Class: Arachnida

Arachnids are distinguished from other insects by the following characters:

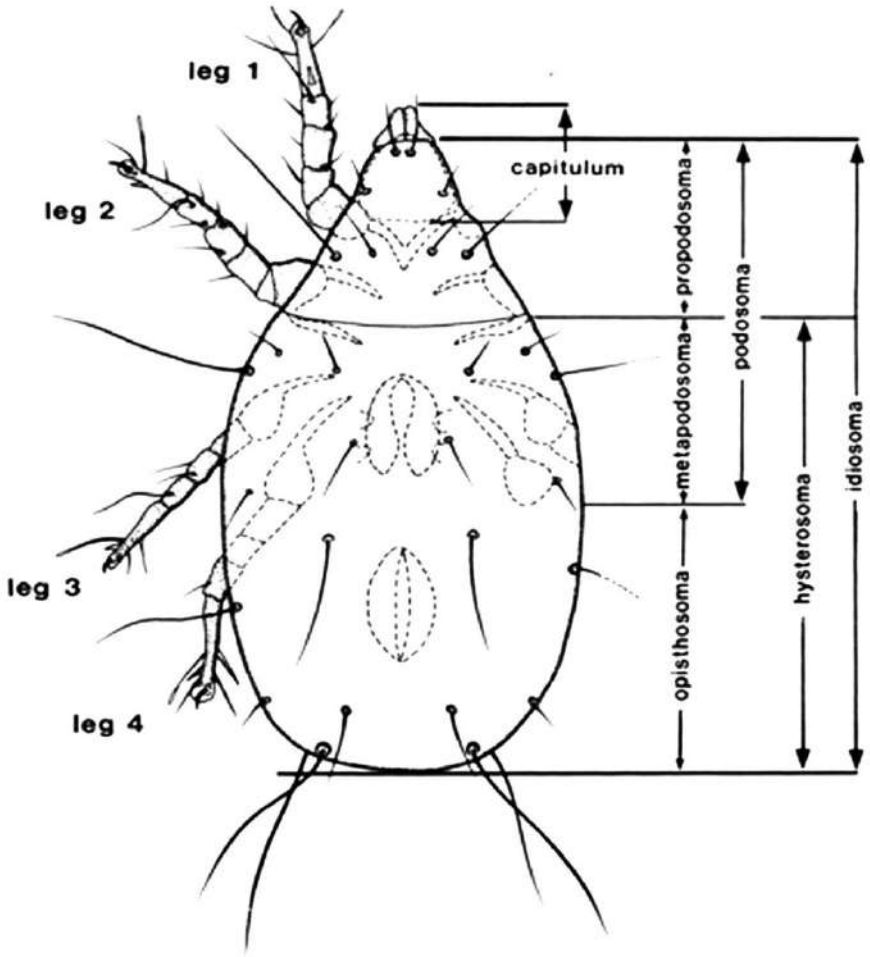
1. The body may consist of 2 portions, cephalothorax and abdomen (e.g. scorpions and spiders), or may be fused to form one segment (e.g. ticks and mites).
2. They have no wings or antennae.
3. The mouth parts is composed of a pair of chelicerae and a pair of pedipalps.
4. Adult stage has 4 pairs of legs.
5. The respiration occurs either through lung books, trachea (stigmata) or cutaneous.
6. They have incomplete metamorphosis.
7. Class Arachnida includes 3 orders: Order Scorpionida (scorpions).
   Order Araneida (spiders).
   Order Acarina (ticks and mites). This order has veterinary and medical importance.

Order: Acarina

(Ticks and mites)

General characters:

1. Acarines are medium to minute-sized.
2. The body is composed of anterior capitulum (gnathosoma) and a posterior body (idiosoma).
3. The body is non-segmented, dorsoventrally compressed and may be covered either completely or partially by a hard chitinous shield, **scutum**, or not.
4. The mouth parts are composed of a pair of **chelicerae**, a pair of **pedipalps** (4-segments) and a single median toothed structure, **hypostome**, in between. These structures are borne on a plate, **capitulum** or **basis capituli**.
5. They have 4 pairs of 6-segmented legs located on the anterior half of the body. The tarsus ends in a pair of sharp claws with pulvilli which act as claw-like in ticks and a hair-like or pad-like or sucker-like in mites.
6. Respiration may be through tracheal tubes that open to the exterior by one pair of spiracles, or it may be cutaneous without respiratory openings.
7. The genital opening is located medioventrally at the level of the 1st pair of legs.
8. The anus is located medioventrally in the posterior third of the body.
9. They are permanent or temporary ectoparasites of animals, birds and humans.
10. The metamorphosis is simply incomplete.



Order Acarina is subdivided into the following suborders:

- Suborder Mesostigmata (free-living, predaceous and parasitic mites).
- Suborder Trombidiformes.
- Suborder Sarcoptiformes.
- Suborder Ixodoidea.

i. Suborder: Mesostigmata

(Gamasid mites)

Mesostigmata have a pair of respiratory spiracles, **stigmata**, usually located posterolateral of the 3rd coxa. Stigmata are usually associated with elongated peritreme.

Family: Dermanyssidae

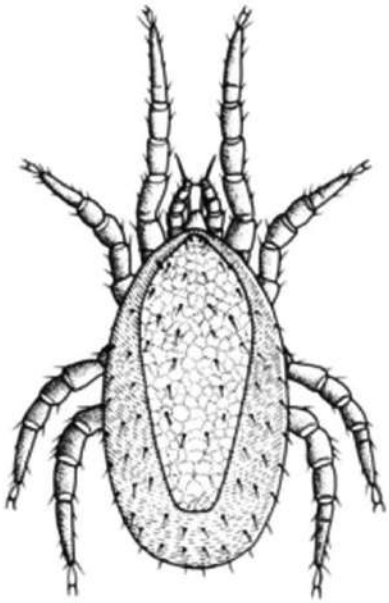
1) Genus *Dermanyssus*

Species *Dermanyssus gallinae*

(Chicken mites, poultry red mites, roost mites)

It has a large range of hosts including several species of wild birds and mammals. Chicken mites hide in nests, cracks, crevices, and litter when they are not feeding. It feeds at night. The adult engorged female measures about 1 mm long. After feeding,

adults become red-colored (they appear black, grey or white when not feed). It has 4 stages in its life cycle beside egg: the larva, 2 nymphal stages (protonymph and deutonymph), and the adult. Larvae has 6 legs and do not feed. After the first moulting, both nymphal stages have 8 legs, and the adults, too. Adult females and nymphs feed on host blood, while males only feed occasionally.



***D. gallinae* female dorsal view**

Image at: http://www.gopetsamerica.com/vet-med/dermanyssus-gallinae-bird-mite.aspx

Life cycle: (7 days)

Chicken mites lay eggs where they hide (nocturnal), in areas such as cracks, crevices, and litter. Eggs are laid in 4-8 clutches (generally 30 eggs in their life span). After hatching, larvae are sluggish, and moult after one day. The protonymph feeds and moults to deutonymph, which then feeds and moults to the adult. Removing the host from an area will not eliminate the mites. The deutonymphs and adults are known to resist desiccation and live as long as 8 months without feeding.

Medical importance:

It affects egg-laying hens causing losses in egg industry due to blood sucking and irritation. It is a vector for the St. Louis encephalitis virus. It spreads fowl poxvirus, Newcastle virus and fowl cholera.

2) Genus *Liponyssus* (*Ornithonyssus*)

Species *L.* (*O.*) *bursa*

(Tropical fowl mites)

They often ectoparasites of birds (fowls, pigeons, sparrows) and may attack humans. It may transmit the fowl pox virus.

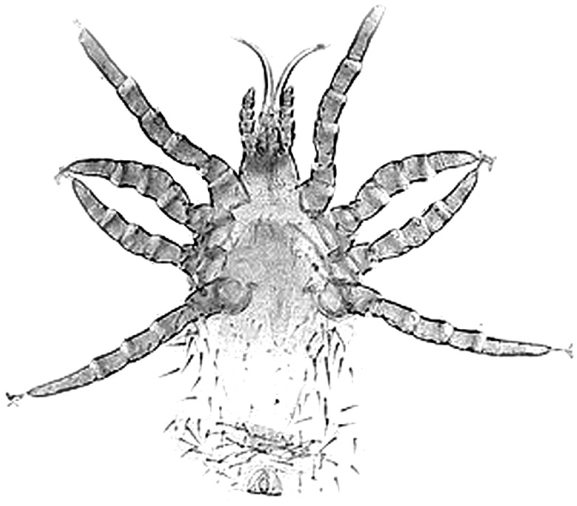


Image at: https://en.wikipedia.org/wiki/Mites_of_livestock

ii. Suborder: Trombidiformes (Prostigmata)

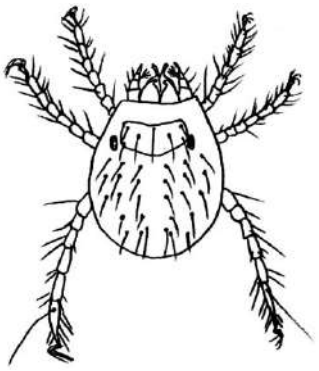
They have anteriorly located stigmata. They contain 2 families of medical importance.

