

## LESSON 16

### PHYLUM ARTHROPODA

#### CLASS INSECTA

Insects, are by far the largest group of organisms on earth, whether measured in terms of numbers of species or numbers of individuals. Insects live in every conceivable habitat on land and fresh water, and a few have even invaded the sea. More than 70% of all named animal species are insects, and the actual proportion is undoubtedly much higher, because millions of additional forms await detection, classification, and naming.

#### General characteristics

1. Body divided into a head, a thorax and an abdomen;
2. Head carries one pair of antennae;
3. Thorax carries 3 pairs of legs;
4. Wings may be present (one or two pairs) or absent.

Class Insecta is divided into 4 orders of medical importance:

Order ANOPLURA (lice)

Order SIPHONAPTERA (fleas)

Order HEMIPTERA (bugs).

Order DIPTERA (mosquitoes and flies)

#### Order ANOPLURA (Lice)

#### General characteristics

1. Body is flattened dorso-ventrally
2. Wingless
3. Short legs

*Pediculus hummus capitis* (Head louse)

*Pediculus hummus corporis* (Body louse)

*Phthirus pubis*

*Morphology* (fig. 1, 2, 3):

- ✓ size: 2-5 mm, male are smaller (P. h. capitis 2-3mm, P. h. humanus 3-5mm, P. pubis -1-1, 5mm);
- ✓ body is divided into a head, a thorax and an abdomen;

- ✓ head is conical and carries: 2 simple eyes; 2 five-segmented antennae; retractile proboscis lying in a sac. Mouthpart is of piercing and sucking type in male and female;
- ✓ thorax: 3 segments fused together and carries: Legs: 3 pairs of short legs, ending in a single tarsal segment and a single claw; one pair of respiratory spiracles;
- ✓ abdomen: consists of 8 segments and carries: 6 pairs of respiratory spiracles on the sides of the first 6 segments;
- ✓ eggs (nits): oval, operculated (crown-like); 0.8 mm; whitish;
- ✓ nymph: resembles the adult but smaller and sexually immature.



**Fig.1.** *Pediculus Humanus capitis* (Male)



**Fig.2.** *Pediculus Humanus corporis* (Female)



**Fig.3.** *Phthyrus pubis*

*Life Cycle:* undergo incomplete metamorphosis.

