MEDICAL ARACHNOENTOMOLOGY

Medical Arachnoentomology deals with the study of arthropods which cause or transmit disease to humans.

PHYLUM ARTHROPODA

Three-fourth of all animal species belong to the Phylum Arthropoda. The name "arthropod" comes from two Greek words, *arthros*, joint, and *podes*, feet.

General characteristics

1. Triploblastic;
2. Bilaterally symmetrical;
3. Segmented body (except ticks);
4. Jointed appendages;
5. Chitinous exoskeleton;
6. Body cavity (haemocoele) containing haemolymph (blood) which bathes the internal organs;
7. ***Digestive system****:* complete, it contains a mouth and an anus;
8. ***Circulatory system***: opened type**;** a pulsating dorsal tube (the heart) with valves pumps the blood (haemolymph) in one direction towards into the aorta. Blood pumped from the aorta bathes all organs and tissues giving them the necessary nourishment and deriving waste products. Blood is pumped again by the heart and so on. The blood is usually colourless and has no respiratory function;
9. ***Respiratory system*****:** depending on the habitat the trachea, lungs or gills;
10. ***Excretory system:*** Malpighian tubes lie free in the haemocoele and open at the junction between the midgut and hindgut;
11. ***Nervous system***: it is composed of: nerve ganglia in the head (brain), nerve ganglia in the ventral part of the body (ventral nerve cord), nerves extend from these ganglia to different parts of the body;
12. ***Reproductive system*** (separate sexes);
13. The male genital system: two testes, two vas deferens, seminal vesicle, penis;
14. The female genital system: two ovaries, two oviducts, vagina opening externally in the vulva.

Life cycle*:*

✓ *Incomplete metamorphosis:* the intermediate stages (Nymph) resemble the adult stage.

✓ *Complete metamorphosis*: the intermediate stages (Larva and Pupa) differ from the adult stage.

Medical importance of arthropods

Arthropods may affect the health of man by any of the following methods:

1. Direct agent of disease or discomfort (*Sarcoptes scabiei*).
2. Disease transmission:

a) ***Mechanical (***the arthropod is a passive carrier):

- ✓ Indirect mechanical (contaminative): non-biting insects (*House fly*).
- ✓ Direct mechanical: by interrupted feeding of biting insects (*Stable fly*).

b) ***Biological (***the arthropod is an obligatory vector or a natural vector which is an integral part of the life cycle of the parasite or pathogen):

- ✓ Propagative: multiplication of the pathogen without a developmental change e. g. Plague (*flea)*, yellow fever (*Aedes);*
- ✓ Cyclopropagative: multiplication and developmental change of the patogen, e. g. Malaria (*Anopheles),* Trypanosomiasis (*testse fly*), and Leishmaniasis (*sandfly*);
- ✓ Cyclodelopmental: developmental change without multiplication, e. g. Filariasis (*Culex);*
- ✓ Transporting: the pathogen remains without multiplication or development, e. g. Diphyllobotrium latum (*Cyclops);*
- ✓ Transovarian: organisms transmitted to progeny through ova, e. g. Scrub typhus (*red bugs).*

Phylum Arthropoda includes 3 classes of medical importance (tabl. 1):

CLASS CRUSTACEA: cyclops, crabs.

CLASS ARACHNIDA (OCTAPODA): scorpion, ticks and mites.

CLASS INSECTA (HEXAPODA): mosquitoes, flies, bugs, lice and fleas.

Table 1

General characters of different classes of arthropods

	CRUSTACEA	ARACHNIDA	INSECTA
Body	cephalothorax, abdomen	cephalothorax, abdomen	head, thorax, abdomen
Antennae	two pairs	absent	one pair
Legs	4 pairs	4 pairs	3 pairs
Wings	absent	absent	1-2 pairs (sometimes absent)

CLASS ARACHNIDA

The Class Arachnida is a group of more than 100, 000 species, including spiders, scorpions, ticks, and mites. Most arachnids are adapted to kill prey with poison glands, stingers, or fangs.

General characteristics

1. Body divided into cephalothorax (head and thorax fused) and abdomen;
2. 4 pairs of legs;
3. Wingless;
4. Antennae absent;
5. Undergo incomplete metamorphosis.