Family: Trombiculidae

Trombiculidae are generally parasitic in the larval stage and free-living predators in the adult and nymphal stages.

Genus *Trombicula*

Species *T. autumnalis* (Harvest mites)



They infest humans and other domesticated animals as well as poultry. Larvae (nymphs and adults are non-parasitic) attack the head, face and legs producing an itching dermatitis with loss of hairs. Parasitic larvae do not burrow into the skin, but they remain on the surface. The host reaction appears as a firm papule with tense itching. In humans, it produces extensive rashes with itching as well as they transmit rickettsial pathogens causing scrub typhus.

Family: Demodicidae

Genus *Demodex*

Common species:

Demodex canis (dogs), *Demodex bovis* (cattle), *Demodex equi* (equines) and *Demodex folliculorum* (humans). It causes demodicosis, a common dermatosis in dogs and may be cats. It is limited to the hair follicles and, rarely, sebaceous glands.

Habitats:

They are found in hair follicles and sebaceous glands of various animals and humans causing demodectic and follicular mange (around the nose, cheeks and forehead).

Morphology:

It is worm-like and elongated with minute size of 0.25 mm long. The capitulum is anteriorly located, looks like a head and bears a pair of pedipalps, a pair of chelicerae and a single median hypostome. The body is divided into a cephalothorax and abdomen. The former bears four pairs of short stumpy legs. The later is elongated, cigar-shaped and transversely striated dorsoventrally.

Life cycle:

The female lays eggs that hatch to larvae (with short legs endings in a single trifid claw). Larvae moult **twice** (unusual feature of the life cycle). The 2nd larval form

produces 3 nymphal stages that moult into the adult. The infection occurs by direct contact or by a mechanical transmission. All stages of the life cycle are often present in the same hair follicle.

Pathogenecity:

They produce acne-like appearance as follows:

The primary lesions include spontaneous alopecia, scaling, follicular casts (keratosebaceous materials adhered to the hair shaft), papules, crusts, erythema, hyperpigmentation, and lichenification. *Demodex canis* is a part of the normal cutaneous flora in dogs. Mites number are kept low by a dog's immune system.

Diagnosis:

1. Clinical symptoms.
2. Skin scrapings. It must be deep associated with pressing on the affected glands/ follicles and examining the extruded substances under microscopy.
3. The presence of large numbers of mites at other sites proves the demodicosis.

Treatment of demodecosis in dogs:

Bathing dogs with a shampoo of antibacterial activity. The use of antibiotics. Application of selective miticidal drugs. Skin scraping must be done after treatment weekly or bi-weekly, and 2 negative skin scraping indicates a cure.

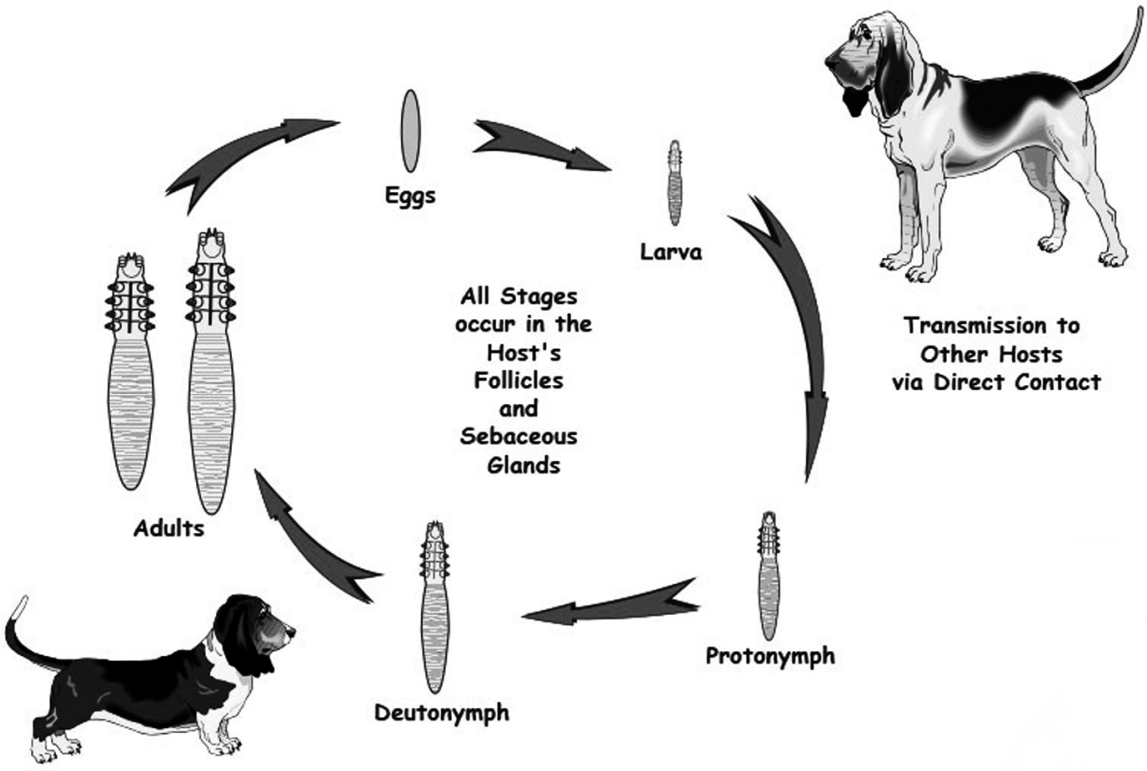


Image at: https://parasitology.cvm.ncsu.edu/life_cycles/arthropods/demodexcanis.html

iii. Suborder: Sarcoptiformes

Group (1) Oribatidae (Oribatid mites, beetle mites) (Cryptostigmata)

Non-parasitic tiny mites live in soil on roots of plants lower parts of plant stem and attracted to the mucoid materials covering fecal pellets of sheep. They are often ingested by sheep and other grazing animals. They act as intermediate host for the cestodes, family Anoplocephalidae.

Group (2) Acaridae (Astigmata) (Itching mites)

They induce all types of mange of domestic animals (except demodectic mange) and scabies of humans as well as scaly disease in birds. They include 2 families of veterinary medical importance; Sarcoptidae and Psoroptidae.

Family: Sarcoptidae (Burrowing mites)	**Family: Psoroptidae (Non-burrowing mites)**
Habits	
- Not-host specific. - Species burrow more or less deeply into the substance of the skin living in tunnels and cause marked thickening of skin rather than scab formation. They prefer areas not covered with hairs.	- Host specific. - Species do not burrow but they are parasitic on the skin surface causing the formation of thick heavy scabs rather than skin thickening. They prefer areas covered with hairs/wool.
Morphology	
- Body is globose (broad oval) or roughly circular in outline. The adult male measures 0.2 mm and the female is 0.4 mm in diameter. - The dorsal surface has a large area of spines and backward pointing scales (transverse ridges and triangular scales or spines). - Mouth parts are anteriorly protruded and sheathed. - Four pairs of short, 5-segmented and telescoped (not extend beyond body	- Oval body (more elongated). - No dorsal spines. - Legs are strong and extend beyond the margin of the body. - Suckers are carried out on **segmented** (in *Psoroptes* only) stalks. - Leg 4 of males is **shorter** ending with hairs. - Leg 3 of females bears **2 long terminal bristles** (in *Otodectes*, leg 4 ends with hairs). - In males, the posterior part of the body

margins) legs are present; 2 pairs arise anteriorly and 2 pairs posteriorly. - Bell-shaped suckers (caruncles) are carried out on **non-segmented** stalks (pedicels) on tarsi of some/all legs. In **females**, legs 3, 4 end with bristles (no suckers), while in **males** the 3rd leg only ends with bristles. Long apodemes (dark-colored plates associated with base of legs) are found in legs 1 and 2 on the first segment and joined in a Y shape, while they are shorter and not joined in legs 3, 4. - Terminal anus (dorsal in *Notoedres*). - The posterior margin of males is **not** bilobed.	has **2 adanal suckers** and is **bilobed**. - Anterior legs are distinctly stronger than posterior ones.
Common species	
1- Genus *Sarcoptes*. 2- Genus *Notoedres*. 3- Genus *Cnemidocoptes*.	1- Genus *Psoroptes*. 2- Genus *Otodectes*. 3- Genus *Chorioptes*.
Life history (incomplete metamorphosis)	
Females deposit 2-3 eggs/daily in skin tunnels. Eggs hatch in 3-4 days to give larvae which migrate to the skin surface and burrow into the intact stratum corneum to give nymphs (2 nymphal stages), and then adults. Larvae and nymphs may often be found in moulting pouches or in hair follicles and are similar to adults, only smaller. Under the most favorable of conditions, about 10% of eggs eventually give rise to adult mites. Males are rarely seen; they make temporary shallow pits in the skin to feed until they	The development from eggs through the larval and nymphal stages to mature adults occurs entirely on the skin and takes about 10 days.

locate a female's burrow and mate. Transmission occurs primarily by the transfer of the impregnated females during skin-to-skin contact.	