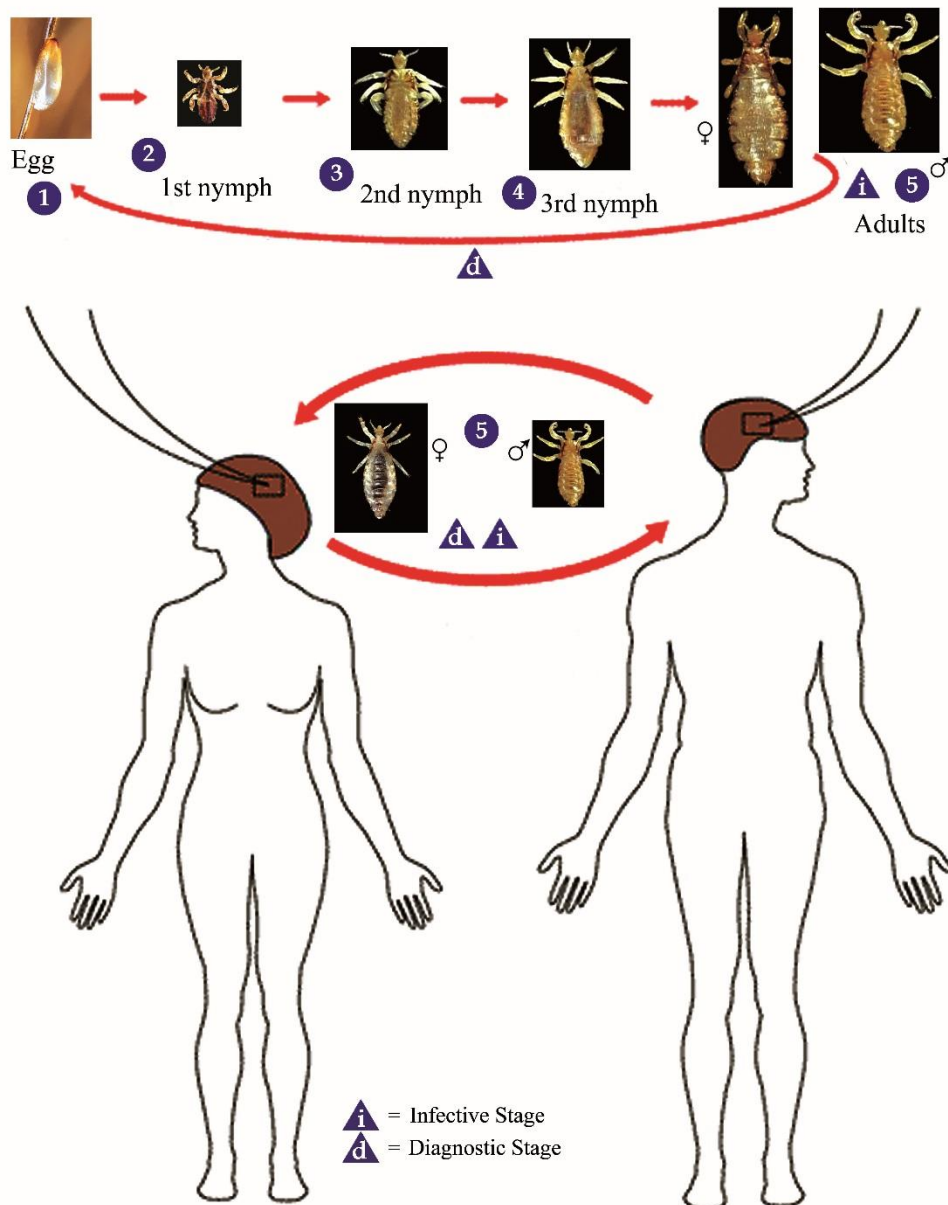
The main *mode of transmission* of head lice is contact with a person who is already infested (i.e. head-to-head contact). Contact is common during play (sports activities, playgrounds, at camp, and slumber parties) at school and at home. Wearing clothing, such as hats, scarves, coats, sports uniforms, or hair ribbons worn by an infected person; using infested combs, brushes or towels; or lying on a bed, couch, pillow, carpet, or stuffed animal that has recently been in contact with an infected person may result in transmission. Of note, both nymph and adult lice forms need to feed on blood to live. If an adult louse does not have a blood meal, it can die in 2 days.

The life cycle of the head louse has three stages: egg, nymph, and adult.

**Eggs:** Nits are head lice eggs. They are hard to see and are often confused for dandruff or hair spray droplets. Nits are laid by the adult female and are cemented at the base of the hair shaft nearest the scalp ❶. They are 0.8 mm by 0.3 mm, oval and usually yellow to white. Nits take about 1 week to hatch (range 6 to 9 days). Viable eggs are usually located within 6 mm of the scalp.

**Nymphs:** The egg hatches to release a nymph ❷. The nit shell then becomes more visible dull yellow and remains attached to the hair shaft. The nymph looks like an adult head louse, but is about the size of a pinhead. Nymphs mature after three molts (❸, ❹) and become adults about 7 days after hatching.

**Adults:** The adult louse is about the size of a sesame seed, has 6 legs (each with claws), and is tan to grayish-white ❺. In persons with dark hair, the adult louse will appear darker. Females are usually larger than males and can lay up to 8 nits per day. Adult lice can live up to 30 days on a person's head. To live, adult lice need to feed on blood several times daily. Without blood meals, the louse will die within 1 to 2 days off the host (fig. 4).



**Fig.4.** Life cycle of *P. humanus capitis*

**Body lice** are morphologically similar to head lice. They have a different life cycle, whereas body lice reside on and lay their eggs on the clothing and fomites of infected individuals and migrate to the human body to feed.

*Geographic distribution:* Head lice infestation is very common and is distributed worldwide. Preschool and elementary-age children, 3 to 11 years of age are infested most often. Females are infested more often than males, probably due to more frequent head to head contact. Body lice are also cosmopolitan but are less common and usually seen in settings of poverty, war, and homelessness.

*Habits:* they are ectoparasites whose only known hosts are humans. They leave the host if the temperature rises (fever) or falls (death). They feed on blood several times a day. Season: winter (crowding).

*Pathogenesis:* the majority of head lice infestations (*pediculosis*) are asymptomatic. When symptoms are noted they may include a tickling feeling of something moving in the hair, itching, caused by an allergic reaction to louse saliva, and irritability. A secondary bacterial infection may be a complication.