Class Arachnida includes 3 orders of medical importance:

Order SCORPIONIDA (Scorpions)

Order ARANEIDA (Spiders)

Order ACARINA (Ticks and Mites)

Order ACARINA

General characteristics

1. Body compressed dorso-ventrally;
2. The body is composed of cephalothorax and abdomen fused together;
3. 4 pairs of legs in the adult and nymph, 3 pairs in the larva;
4. Wingless.
5. Antennae absent.

TICKS

Ticks includes 2 families:

Family Ixodidae (hard ticks).

Family Argasidae (soft ticks).

Morphology: The most obvious distinctions between the Argasidae and the Ixodidae are as follows (fig. 1):

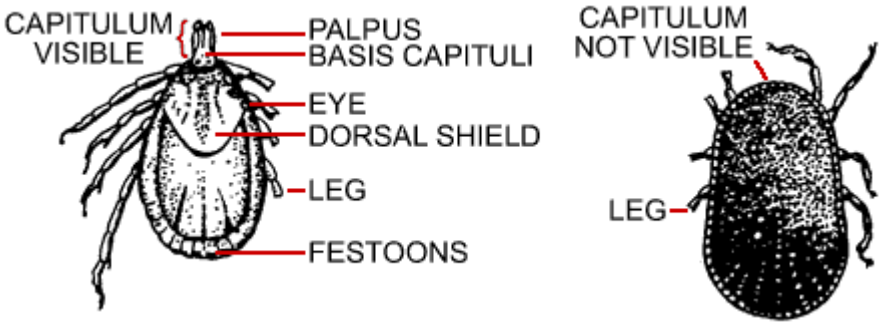

Fig.1. Morphology of Hard and Soft ticks

- ✓ they have no *scutum*;
- ✓ a capitulum is concealed beneath the body.

Life cycle: ticks undergo incomplete metamorphosis. Most tick species undergo one of four different life cycles. Members of the family Ixodidae undergo either one-host, two-host or three-host life cycles. Most ticks of public health importance undergo the *three-host life cycle*, whereby the tick leaves the host after the larval and nymphal stages.

Three-host ixodid ticks have a life cycle that usually spans three years, although some species can complete the cycle in only two years. Adult females drop off the third host to lay eggs after feeding ❶, usually in the fall. Eggs hatch into six-legged larvae ❷ and overwinter in the larval stage. In the spring, the larvae seek out and attach to the first host, usually a small rodent ❸. Later in the summer, engorged larvae leave the first host ❹ and molt into nymphs ❺, usually in the fall. The ticks overwinter in this stage. During the following spring, the nymphs seek out and attach to the second host ❻, usually another rodent or lagomorph. The nymphs feed on the second host and drop off later in the summer ❼. Nymphs molt into adults ❼a- ❼b drop off the host in the late summer or fall, and overwinter in this stage. The next spring, adults seek out and attach to a third host, which is usually a larger herbivore (including cervids and bovids), carnivore, or human ❽. The adults feed and mate on the third host during the summer. Females drop off the host in the fall to continue the cycle. Females may reattach and feed multiple times. The three hosts do not necessarily have to be different species, or even different individuals. Also, humans may serve as first, second or third hosts (fig, 2).