Genus *Sarcoptes*

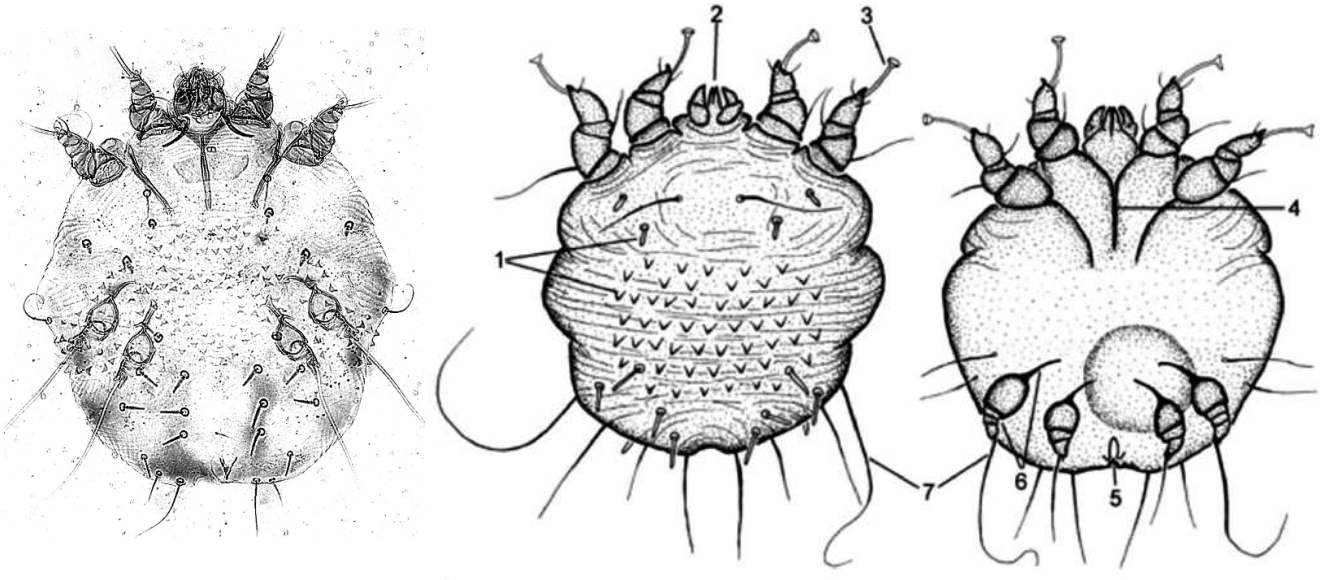
Species *S. scabiei*

• It infests a wide range of hosts causing sarcoptic mange in animals (sheep, goats, cattle, pigs, equines, dogs, rabbits, ….etc) and scabies in humans. It is physiologically adapted to one or more hosts, but it can live temporary on unusual hosts i.e. the species of equines is termed *S. scabiei* var *equi* as it is initially confined to equines, but is can also live on humans.

• Ears, muzzle, face and elbows are the predilection sites of sarcoptic mange, but in heavy infestations, it may extend over the whole body. Firstly, there is an erythema with papule formation which accompanied by an intense itching and scratching (due to pruritis) and ended by scale and crust formation as well as alopecia.

• Diagnosis is based on clinical signs and proved by skin scrapings.

Image at: at: https://en.wikipedia.org/wiki/Mites_of_livestock



Female dorsal view Female ventral view

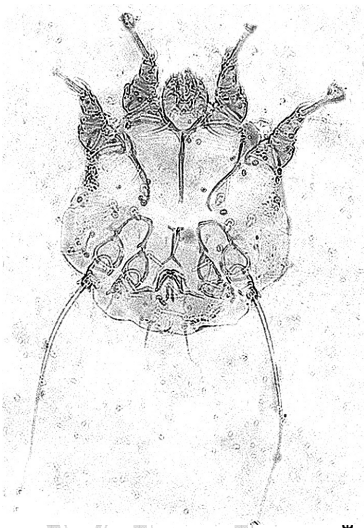
Image at: https://en.wikibooks.org/wiki/Parasitic_Insects,_Mites_and_Ticks:_Genera_of_Medical_and_Veterinary_Importance/Burrowing_mites

Genus *Notoedres*

Species *N. cati*

• It causes notoedric mange in cats, rabbits and rats.

• Morphologically, it could be distinguished from *Sarcoptes* by the presence concentric thump print striations on the dorsal surface, **no** spines and females are characteristically aggregate in groups known as "**nests**". Severe cases are noted on the face and head of rabbits.



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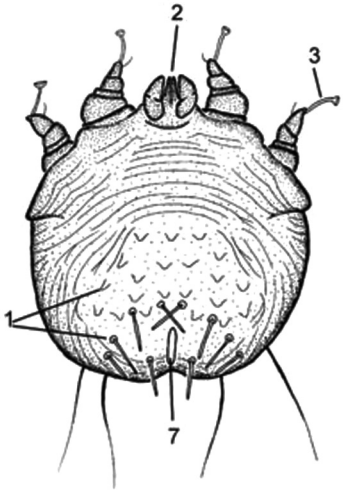
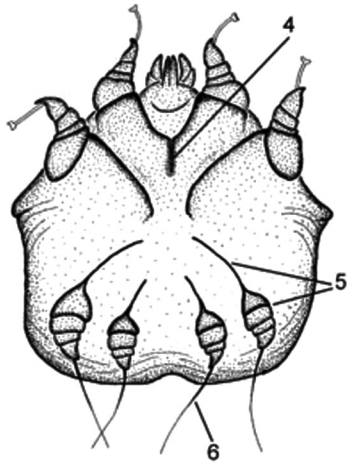


Female dorsal view



Female ventral view

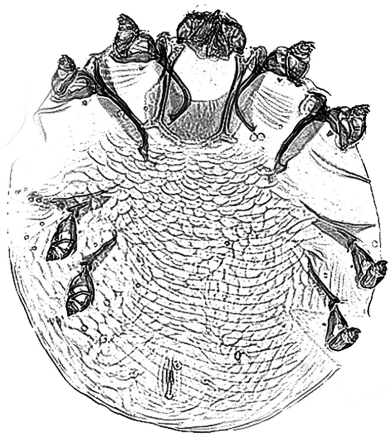
Image at: https://en.wikibooks.org/wiki/Parasitic_Insects,_Mites_and_Ticks:_Genera_of_Medical_and_Veterinary_Importance/Burrowing_mites

Genus *Knemidocoptes*

They are the burrowing mites of domestic birds.

1- *Knemidocoptes gallinae* (Depluming itch in poultry):

The mite burrows into the feathers' shaft causing itching and inflammation. Feathers break off readily and easily pulled by the birds especially at the neck and wings.



Knemidocoptes jamaicensis **adult female (dorsal view)**

Image at: Fuentes-Castillo et al. (2016). Braz. J. Vet. Parasitol 25 (4): 476-483

2- *Knemidocoptes mutans* (Scaly leg disease in poultry):

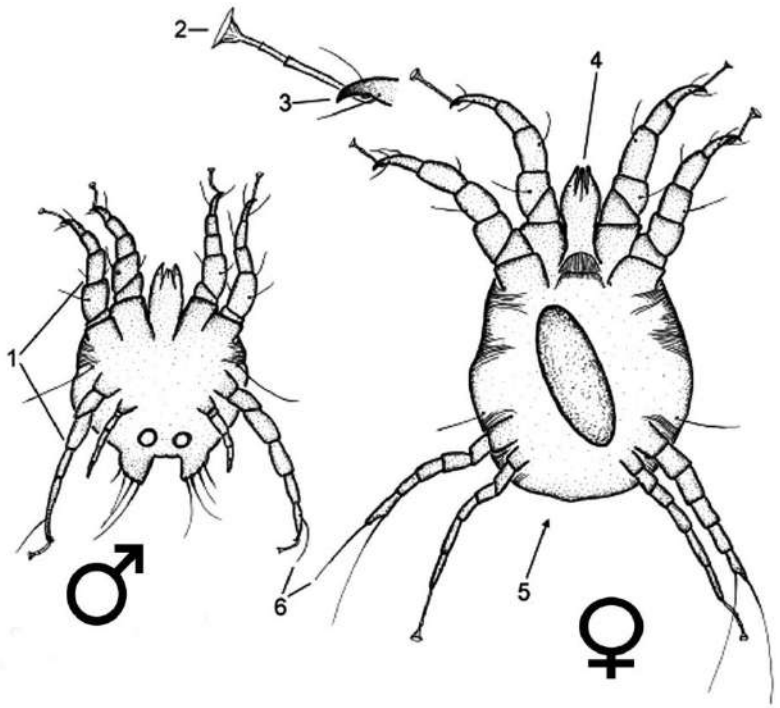
The parasite pierces the skin underneath the scales of legs causing inflammation with exudates that harden and thicken on the surface of legs and toes, and thus, scales are replaced by the newly produced keratinized tissues. This process is responsible for the thickened scaly feature of the disease. The disease may lead to lameness and distortion of the feet and claws.