*Medical importance of lice:*

✓ Lice can serve as causative agent of *Pediculosis* (*Vagabond's diseases*);

✓ Body lice can serve as vectors for *Rickettsia prowazekii* (epidemic typhus), *Bartonella quintana* (trench fever), and *Borrelia recurrentis* (louse-borne relapsing fever).

*Prevention and control:*

- ✓ head examination among children;
- ✓ keep your clothes and body clean;
- ✓ keep public places like: hostels, hospitals, hair dresser's clean.

## **Order SIPHONAPTERA (Fleas)**

### **General characteristics**

1. Wingless;
2. Body is bilaterally compressed and covered with stiff hairs backwardly directed;
3. Strong legs help fleas to jump.

*Pulex irritans* (*Human's Flea*).

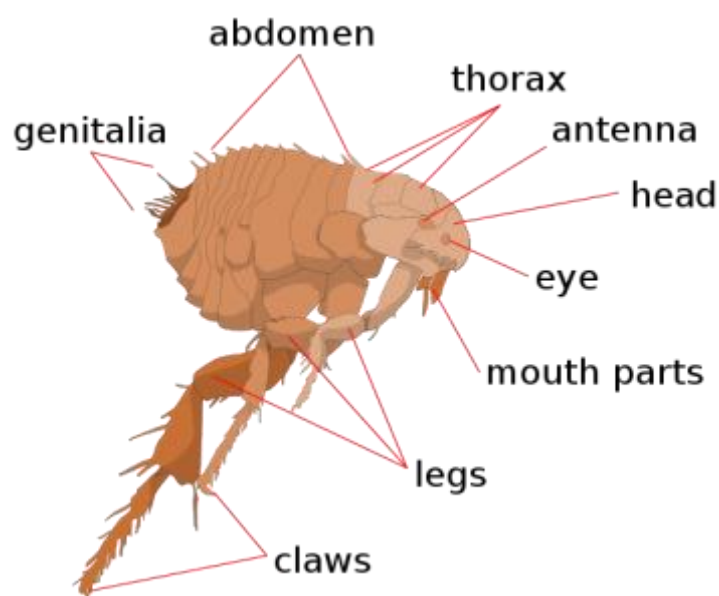
*Ctenocephalus canis* (*Dog's Flea*).

*Morphology* (fig. 5):

- ✓ size 2-3 mm;
- ✓ Body is divided into a head, a thorax and an abdomen;
- ✓ Head is round or angular and carries 2 simple eyes (may be absent); ocular hairs (in front or below the eyes); post-cephalic hairs (one or

more hairs); 2 short three-segmented antennae lying in the grooves behind the eyes;

- ✓ Proboscis is of piercing and sucking type in male and female;
- ✓ Thorax composed of 3 segments;
- ✓ 3 pairs of strong legs;
- ✓ Abdomen consists of 10 segments;
- ✓ Eggs are oval with blunt ends. 0.5 mm. Pearly white;
- ✓ Larva is worm-like, divided into a head, a thorax (3 segments) and an abdomen (10 segments). All segments carry backwardly-directed hairs. The last abdominal segment carries a pair of conical hooked processes (anal struts);
- ✓ Pupa is enclosed in a cocoon.

