of transmitting over 40 infectious microorganisms. In contrast to that for mosquitoes or ticks, the literature evidence level for disease transmission by bedbugs is very heterogeneous and sometimes incomplete.

Q fever is a cosmopolite disease transmitted by aerosolization of *Coxiella burnetii* spores contained in goat, sheep, or cattle bedding or by consumption of unpasteurize milk products. It has transstadial transmission (i.e. pathogen remains with the vector from one life stage to the next).

Aspergillus spp, along with various other molds (eg, *Penicillium* spp and *Seopulariopsis* spp) and bacteria (eg, *Enterobacter* spp and *Staphylococcus* spp), have been found on bedbugs. Like any biting or walking insect (such as cockroaches), bedbugs can be very good transporters and thus can participate in spreading molds.

According to the literature, Hapatitis B virus (HBV) is the best candidate for transmission by bedbugs. However, HBVhas frequently been detected in wild bedbugs.

Some bacterial agents are likely to be obligate endosymbionts necessary for bedbug survival and evolution (eg, *Wolbachia* spp and other proteobacteria), whereas others are likely to be transstadially transmitted, such as HBV. Hence, the bedbug might only play the role of vector in pathogen tranmission and, consequently, may be involved in human disease. Recent studies reported that bed bugs may act as competent vectors for pathogens, such as *Bartonella quintana* and *Trypanosoma cruzi*, the causes of trench fever and Chagas disease, respectively. Additionally, other members of the family Cimicidae are competent vectors for arboviruses for birds and, also likely for wild bats.

7.6 Control and prevention measures

Control of kissing bugs is relatively simple compared to that of other vector-borne disease. As zoonotic cycles continue to exist, Chagas' disease may disappear for a time in some areas only to reemerge later as favorable conditions reappear and a bridge from the sylvatic (the fraction of pathogen population's lifespan spent cycling between wild animals and vectors) to the human disease cycle takes place. Accordingly, studies emphasis on bugs is shifting from domestic species to those that are peridomestic and may serve as bridge vectors.

Control of Triatomine (Hemiptera, Reduviidae) is a primary component of strategies to halt the transmission of Chagas disease, with serological screening of blood donors to reduce the likelihood of transmission through infected blood transfusions.

T. cruzi can infect several species of the triatomine bugs, the vast majority of

which are found in the America. Depending on the geographical area, WHO recommends the following approaches to prevention and control:

- spraying of houses and surrounding areas with residual insecticides;
- house improvements and house cleanliness to prevent vector infestation;
- personal preventive measures such as bednets;
- good hygine practices in food preparation, transportation, storage and consumption;
- screening of blood donors and receivers;
- access to diagnosis and treatment of people with medical indication or recommendation to do antiparasitic treatment, especially children and women of child-bearing age before pregnancy; and
- screening of newborns and other children of infected mothers without previous antiparasitic treatment to provide early diagnosis and treatment.

Bed bugs are a significant socioeconomic burden. Complete eradication of bed bugs is challenging as bed bugs are very mobile and can travel extensively to neighboring units. Vacumming helps with reducing bed bug infestations, but does not eliminate bed bugs hidden inside of materials. Carefully vacuum rugs, floors, upholstered furniture, bed furniture, bed frames, under beds, around bed legs, and all cracks and crevices around the room. Change the bag after each use so the bed bugs can't escape.

Some of the easiest ways to get rid of bed bugs permanently:

1. Know the signs of bed bug activity.
2. Vacuum the house thoroughly.
3. Wash infested items in hot water.
4. Be careful when traveling.
5. Do not use bed bug bombs and pesticides.
6. Use diatomaceous earth powder.
7. Trap the bugs.
8. Discard heavily infested items.

7.7 Summary

- Several bugs, belonging to Order Hemiptera, acts as vectors for disease causing agents like *Trypanosoma cruzi, Aspergillus* spp, staphylocus etc.
- Chagus disease caused by traiatomine bugs, is a major threat in several parts of the world.
- Bed bugs are also one of the most important pest in the world.

7.8 Questions

1. Write a note on Hemiptera as vector.
2. Write the scientific name of vector of Chagas disease.
3. State the sign and symptoms of Chagas disease.
4. How *Trypanosoma cruzi* is transmitted by the vector?
5. What is Q fever and who transmit the fever?
6. State the control measures of triatomine bugs.
7. How to get rid of bed bugs?
8. Name the diseases those are transmitted by bedbugs.
9. What is a syivartic sycle?