3- *Knemidocoptes pilae* (Scaly face in cage birds):

It attacks bare and slightly feathered areas including back, head, neck, inside the wings, legs and feet. It causes a little pruritis. Lesions develop slowly, over several months.

Genus *Psoroptes*

Common species: *P. ovis* (sheep), *P. equi* (equines), *P. natalensis* (cattle) and *P. cuniculi* (ear mange of rabbits, goats, sheep and equines). All species are morphologically indistinguishable from each other, but they are identical to the family Psoroptidae. They are host specific.



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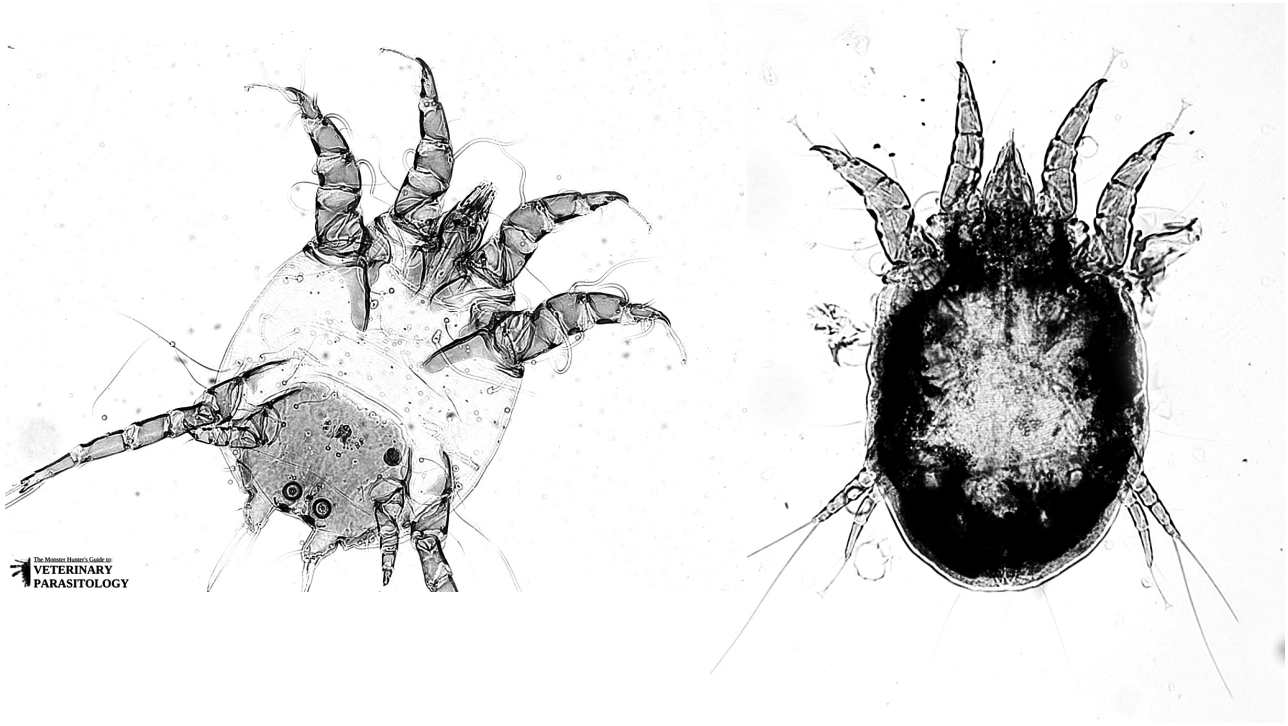


Images at: https://www.veterinaryparasitology.com/psoroptes.html

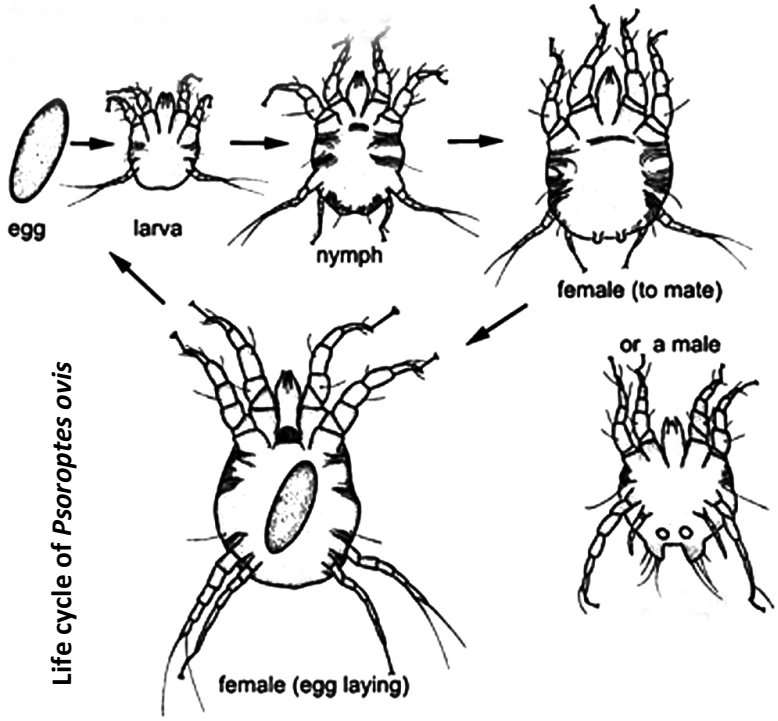


Image at: https://en.wikipedia.org/wiki/Mites_of_livestock

Pathogenesis:

• They are responsible for induction of psoroptic mange in animals (in sheep, it causes **sheep scabs**).

• Piercing and chewing mouth parts are the responsible for pathogenecity of *Psoroptes* species.

• Direct damage to the affected parts occurs. Firstly, inflammatory zones with small vesicles and serous exudates appear. As the lesion progresses, the center becomes dry and covered by yellow crusts, while the borders are still moist, where the mites are feed and multiply.

• In rabbits, it secretes waste products like feces and mucus, which are highly proteinaceous and allergenic to the rabbit's skin. The inflammatory reaction results in redness, heat, swelling and itchiness of the ear canal skin. The rabbit starts scratching and shaking its ears because of this inflammatory pain and itchiness.

Genus: *Chorioptes*

Species *C. bovis*

It infests cattle, sheep, goats and equines.

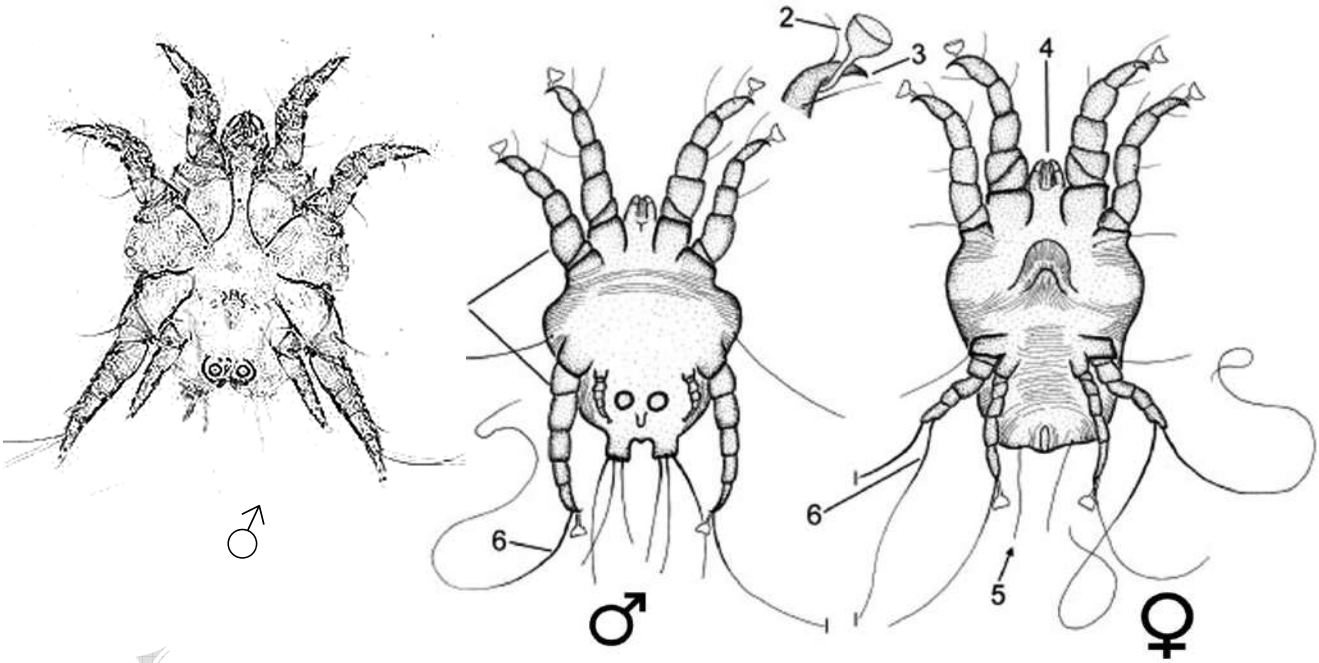
Morphology:

It resembles *Psoroptes* except:

1. Mouth parts are distinctly rounded and adapted for chewing only.
2. Tarsal pedicels are non-segmented and ended with cup-shaped suckers.

Pathogenesis:

It causes chorioptic mange in affected animals. Although lesions are mostly localized, severe pruritis results in scratching and rubbing with subsequent economic losses due to the damaged hide in cattle occur. A mild harm is caused in sheep.



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Genus: *Otodectes*

Species *O. cynotis*

It causes ear mange in cats and dogs. Morphologically, it resembles *Psoroptes* and *Chorioptes* except for:

1- Larger in size.

1- The external ear of dogs and cats being the predilection site.

2- Apodemes adjacent to the 1st and 2nd pairs of legs are closed.

3- Tarsal pedicels are non-segmented.

Pathogenesis:

• In cats, severe lesions with significant quantities of dark cerumen and sometimes even blood present in ears (only 1-2 mites are often present).

• In dogs, it is the common cause of otitis externa, associated with brownish to black waxy deposits and exudates in the ear canal. The secondary bacterial infections may complicate the condition resulting in purulent otitis. The common clinical signs are shaking of the head and scratching the ears due to severe prutitis.

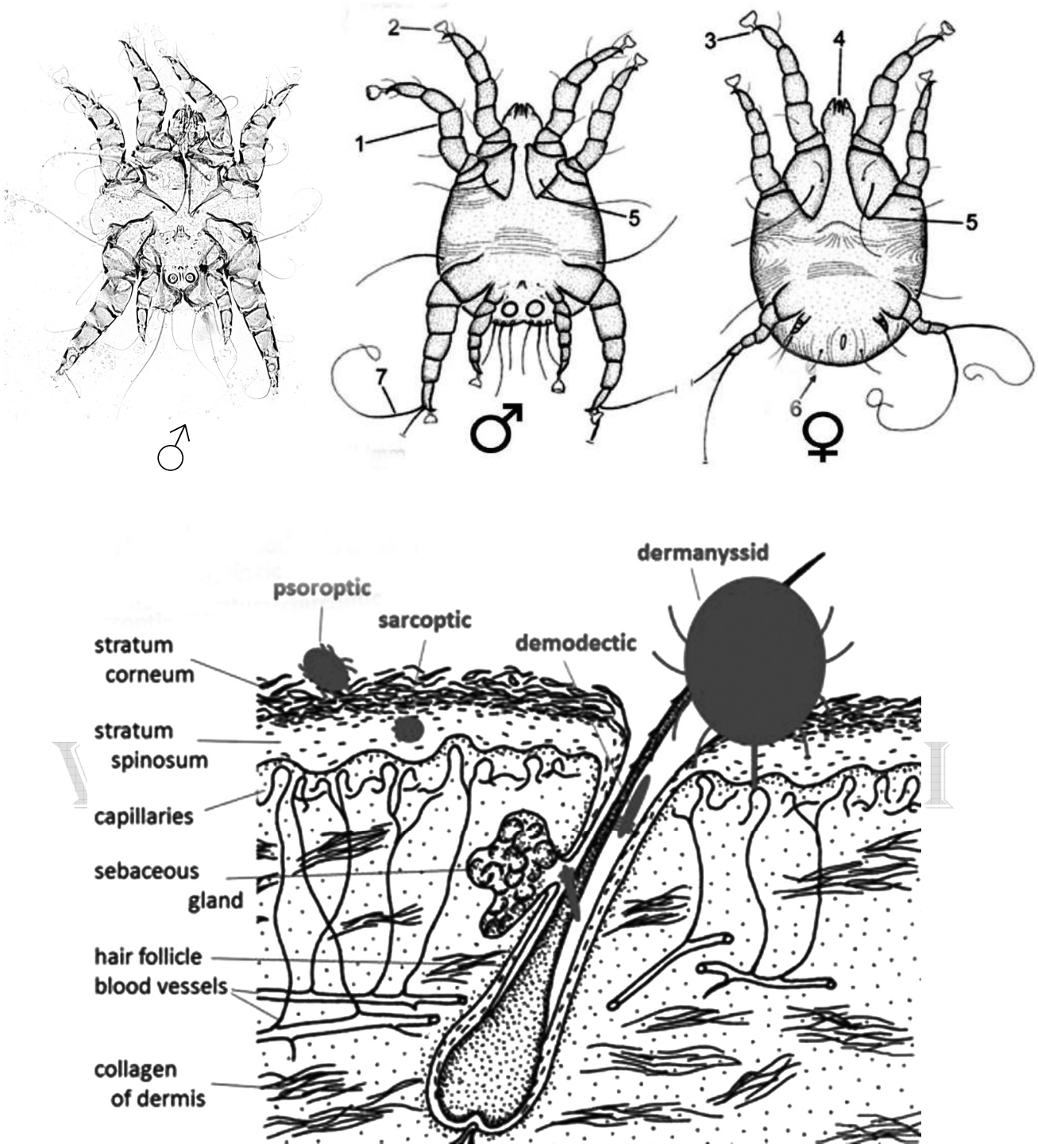

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Image at: https://en.wikipedia.org/wiki/Mites_of_livestock

Sites of infestation of various mites

Diagnosis of mange:

I. Symptomatically:

Intense irritation, itching, scratching and the appearance of areas denuded of hairs and wool associated with scabs formation are common signs.

II. Laboratory techniques:

The lesion is scraped, from the periphery to the center, by a scalpel till blood oozing. Smearing with a little glycerin or water is preferable to hold scrapings together.

Scrapings are heated (**NOT** boiled) in a solution of 10% caustic soda in a water bath for few minutes until the associated hairs/wool are dissolved. Cool, centrifuge and examine the sediment microscopically to detect the mites.

Control of mange:

1) Treatment of affected animals via dipping, spraying or bathing. Repeated treatment is mandatory to kill larvae hatched after the first exposure. e.g. malathion, diazinon and sulphur ointment.

2) Good feeding and exercises.

3) Cleaning and disinfecting all animals, premises and utensils.

iv. Suborder: Ixodoidea (Metastigmata)
(Soft and hard ticks)

Distribution and habits:

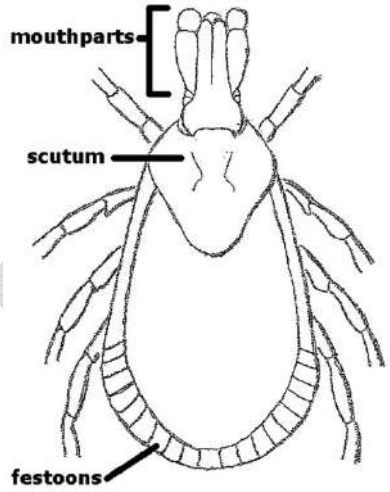


Image at: http://www.idph.state.il.us/envhealth/tickkey.htm

• Ticks are small ectoparasites (permanent or temporary), typically 3-5 mm long, a part of the order Parasitiformes, along with mites and feed on the blood of mammals, birds, and sometimes reptiles and amphibians.

• They are widely distributed worldwide, especially in warm and humid climates.

• Adults have ovoid or pear-shaped bodies and eight legs. Some species possess a hard shield on their dorsal surfaces, while others not.