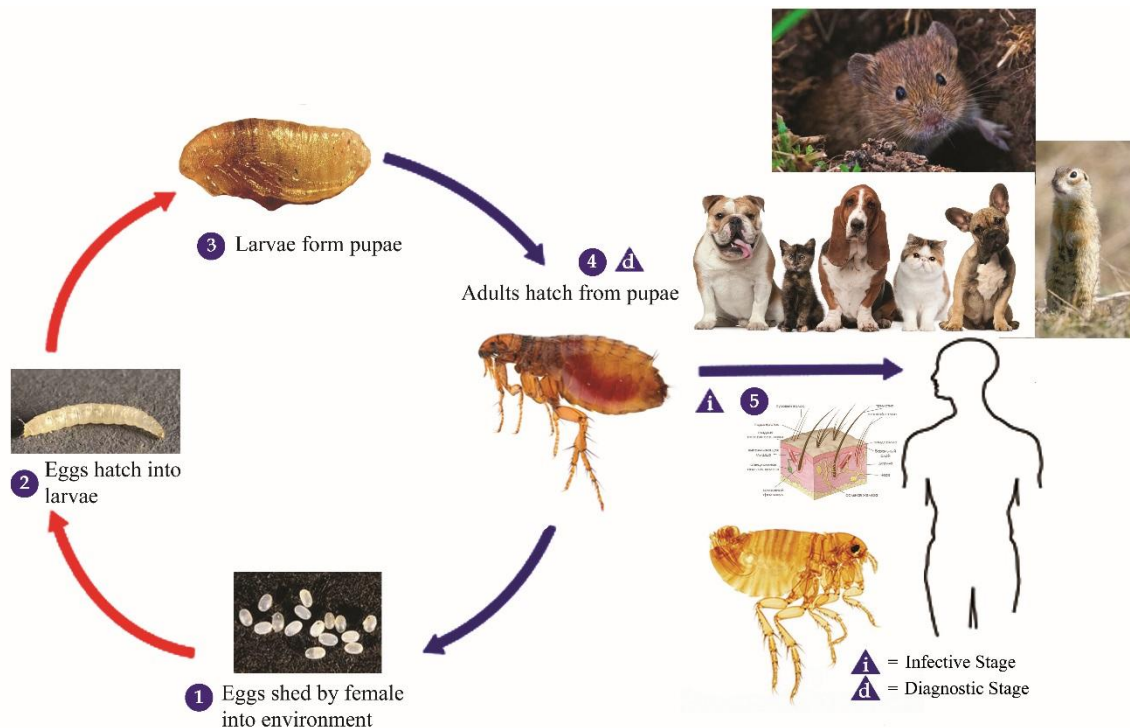


**Fig.5.** Morphology of fleas

*Life Cycle:* undergo complete metamorphosis.

Fleas, like other holometabolous insects, have a four-part life cycle consisting of eggs, larvae, pupae, and adults. Eggs are shed by the female in the environment ❶. Eggs hatch into larvae ❷ in about 3-4 days and feed on organic debris in the environment. The number of larval instars varies among the species. Larvae eventually form pupae ❸, which are in cocoons that are often covered with debris from the environment (sand, pebbles, etc). The larval and pupal stages take about 3-4 weeks to complete. Afterwards, adults hatch from pupae ❹ and seek out a warm-blooded host for blood meals. The primary hosts

for *Ctenocephalides felis* and *C. canis* are cats and dogs, respectively, although other mammals, including humans, may be fed upon. The primary hosts for *Xenopsylla cheopis* are rodents, especially rats. Humans are the primary host for *Pulex irritans* (fig. 6).



**Fig.6.** General Life Cycle of Flea

*Geographic distribution:* worldwide.

*Habits:* fleas are either temporary ectoparasites (human flea) or permanent ectoparasites (rat flea). They feed on blood more than once daily, but can withstand starvation for a long time.

*Pathogenesis:* bites of fleas causes itching and scratching with possible development of secondary (bacterial) infection.

*Medical importance of lice:*

- ✓ Vector of *plague* caused by *Yersinia pestis*. The bacilli multiply and block the gut. Infection occurs by the bite of the blocked flea;

- ✓ Vector of *murine typhus* caused by *Rickettsia typhi*. *Rickettsia* invade the gut wall of the flea and multiply. After rupture of epithelial cells they are liberated into flea's lumen and come out with the faeces. Mode of transmission of murine typhus is contamination of bite wound or mucous membranes by faeces;

- ✓ Fleas may be a vector of *tularemia*;

✓ Occasionally a flea serves as an intermediate host for *Hymenolepis nana*.

*Prevention and control:*

- ✓ Human flea: a) cleaning and dusting of dust from floor and carpets, b) application of insecticides and repellents (naphthaline);
- ✓ Dog and cat flea: animals and their resting-places should be treated with insecticides.

## Order DIPTERA (Mosquitoes and Flies)

### General characteristics

- ✓ Mesothoracic pair of wings;
- ✓ Metathoracic pair of wings is modified into halteres or balancers;
- ✓ Mouthparts are sucking or piercing;
- ✓ Complete metamorphosis.

Order Diptera includes two families of medical importance:

*Family Culicidae* (mosquitoes).