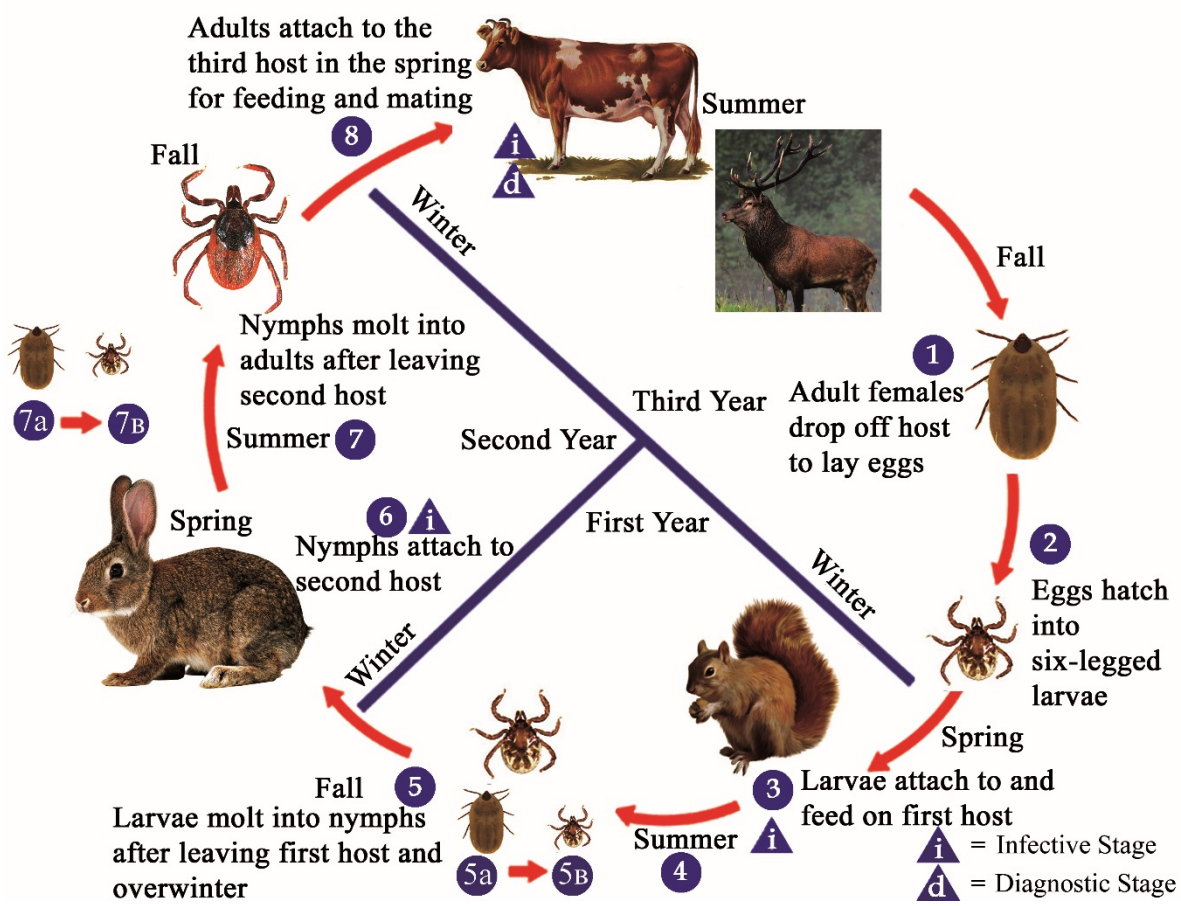

Fig.2. Three-host Ixodid Ticks life cycle

Members of the family Argasidae undergo what is called a *multihost life cycle* (fig. 3). Argasid ticks have two or more nymphal stages, each requiring a blood meal from a host.

Mating usually occurs, and egg-laying always occurs, off the host in a sheltered area (usually an animal nest). Eggs hatch into six-legged larvae ❶ in the parents' sheltered area. They quest for a host in the vicinity of the sheltered area. Once a suitable host is found, they feed for anywhere from one hour to several days, depending on the species ❷. After feeding, the larvae leave the host and molt into the first nymphal instars in the sheltered area ❸a- ❸b. The nymphs quest for, and feed on, the second host ❹ rapidly (usually about an hour). The second host is usually the same species, and often the same individual, as the first host. The first nymphal instars leave the host and molt into the next nymphal instars in the sheltered area ❺a- ❺b. This cycle can continue to accommodate up to seven nymphal instars ❻, depending on the species. After the last nymphal instar has fed, it leaves the host and molts into an adult ❼a- ❼b in the sheltered area. Adults may continue to feed on the host ❽, feeding rapidly and detaching after each blood meal. Females of some species lay egg

batches after each meal. Humans are usually only incidental hosts for argasid ticks and may be fed upon by any of the stages.