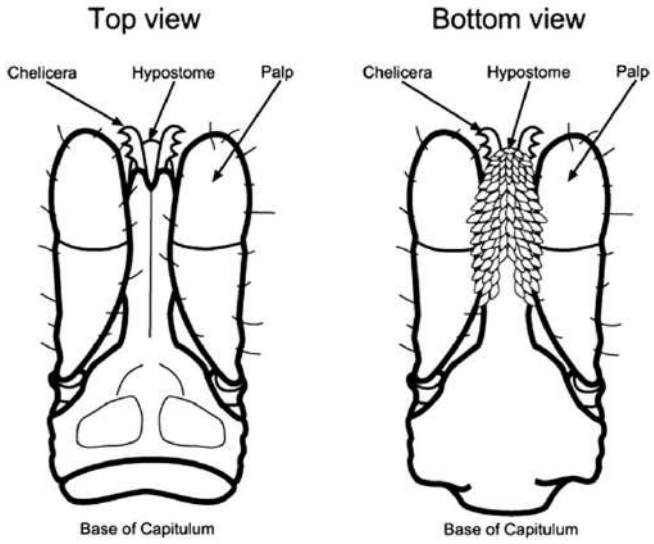


Image at: https://extension.entm.purdue.edu/publichealth/insects/tick.html

• Almost all ticks belong to two major families, Ixodidae (hard ticks) and the Argasidae (soft ticks).

• Ticks have four stages to their life cycle; egg, larva, nymph, and adult (incomplete metamorphosis). Ixodid ticks have three hosts, taking at least a year to complete their life cycle. Argasid ticks have up to 7 nymphal stages, each one requiring a blood meal.

• Because of their habit of ingesting blood, ticks are vectors of at least 12 diseases that affect humans and other animals.

Family: Ixodidae (Hard ticks)

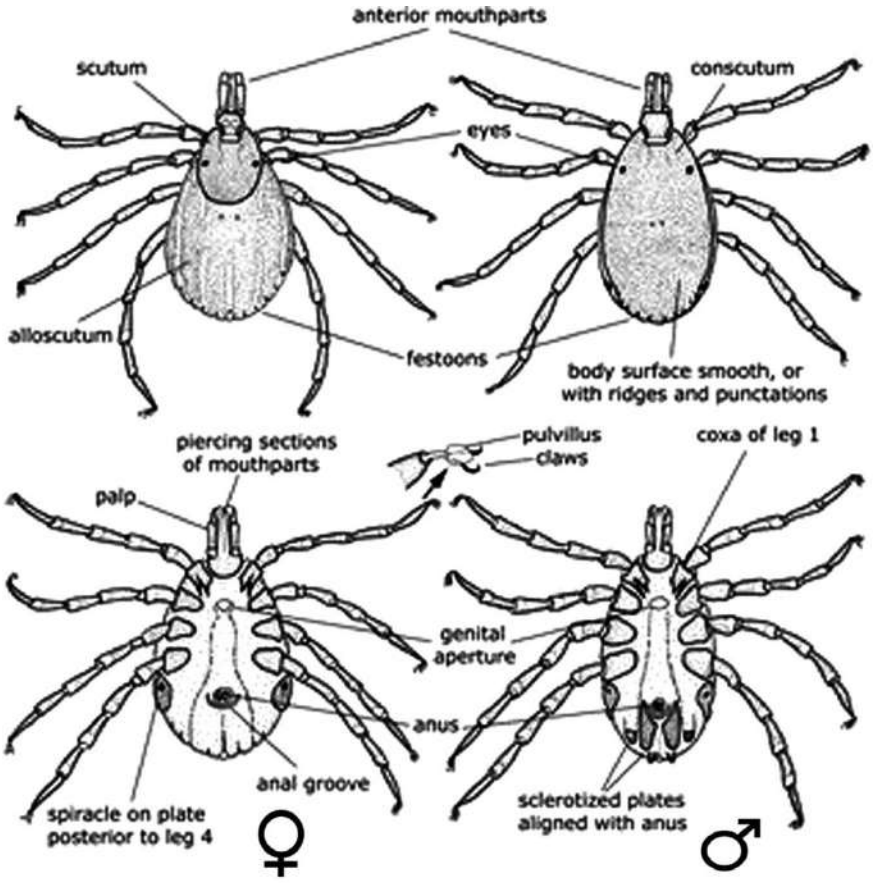
• The family Ixodidae is the largest and economically most important family with 13 genera and approximately 650 species.

• Hard ticks feed for extended periods on their hosts, varying from several days to weeks, depending on such factors as life stage, host type, and tick species.

• Instars are found in the perineal region, under the tail, on udder, legs and inner surface of ears.

General and morphological characters:

• They are **permanent** ectoparasites of mammals i.e. obligate blood suckers all the day. Instars bury proboscis deeply into host tissues and remain attached till engorged with blood. If detached before engorgement, they rarely feed again. They are dorsoventrally flattened in unfed status, while having bulged margins tapered towards the anterior end when suck blood.



• The body is a single unit. In average, larva is 0.5-1 mm, nymph is 1-2.5 mm and adult is 1-1.5 cm long.

• They are so called due to the presence of a rigid chitinious covering (**scutum**) which covers the **entire** dorsal surface of the **male**, while in **female, larva** and **nymph**, it covers only a small area at the **anterior third** of the body leaving the abdomen able to be enlarged after feeding.

• Mouth parts (wedge-like) are **well visible** dorsally and carried on a capituli and are visible from a dorsal view. It includes paired chelicerae, paired 4-segmented pedipalps, and the ventrally single median toothed hypostome. All are carried on the basis capituli.

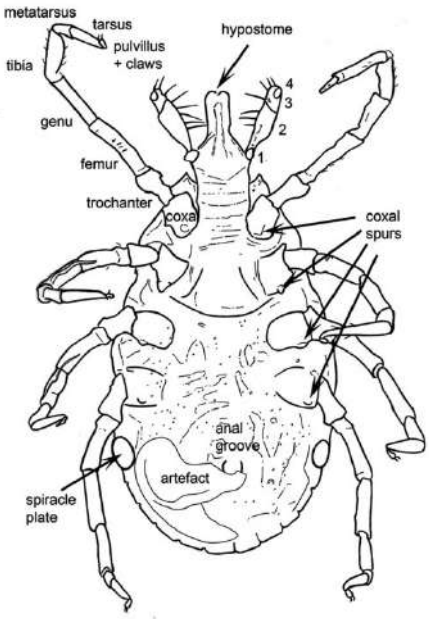


Image at: Chitimia-Dobler L, Pfeffer T, Dunlop JA (2018). Parasitology 145 (11): 1440-1451.

• Eyes, if present, are located at the lateral margins of the scutum.

• In legs, tarsal claws contain pulvilli in between. Also, coxae have **spurs**.

• The posterior part of the body has a row of notches or wrinkles (**festoons**).

• A pair of triangular respiratory spiracles (stigmata) are found **posterolateral** to the coxae of 4th leg.

• Males of some species may have chitinous plates on the ventral surface.

• Genital opening is located at the ventral midline at the level of the 1st pair of legs, while the anus lies ventrally in the posterior third of the body (surrounded by 2 anal shields in males).

• Sexual dimorphism is **marked**.

Life cycle: (Incomplete metamorphosis)

• Mating takes place on the host, then the female sucks blood and become engorged, drop off the host seeking for a sheltered place to lay eggs (usually in cracks, under stones in the ground). The female lays eggs in one batch and **dies**, while the male remains much longer on the host.

• Within 20-50 days (according to temperature, humidity and species of ticks), eggs hatch giving 6-legged larvae which climb on the grasses searching for the suitable host to suck blood. The newly hatched larvae are termed **seed-ticks**. Larvae resemble adults but with no genitalia.

• They climb on grasses, and if appropriate host is present, they engorge and moult (on the host/ground) giving 8-legged nymphs (without a genital opening). On a suitable host, they suck blood and become engorged and lastly molt (on the host/ground) to give adults (with 4 pairs of legs and a genital opening). The infested host may be the same animal or other.

• The life cycle from egg to egg lasts for 1-4 years according to temperature, humidity, type of host and period of larval stages.

• According to the number of hosts needed for ticks during the entire life cycle, ticks could be classified into:

(1) One-host ticks:

The entire parasitic development, from larvae to adults, takes place one host. e.g. *Boophilus* species.