*Family Muscidae* (flies):

### Family CULICIDAE

#### General characteristics

- ✓ Mosquitoes have general morphology of insects;
- ✓ They have only one pair of wings, the second pair being rudimentary knobs called halteres.

Three genera, *Anopheles*, *Aedes*, *Culex*, transmit disease to humans.

*Morphology:* *Anopheles* and *Culex* have some differences at each stage of life cycle (tabl. 1; fig. 7).

Table 1

#### Differences between *Anopheles* and *Culex*

EGG

<b>Culex</b>	<b>Anopheles</b>
Eggs are vertically laid in clusters on the surface of the water.	Eggs are laid singly and horizontally on the surface of the water.



Eggs are cigar shaped.	Eggs are boat shaped.
Eggs of culex mosquito are not provided with lateral air floats.	Each egg has two lateral air floats, which help them in floatation.
Eggs are laid on dirty water.	Eggs are laid on clean water.

#### LARVA

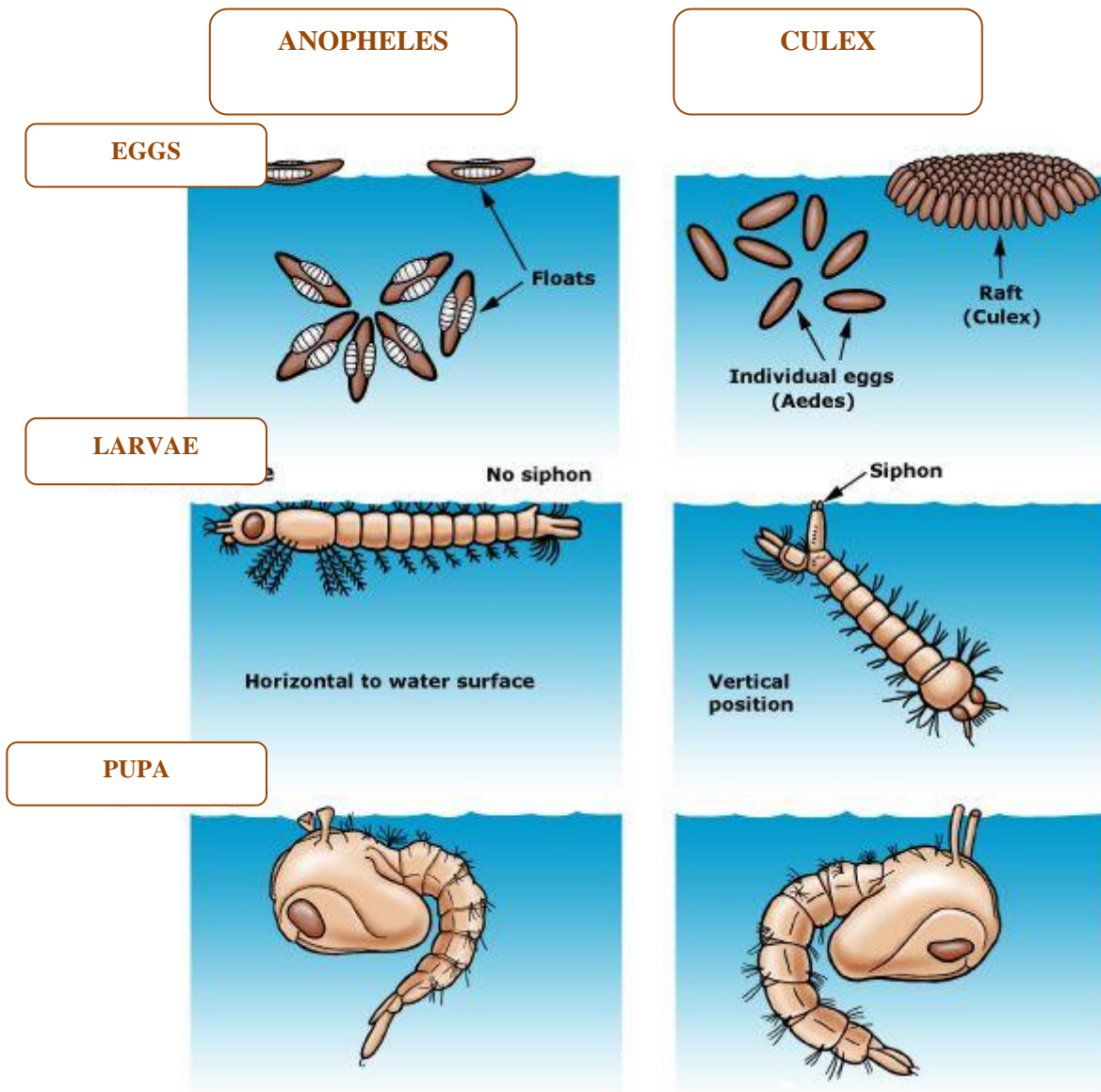
Larva of culex mosquito is bottom feeder.	Larva of anopheles mosquito is surface feeder.
The respiratory siphon is long.	The respiratory siphon is short.
It forms an angle inside water.	It remains parallel with water surface.