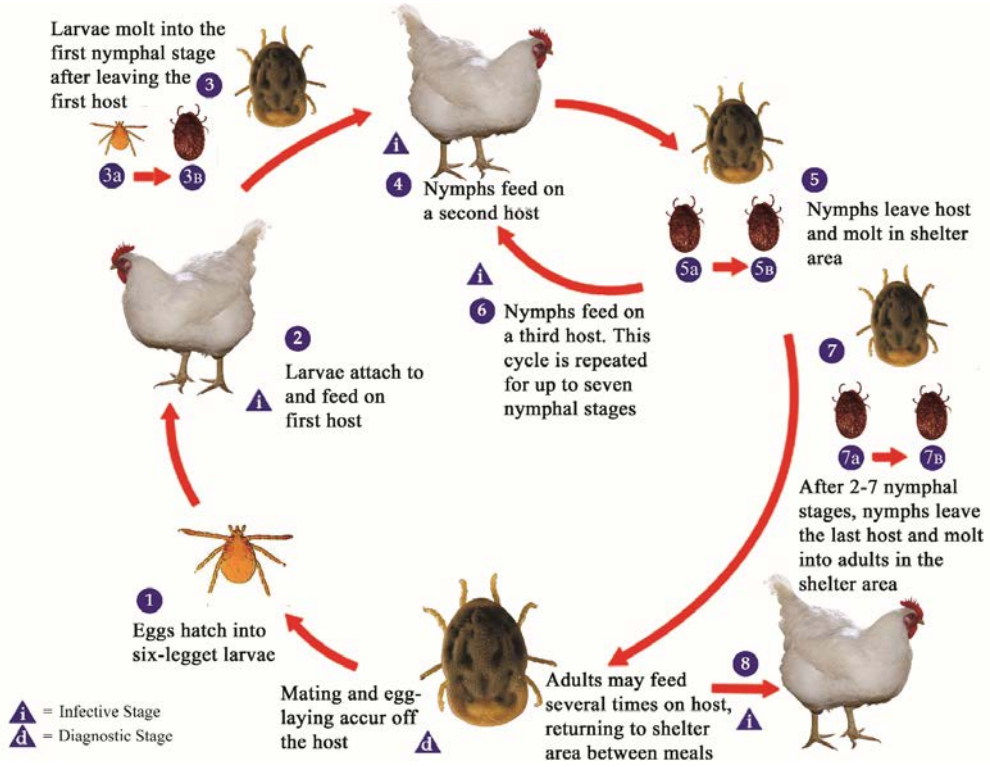

Fig.3. Muitihost Argasid Ticks life cycle

Geographic distribution: tick species are widely distributed around the world.

Habits: ticks are *obligate ectoparasites*, needing blood to survive and move from one stage of life to another. Ticks unable to find a host to feed on will die. Ticks extract the blood by cutting a hole in the host's epidermis, into which they insert their hypostome, and keep the blood from clotting by excreting an anticoagulant or platelet aggregation inhibitor.

Ticks find their hosts by detecting animals' breath and body odors, or by sensing body heat, moisture and vibrations. They are incapable of flying or jumping, but many tick species wait in a position known as "questing". While questing, ticks hold on to leaves and grass by their third and fourth pair of legs. They hold the first pair of legs outstretched, waiting to climb on to the host. When a host brushes the spot where a tick is waiting, it quickly climbs onto the host. Some ticks will attach quickly while others will wander looking for thinner skin like the ear. Depending on the species and the life stage, preparing to feed can take from ten minutes to two hours. On locating a suitable feeding spot, the tick grasps the skin and cuts into the surface.

Ixodidae that attach to a host will bite painlessly and generally unnoticed, and they remain in place until they engorge and are ready to change their skin; this process may take days or weeks.

Some species drop off the host to moult in a safe place, whereas others remain on the same host and only drop off once they are ready to lay their eggs.

The Argasidae differ from the Ixodidae in their habits and ecology. Many of them feed primarily on birds or mammals and are extremely harmful. They feed rapidly, typically biting painfully and gorging within minutes and none of the species will stick to the host in the way that hard ticks do. Unlike the Ixodidae that have no fixed dwelling place except on the host, they live in sand or in crevices or similar shelters near animal dens or nests, or in human dwellings where they might come out nightly to attack roosting birds, or emerge only when they smell carbon dioxide in the breath of their hosts and emerge from the sand to attack them.

Pathogenesis: most ticks do not elicit any response from their host while feeding. Ticks in the genera Dermacentor and Ixodes have been implicated in tick paralysis, a condition characterized by an acute, ascending, flaccid motor paralysis that can result in death if the tick is not removed. The condition is believed to be caused by toxins in the ticks' saliva.