(2) Two-host ticks:

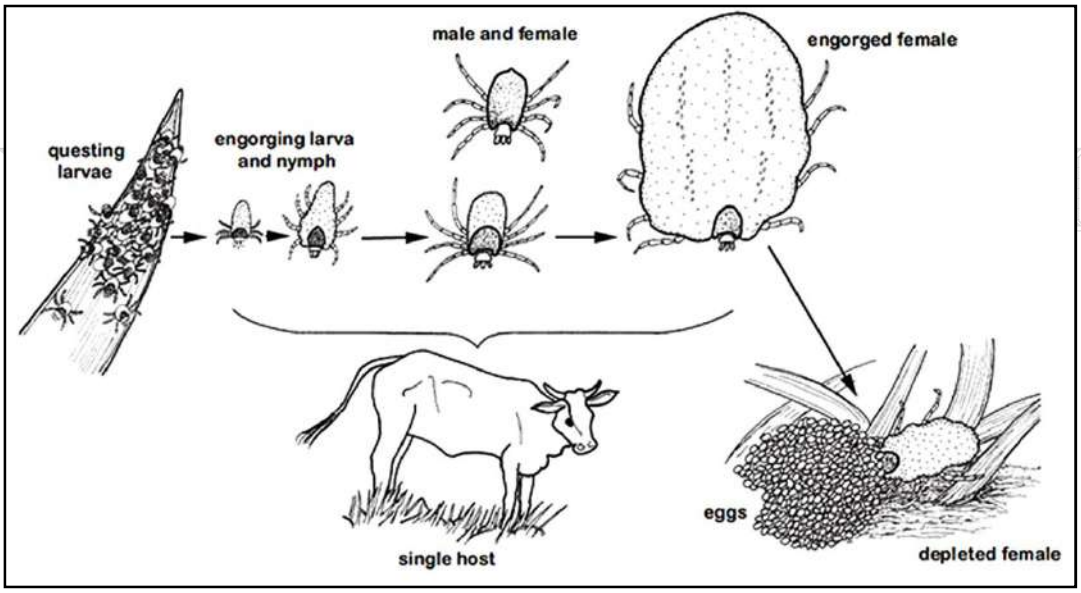
Larvae and nymphs occur on one host, then nymphs leave, drop off the ground and moult to adults, which in turn climb onto another host (the same animal/species or others). e.g. *Hyalomma* species.

(3) Three-host ticks:

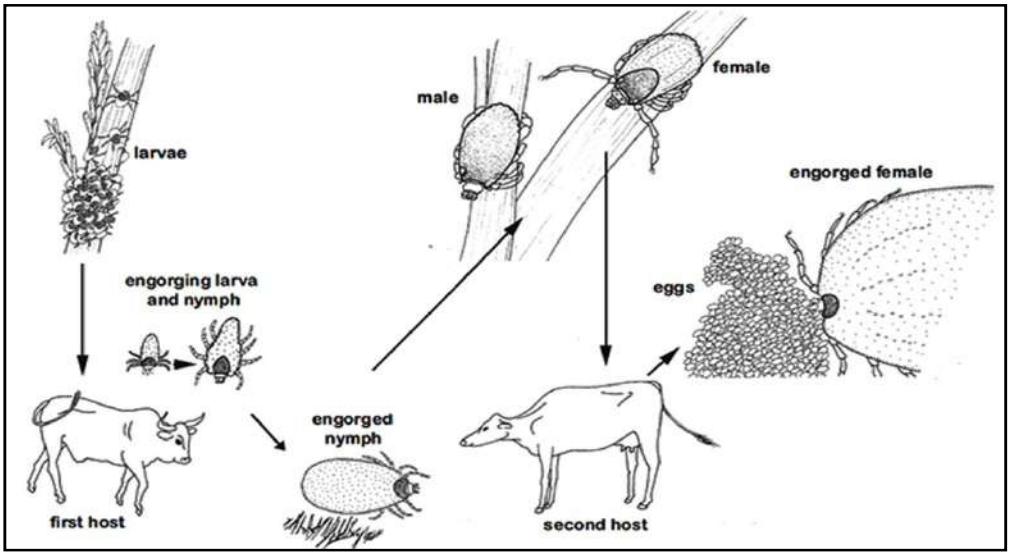
Each instar takes place on a particular host and moulting occurs on the ground in between stages. e.g. *Amblyomma*, *Ixodes* and some species of *Dermacentor.*

Common species in Egypt:

Boophilus annulatus, *Hyalomma anatolicum*, *Rhipicephalus sanguineus*, *Haemaphysalis leachii*.



Life cycle of one-host ticks



Life cycle of two-host ticks

Images at: http://www.afrivip.org/sites/default/files/Ticks_identification/lifecycle.html

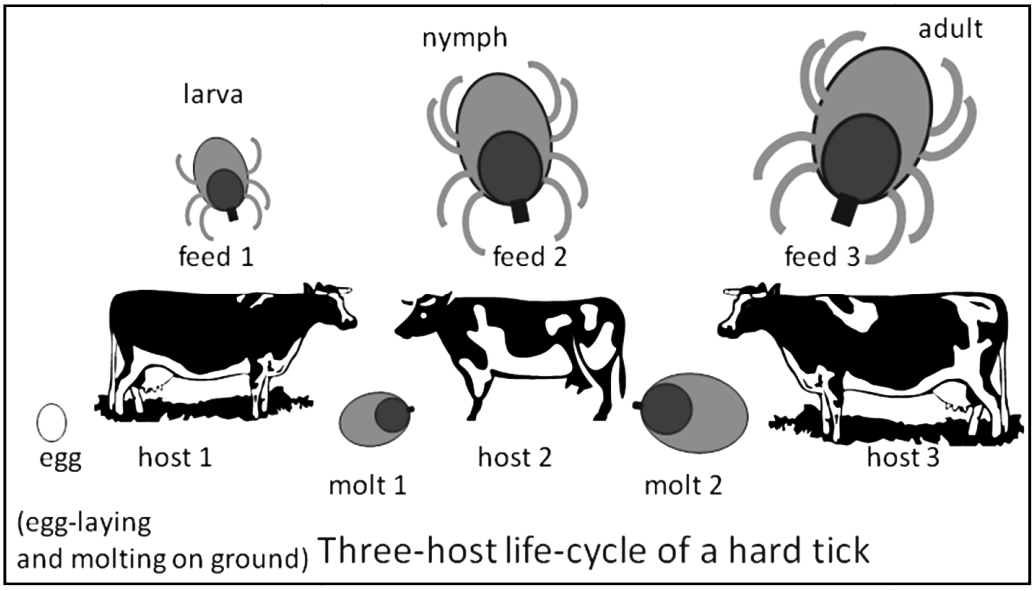


Image at: https://commons.wikimedia.org/wiki/File:Three-host-life-cycle-hard-tick.png

Medical importance:

• Irritation, restlessness, loss of condition and anemia (adult female engorges 0.5-2.0 ml blood).

• Ticks transmit various diseases (**tick-borne diseases**) as:

- Parasitic diseases. e.g. babesiosis, theileriosis and hepatozoonosis.

- Bacterial diseases. e.g. pasteurellosis, borreliosis.

- Rickettsial diseases. e.g. anaplasmosis.

- Viral diseases. e.g. a disease caused by equine encephalitis virus.

• Their biting predispose to blowflies and screw-worm myiasis.

• Tick toxicosis and tick paralysis due to hypersensitivity to toxins injected by ticks, often adults.

• The value of skin and or fleece may be reduced due to skin perforation. The later may be a predisposing cause to blow fly myiasis.

Family: Argasidae (Soft ticks)

General characters:

• They are temporary ectoparasites on birds and mammals unless the larval stages are permanent under the bird wings.

• Most of argasids are fast feeders, ingesting a relatively small amount of blood per meal and adult specimens can feed and reproduce repeatedly.

• Argasids are very resistant to starvation and can survive for several years without feeding (adults become sexually active after emergence and they do not require a blood meal to initiate gametogenesis).

• Adults and nymphal stages feed during night and hidden under the stones, in cracks, and bedding during the day. Females feed several times and produce several egg batches. The eggs are large-sized and few in number.

• They **lack scutum** and uniquely possess a tough leathery integument (not in larval stages), which is wrinkled, granulated, mammillated/covered with tubercles and with sharp edges. The dorsal body surface is ornamented with radial arranged round discs.

• The capitulum is recessed ventrally near the anterior end and is **not visible dorsally** (except in larvae).

• Argasid ticks appear as a flattened oval-shaped.

• Eyes are often absent (when present, they are anterolaterally located).

• Respiratory spiracles occur in supracoxal folds **anterolateral** to the coxae of 4th legs.

• Sexual dimorphism between male and female is **difficult** (the genital opening is larger in females).

1) Genus *Argas* (Bird ticks)

Species *A. persicus* (chicken tick), *A. reflexus* (pigeons tick)

General characters:

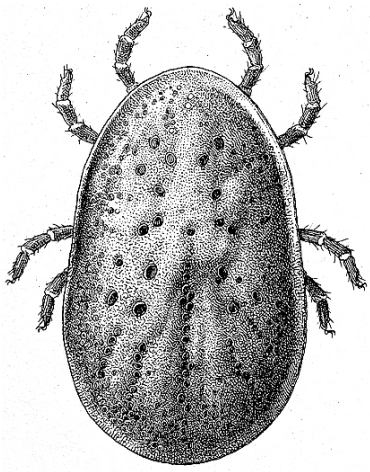
The same characters plus

• The fowl tick, *A. persicus*, is found worldwide in tropical and subtropical countries.