#### PUPA

The pupa is colourless.	The pupa is green.
The respiratory trumpets are long and narrow.	The respiratory trumpets are short and wide.
The abdomen is less bent.	The abdomen is more bent.

#### ADULT

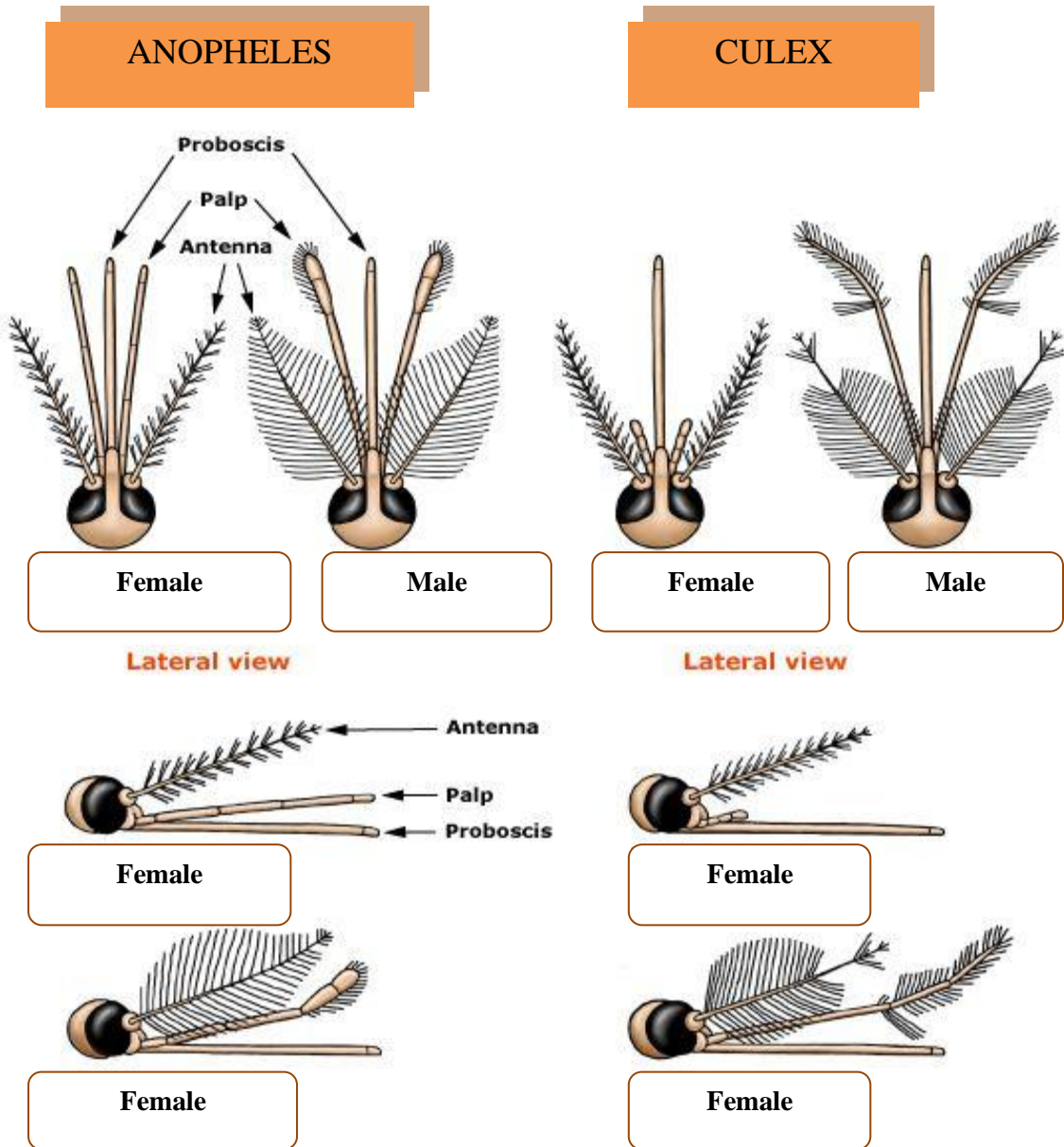
Body is provided with stouter legs.	Body is provided with delicate legs.
Wings are transparent and can fly for long distance.	Wings are spotted and cannot fly for long distance.
At rest body lies parallel to the surface.	At rest body is inclined at an angle of 45° to the surface.
It transmits filarial parasite.	It transmits malarial and filarial parasite.