7.9 Suggested readings

Dasgupta, B. 1986. Parasitology Including Entomology and Acarology. New Central Book Agency, Kolkata.

Hati, A. K. 1979. Medical Entomology. Allied Book Agency, India.

Johnson, N. and Triplehorn, C.A. 2004, Borror and De Long's Introduction to the Study of insects.

Loker. E. S. and Hofkin, B. V. 2015. Parasitology: A Conceptual Approach. Garland Science, New York.

Marcondes, C. B, (ed). 2017. Arthropod Borne Diseases. Springer.

Marquardt, W. 2004. Biology of Disease Vectors. Academic Press, London.

Mullen, G. R. And Durden. L. A. 2018. Medical Veterinary Entomoloev. Academic Press, London. Brooks/Cole.

Noble, G. A. and Noble, E. R. 1971. Parasitology: The Biology of Animal Parasites. Lea & Febiger, London.

Roberts. L. and Janovy Jr. J. 2008. Foundations of Parasitology. Me Graw-Hill, London.

Service, M. 2008. Medical Entomology for Students. Cambridge University Press. Cambridge.

Soulsby, E. J. L. 1968. Helminths, Arthropods & Protozoa of Domesticated Animals. 6th edition, BaJliere, Tinacell & Cassell, London.

Unit 8 ❑ Glossary

Antennae: Antennae, sometimes referred to as "feelers", are paired appendages used for sensing in arthropods. Antennae are connected to the first one or two segments of the arthropod head.

Bedbugs: Bedbugs are small, oval, brownish insects that live on the blood of animals or humans. Adult bedbugs have flat bodies. Bedbugs do not fly, but they can move quickly over floors, walls and ceilings.

Biological vector: Active biological vectors have the infectious pathogen growing in them. They have an larger load and higher virulence because the pathogen can strive inside the host.

Bug: The Heteroptera are a group of about 40,000 species of insects in the oder Hemiptera. They are sometimes called "true bugs".

Carrier: Asymptomatic carrier, a person or organism infected with an infectious disease agent, but displays no symptoms.

Chagas disease: Chagas disease, also known as American trypanosomiasis, is a tropical parasitic disease caused by the protist *Trypanosoma cruzi*. It is spread mostly by insects known as Triatominae, or "kissing bugs". The symptoms change over the course of the infection.

Chikungunya: Chilungunya is an infection caused by the chikungunya virus (CHIKV). Symptoms include fever and joint pain.

Cutaneous leishmaniasis: Cutaneous leishmaniasis (also known as oriental sore, tropical sore, chiclero ulcer, chiclero's ulcer, Aleppo boil, Delhi Boil or desert boil) is the most common form of leishmaniasis affecting humans. It is a skin infection caused by a single-celled parasite that is transmitted by the bite of a phlebotomine sandfly.

Dengue: Dengue is a mosquito-borne viral infection causing a severe flu-like illness and sometimes causing a potentially lethal complication called severe dengue.

Fly: Flies are insects with a pair of functional wings for flight and a pair of specialized

hindwings called halteres for balance. They are classified as an order called Diptera.

Filariasis: Filariasis is a parasitic disease caused by an infection with roundworms of the Filarioidea type. These are spread by blood-feeding diptera as black flies and mosquitoes. Atropical parasitic disease, that affects the lymph nodes and lymph vessels of the host.

Flea: Flea, the common name for the order Siphonaptera, includes 2,500 species of small flightless insects that survive as external parasites of mammals and birds. Fleas live by consuming blood or hematophagy, from their hosts.

Hemiptera: Hemiptera is a major order of insects, collectively known as true bugs, characterized by sucking mouthparts, rather than chewing mouthparts.

Host specificity: Host specificity can be defined as natural adaptability of a particular parasite to certain species or group of host. Parasites can be very particular about which host species they will use.

Houseflies: Dipteran insect, carriers of diarrhoeal diseases and skin and eye infections. It is the most common fly species found in houses. Adults are grey to black, with four dark, longitudinal lines on the thorax, slightly hairy bodies, and a single pair of membranous wings. They have red eyes, set farther apart in the slightly larger female.

Insects: Insects or Insecta are hexapod invertebrates and the largest group within the arthropod phylum. Insects have a chitinous-exosleleton, a three-part body (head, thorax and abdomen), three pairs of jointed legs in thorax, compound eyes and one pair of antennae.

Lice: Lice are tiny, wingless, parasitic insects that feed on our blood. Lice are easily spread especially by school children-through close personal contact and by sharing belongings.