Medical importance of ticks:

There are many genera and species of ticks in the families Ixodidae (hard ticks) and Argasidae (soft ticks) that are of public health importance.

Hard-bodied ticks are carriers of: *tularemia, Rocky Mountain spotted fever, Colorado tick fever, Siberian tick typhus, Crimean-Congo hemorrhagic fever, Lyme disease, babesiosis, Russian spring-summer encephalitis*;

Soft-bodied ticks (Ornithodorus) are vectors of *tick-borne relapsing fever, Q-fever.*

Prevention and control:

- ✓ Repair of cracks;
- ✓ Spraying insecticides on floors and cracks;
- ✓ Infested animals are dusted or dipped in insecticide solution.

MITES

Mites are minute, much smaller than ticks.

Sarcoptes scabiei (Itch mite)

*Morphology (*fig. 4):

- ✓ size - a male (0, 2 mm) is smaller than a female (0, 4 mm);
- ✓ body is oval, dorsally convex and ventrally flat; the cuticle is striated and carries several hairs;

✓ mouth parts: rudimentary hypostome without teeth, chelicerae end in pincer-like structures, pedipalps are short and 3-segmented;

✓ legs: a female mite has 4 short pairs (2 anterior and 2 posterior); the anterior pairs are completed by sucker-like structures; the posterior pairs are completed with long bristles. Male mite legs are similar, but the 4th pair is ended with suckers instead of bristles;

✓ larva has 3 pairs of legs (2 anterior and 1 posterior). The posterior pair is completed with bristles;

✓ nymphs are usually quite similar to the adults, differing mainly in their smaller size.

Mode of transmission: transmission occurs primarily by the transfer of the impregnated females during person-to-person, skin-to-skin contact. Occasionally transmission may occur via fomites (e. g., bedding or clothing). Human scabies mites often are found between the fingers and on the wrists.

Fig.4. Morphology of Sarcoptes scabiei

Life cycle:

Sarcoptes scabiei undergoes four stages in its life cycle: egg, larva, nymph and adult. Females deposit 2-3 eggs per day as they burrow under the skin ❶. Eggs are oval and 0. 10 to 0. 15 mm in length ❷ and hatch in 3 to 4 days. After the eggs hatch, the larvae migrate to the skin surface and burrow into the intact stratum corneum to construct almost invisible, short burrows called molting pouches. The larval stage, which emerges from the eggs, has only 3 pairs of legs ❸ and lasts about 3 to 4 days. After the larvae molt, the resulting nymphs have 4 pairs of legs ❹. This form molts into slightly larger nymphs before molting into adults. Larvae and nymphs may often

be found in molting pouches or in hair follicles and look similar to adults, only smaller. Mating occurs after the active male penetrates the molting pouch of the adult female ❺. Mating takes place only once and leaves the female fertile for the rest of her life. Impregnated females leave their molting pouches and wander on the surface of the skin until they find a suitable site for a permanent burrow. While on the skin's surface, mites hold onto the skin using sucker-like pulvilli attached to the two most anterior pairs of legs. When the impregnated female mite finds a suitable location, it begins to make its characteristic serpentine burrow, laying eggs in the process. After the impregnated female burrows into the skin, she remains there and continues to lengthen her burrow and lay eggs for the rest of her life (1-2 months). Under the most favorable of conditions, about 10% of her eggs eventually give rise to adult mites. Males are rarely seen; they make temporary shallow pits in the skin to feed until they locate a female's burrow and mate (fig. 5).