**Fig.7.** Differences between Anopheles and Culex  
(Cheryl Whitehorn<sup>1</sup>)

Females have elongated mouthparts and a distinct proboscis well suited for piercing and sucking blood. Scales are present along the wing veins and along the lower wing margins. The sexes can be distinguished by the antennae: in females they are long and slender with a few short hairs; in the male they are feathery and plumose. Close examination shows the antennae to be composed of 14 or 15 segments. The venation of the wings is also characteristic for mosquitoes and is helpful in species identification (fig. 8).

<sup>1</sup>Modified from figures courtesy of Cheryl Whitehorn, MSc.



**Fig.8.** Differences between heads of Anopheles and Culex (male, female).

*Life Cycle:* undergo complete metamorphosis.

*Geographic distribution:* worldwide.

*Habits:* mosquitoes are particularly attracted to humans and animals, especially to bright light and dark-colored clothing. The females are the bloodsuckers and cannot produce fertile eggs without ingesting blood. It is postulated that the blood supplies serotonin and epinephrine necessary for production of the gonadotropic hormone by the mosquito, required for ovulation. The eggs are laid on the surface of water and hatch into aquatic “wiggletails”. These subsequently metamorphose into adults.

*Pathogenesis:* bites of mosquitoes cause itching and scratching with possible development of a secondary (bacterial) infection.

*Medical importance of mosquitoes:*

Anopheles transmit causative agents of *malaria, filariasis*;

Culex transmit causative agents of *yellow fever, dengue fever, filariasis, and encephalomyelitis*.

*Prevention and control:*

***Mechanical methods:***

- ✓ wire screens for windows and doors;
- ✓ mosquito nets;
- ✓ repellants; certain lotions or creams applied to the skin repel mosquitoes from biting e. g. citrignella oil, Indalone;
- ✓ animal barrier: placing farm animals between the breeding places and human habitations would deviate mosquitoes (particularly zoophilic) from biting humans.

***Natural or physical methods*** (ecological interference):

- ✓ changing the environment so as to become unsuitable for the mosquito e. g. filling or drainage of the breeding place;
- ✓ shading if larvae require sunshine and vice versa;
- ✓ changing water level, water current, pH.

***Biological methods:***

- ✓ introduction of a natural enemy (predator):
  - a) fish (*Gambusia affinis*) feed on larvae and pupae;
  - b) release of sterilized males (X-ray or chemical agents) which compete with males in nature, mating with females, and resulting in reduction of the forthcoming generation.

***Chemical methods*** (insecticides):

- ✓ against adults (adulticides);
- ✓ preventing aquatic stages.

Practically, no single method alone is efficient in control. The combined use of two or more methods (integrated control) would provide a higher and more efficient level of abatement. Insects which escaped one method, are killed by another one.

## Family MUSCIDAE

### General characteristics

1. Share general morphology of insects;
2. One pair of wings, the second pair being rudimentary knobs called halteres;
3. Three pairs of jointed legs that end in hooked claws or in hairy pads which may secrete a sticky substance;
4. The head possesses a pair of large, compound eyes that may or may not meet in the midline and a pair of sensory antennae which are jointed in different ways depending upon the species;
5. The mouthparts of the bloodsucking;
6. In the female, the terminal segment of the abdomen contains the ovipositors;
7. They undergo complete metamorphosis.

There are many species of flies. Broadly, they can be divided into *bloodsucking* and *nonbloodsucking* types, and the mouthparts for each are appropriately adapted.