Malaria: Malaria is a mosquito-borne infectious disease that affects humans and other animals. The causative parasite of the genus is *Plasmodium.* A disease caused by a *plasmodium* parasite, transmitted by the bite of infected anopheles mosquitoes.

Mechanical vector: Mechanical transmission is facilitated by a mechanical vector, an animal that carries a pathogen from on host to another without being infected itself.

Mosquito: The word "mosquito" is Spanish for "little fly". Mosquitoes have a slender segmented body, a pair of wings, three pairs of long hair-like legs, feathery antennae, and elongated mouthparts. Female mosquitoes is blood feeding insect transmit many blood diseases.

Myiasis: Myiasis is infection with a fly larva, usually occurring in tropical and subtropical areas. There are several ways for flies to tranmit their larvae to people. Some flies attach their eggs to mosquitoes and wait for mosquitoes to bite people. Their larvae then enter these bites. Other flies' larvae burrow into skin.

Oioxenous parasite: A parasite that is specific for a single host speices is called *Oioxenous* parasite.

Paratenic host: Paratenic host a potential or substitute intermediate host that serves until the appropriate definitive host is reached, and in which no development of the parasite occurs; it may or may not be necessary to the completion of the parasite's life cycle. Example, fleas or mice for certain tapeworms.

Phlebotomous fever: Pappataci fever (also known as Phlebotomus fever and, somewhat confusingly, sandfly fever and three-day fever) is a vector-borne febrile arboviral infection caused by three serotypes of Phlebovirus.

Phthiriasis: Infestation with pubic lice is also called phthiriasis or not elatics *Phthiriasis pubis,* while infestation of eyelashes with pubic lice is called *Phthiriasis palpebrarum* or *Pediculosis ciliarum.*

Plague: Plague is a disease that affects humans and other mammals. It is caused by the bacterium, *Uersinia pestis.* Humans usually get plague after being bitten by a rodent flea that is carrying the plague bacterium or by handling an animal infected with plague.

Relapsing fever : Relapsing fever is a recurring febrile disease caused by several species of the spirocheta *Borrelia* and transmitted by lice or ticks.

Reservoir: In infectious disease ecology and epidemiology, a natural reservoir, also known as a disease reservoir or a reservoir of infection, is the population of organisms or the specific environment in which an infectious pathogen naturally lives and reproduces, or upon which the pathogen primarily depends for its survival.

Sand fly: Sand flies are vectors of *leishmania* belongs to the family psychodidae diptheria *Phlonotominac argeentipis* is the vector for the disease in India.

Siphunculata: An order of secondarily wingless insects comprising the sucking lice: blood-sucking ectoparasites of mammals, with piercing and sucking mouthparts forming a snoutlike proboscis.

Transstadial transmission: Transstadial transmission occurs when a pathogen remains with the vector from one life stage to the next of the life cycle. For example, the bacteria *Borrelia burgdirferi*, the causative agent for Lyme disease, infects the tick vector as a larva, and the infection is maintained when it molts to a nymph and later develops as an adult.

Trench fever: A highly contagious rickettsial disease transmitted by lice that infested soldiers in the trenches in the First World War. It is a louse-borne disease caused by the gram-negative bacteria *Bartonella quinatana*.

Typhus fever: Typhus fever, is a group of infectious diseases that include epidemic typhus, scrub typhus, and murine typhus. Common symptoms include fever, headache, and a rash. Typically these begin one to two weeks after exposure. The diseases are caused by specific types of bacterial infection.

Vagabond disease: A condition of pigmentation of the skin caused by long continued exposure, uncleanliness, and especially by scratch marks and other lesions due to the exposure, uncleanliness, and especially by scratch marks and other lesions due to the presence of body lice.

Vector: A vector is an organism that does not cause disease itself but which spreads infection by conveying pathogens from one host to another. Species of mosquito, for example, serve as vectors for the deadly disease Malaria.

Vectorial capacity: Vectorial capacity is a mathematical approximation of the efficiency of vector-borne disease transmission, measured as the number of new infections disseminated per case per day by an insect vector.

Viral encephalitis: Viral encephalitis is an inflammation of the brain caused by a virus.

Visceral leishmaniasis: Visceral leishmaniasis (VL), also known as kala-azar, black fever, and Dumdum fever, is the most severe form of leishmaniasis and, without proper diagnosis and treatment, is associated with high fatality. Leishmaniasis is a disease caused by protozoan parasites of the genus *Leishmania.*

NOTES

NOTES