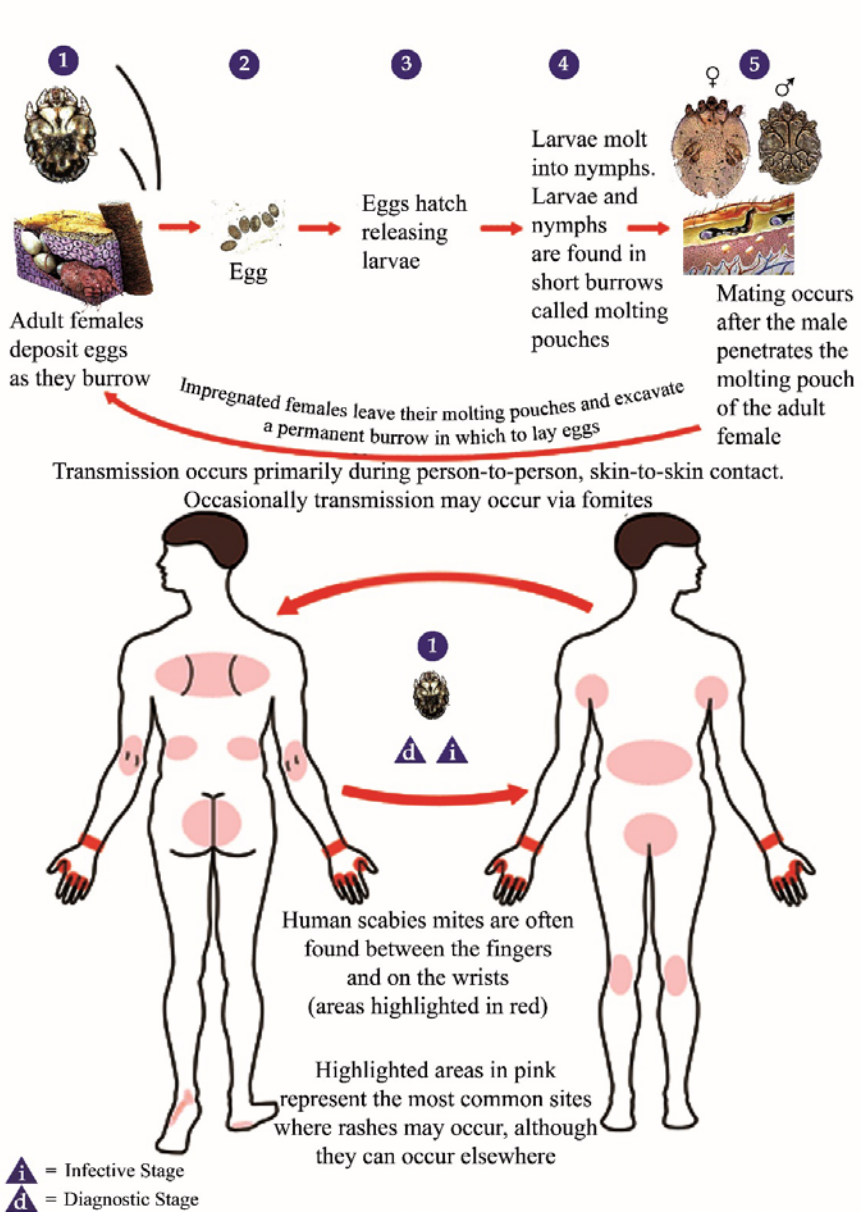

Fig.5. Life cycle of Sarcoptes scabiei

Geographic Distribution: Scabies mites are distributed worldwide, affecting all races and socioeconomic classes in all climates.

Habits: the mites burrow into the upper layer of the skin but never below the stratum corneum. The burrows appear as tiny raised serpentine lines that are grayish or skin-colored and can be a centimeter or more in length.

Pathogenesis: Sarcoptes scabiei is cause of a *scabies.* When a person is infested with scabies mites for the first time, symptoms may not appear for up to two months after becoming infested; however, an infested person can still transmit scabies during this time. If a person has had scabies before, they become sensitized to mites and symptoms generally occur much sooner, within 1 to 4 days. Mites burrowing under the skin cause a rash, which is most frequently found on the hands, particularly the webbing between the fingers; the folds of the wrist, elbow or knee; the penis; the breast; and/or the shoulder blades. Except in crusted (Norwegian) scabies, burrows and mites may be as few as 10-15 in number and can be difficult to find. A papular "scabies rash" may be seen in skin areas such as the buttocks, scapular region and abdomen, where female mites are absent; this may be a result of sensitization from a previous infection. Severe itching, especially at night and frequently over much of the body, including areas where mites are undetectable, is the most-common symptom of scabies. A more severe form of scabies that is more common among persons who are immunocompromised, elderly, or institutionalized is called crusted (Norwegian) scabies and is characterized by vesicles and formation of thick crusts over the skin, accompanied by abundant mites but only slight itching. Complications due to infestation are usually caused by secondary bacterial infections.

Prevention and control:

- ✓ Treatment of infected persons;
- ✓ Sterilisation of clothes and bedding;
- ✓ Personal hugiene.