### Nonbloodsucking flies

Nonbloodsucking flies generally spread disease only by mechanical means, humans can become infected directly by fly larva, known as *maggots*. Myiasis is the term used for this condition. Various tissues or organs may be involved, including the skin and wounds, the intestine, the urinary tract, nasal atria, ears and eyes. Adult flies may deposit their ova directly into wounds or necrotic tissue, or human may become infected by handling soil, filth, or excreta contaminated with fly ova. The worm-like larvae which hatch are equipped with chewing mouthparts with which they can feed on organic material or human tissue.

The adult flies most commonly concerned in myiasis belong either to the Muscidae (housefly) or the Oestridae (bot fly) families. Myiasis resulting from the infection of ova from muscidae flies, which includes the common domestic housefly, is considered accidental in man, since the larvae usually develop in decaying organic material. In contrast, the larvae of the bot fly are obligate parasites of the intestinal tract or other tissues of mammals, including humans. In this sense, they must be considered true

parasites.

### ***Housefly (Musca domestica)***

*Morphology:* a medium-sized flies, measuring between 6 and 10 mm in length; the female is generally slightly larger than the male; an adult fly is gray in color; its body is divided into a head, a thorax, and an abdomen.

*Life Cycle:* eggs are laid into masses of decaying organic substances, garbage, refuse or manure; larvae hatch in 6-24 hours and feed on organic matter; they molt 2 times giving 3 larval stages; the third larva pupates inside the larval skin; the adult emerges after a few days through a circular cut of the puparium; the whole cycle takes about one week.

*Geographic distribution:* cosmopolitan.

*Medical importance:*

- ✓ Indirect mechanical transmission of microorganisms (as *typhoid, poliomyelitis and bacillary dysentery*), eggs of helminthes and cysts of protozoa;

- ✓ Accidental myiasis.

*Prevention and control:*

- ✓ Sanitary disposal of refuses, garbage and manure (breeding media) by dumping, burning or application of insecticides;

- ✓ Control of adult flies by screening or space spraying of insecticides.

### **Bloodsucking flies**

Genus Phlebotomus: *Sandfly, Moth fly, Owl midge.*

*Morphology:*

- ✓ Small size (3 mm);
- ✓ Body and wings are quite hairy;
- ✓ Wings at rest are held in V at 60° angle;
- ✓ Wings veined in parallel lines;
- ✓ Mouthparts structured for piercing and biting;
- ✓ Yellow-buff color.

*Geographic distribution:* cosmopolitan in tropical and subtropical climates.

*Habits:* active nocturnal feeders; female alone are bloodsuckers; breeding places hard to find: under stones, in masonry cracks, poultry houses, hollow trees; breeding places are nonaquatic.

*Pathogenesis:*

Symptoms of bite:

- ✓ Rose-colored papule at the site of a bite, with a 10-20 mm zone of erythema;
- ✓ Stinging pain and itching;
- ✓ Nausea, fever, and malaise in sensitive individuals.

*Medical importance:* may be vector of causative agent of *Leishmania donovani* (kala-azar); *Leishmania tropica* (Oriental sore); *L. braziliensis* (American leishmaniasis); Phlebotomus fever (pappataci fever).

Genus Simulium: *Black fly, Buffalo gnat.*

*Morphology:*

- ✓ small size (2-3 mm);
- ✓ Body is black;
- ✓ Body sturdy, legs short;
- ✓ Short proboscis with blade-like cutting organs;
- ✓ Wings broad and usually clear.

*Geographic distribution:* cosmopolitan in distribution.

*Habits:* breeds along shaded watercourses or woodland streams.

Females bite in daytime.

*Pathogenesis:* bite is initially painless; the wound bleeds profusely.

Pain, itching, and swelling develop later.

*Medical importance:* vector of *Onchocercavolvulus* (onchocerciasis).

Genus Glossina: *Tsetse fly.*

*Morphology:*

- ✓ Slightly larger than housefly;
- ✓ Brownish color;
- ✓ Resting wings overcrossed like scissor blades;
- ✓ Slender proboscis held horizontal to the ground.

*Geographic distribution:* Found in equatorial Africa, *G. palpalis*: hot, dump areas along borders of rivers, lakes, and streams in West Africa.

*Habits:* males and females bite daytime.

*Medical importance:* vector of *Trypanosoma rhodesiense*, *T. gambiense* (African sleeping sickness).