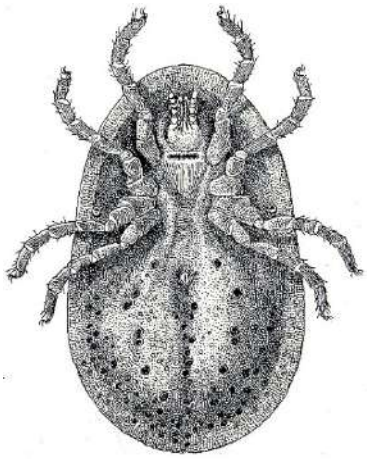
• They are particularly active in poultry houses during warm and dry weather.

• It measures 0.5-1.0 cm x 3 mm, pear-shaped, narrower anteriorly and wide posteriorly.

• Engorged females are dark blue, while the starved ones are yellowish to brown.



Adult female *A. persicus* dorsal view



Adult female *A. persicus* ventral view

Images at:
https://commons.wikimedia.org/wiki/File:A_ventral_aspect_of_the_female_fowl_argas_(Argas_persicus)._Wellcome_V0022606EL.jpg
https://ar.wikipedia.org/wiki/%D9%85%D9%84%D9%81:A_dorsal_aspect_of_the_female_fowl_argas_(Argas_persicus)._P_Wellcome_V0022606ER.jpg

Life cycle:

• Females lay eggs in crakes, crevices, under the stones, between the wall and the door, or in bedding of poultry houses or under the bark of trees. They feed several times during egg laying.

• The eggs are yellowish-brown and spherical. They hatch to larvae (circular outline and subterminal mouth parts **visible** dorsally).

• The larvae attach themselves to the host, particularly under the wing, where they feed for about a week. They fall off and moult into 2 nymphal stages before the adult.

• Adults and nymphs are nocturnal and can resist starvation for 5 years.

Medical importance:

• Fowl ticks produce anemia, weight loss, depression, toxemia, paralysis and decreased egg production. Red spots can be seen on the skin where the ticks have fed.

• It transmits the rickettsia, *Aegyptianella pullorum*, which causes the fowl disease, aegyptianellosis. Also, it is the vector of *Borrelia anserina* (avian spirochetosis).

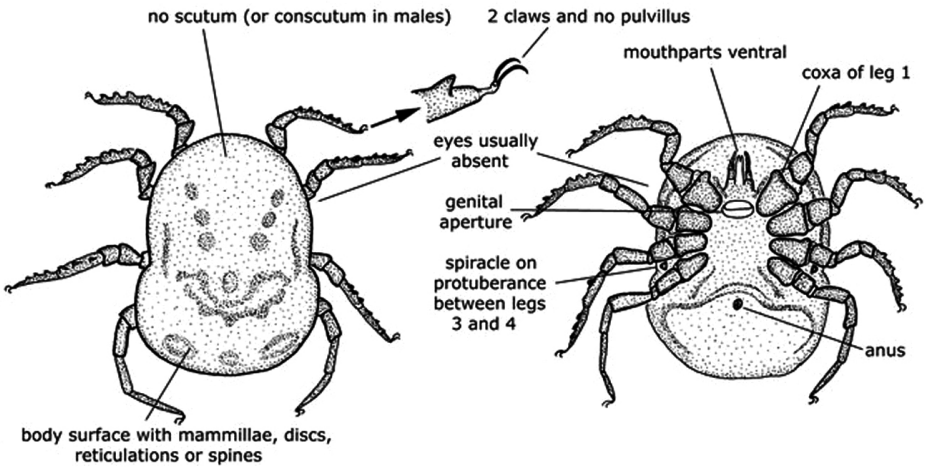
2) Genus *Ornithodoros* (Mammals ticks)

Species *O. moubata*, *O. savignyi* (Eyed or sandy tampan)

It resembles *A. persicus* but:

• It is a species of soft ticks associated with humans and/or domestic animals.

• Edges are thicker and broad anteriorly (bean-shaped) with a mammillated cuticle.



Adult female *Ornithodoros* sp.

Image at: Barker SC, Walker AR (2014): Ticks of Australia. The species that infest domestic animals and humans (Zootaxa 3816). 144 pp.

• Eyes are present on lateral margins.

Life cycle:

• The adult females lay eggs in batches. Eggs are large, spherical, glistening and golden yellow and hatch in about 8 days at 30°C.

• The newly formed larvae did not feed and remain motionless until they molt into nymphs 4 days later. The number of nymphal stages is variable with adult males being produced after 4 nymphal stages and the female after five.

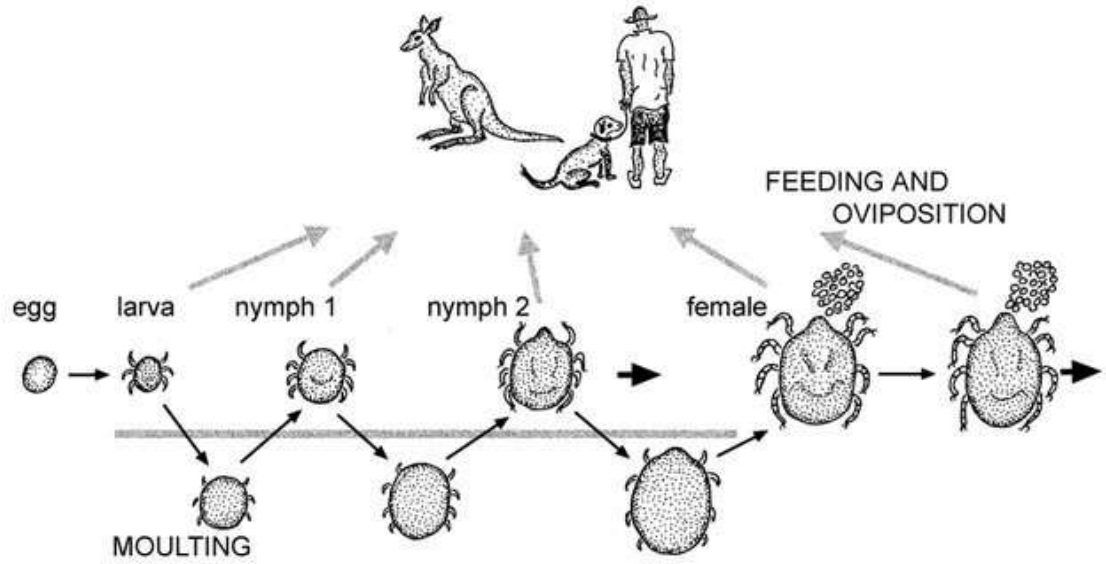


Image at: https://www.researchgate.net/publication/263291136_Ticks_of_Australia_The_species_that_infest_domestic_animals_and_humans/figures?lo=1

Medical importance:

- They transmit *Trypanosoma cruzi*.
- They are vectors of endemic relapsing fever caused by *Borrelia duttoni*.

Differences between Ixodidae and Argasidae:

Characteristics	Ixodidae (Hard ticks)	Argasidae (Soft ticks)
Hosts	Only mammals	Mammals and birds
Habits	Permanent ectoparasites	Temporary ectoparasites
Scutum	Present	Absent
Capitulum	Terminal and can be seen dorsally	Subterminal and cannot be seen dorsally
Mouth parts	Protrude anteriorly and could be seen from the dorsal aspect	Situated ventrally and cannot be seen from the dorsal aspect
Pedipalps	Segments are fixed	Segments are movable
Spurs	Present	Absent
Festoons	May present posteriorly	Absent
Eyes	Present marginally to the scutum	Usually absent
Spiracles	Posterolateral to the 4thcoxa	Anterolateral to the 4thcoxa
Pulvilli	Always present	Rudimentary or absent
Sexual dimorphism	Easy and marked	Difficult
Examples	*Boophilus annulatus*, *Rhipicephalus sanguineus*, *Hyalomma* species	*Ornithodoros moubata*, *Argas persicus*

Control of ticks:

I. Chemical control

Eradication of ticks at the animal body by dipping of animal in a suitable tank containing the acaricide in a aqueous solution, suspension or emulsion, spray or showers and washing the animal (individuals). All animals must be watered and free from any wounds. e.g. Arsenics (disadvantages are toxicity and resistance), carbamates, butocarbonl, formamidine, amitraz, and some synthetic pyrethroids. Ivermectin or closantel is useful against the one-host tick *Rhipicaphalus* spp.

Problems of chemical control methods

• The development of resistance to successive acaricides has been a major problem.

• The increasing cost of acaricides, illegal cattle movement, poor management and inadequate maintenance.

• The use of acaricides may pollute the environment and may also contaminate milk and meat.

II. Ecological control

• Removal of vegetations that shelter ticks. It is done periodically by burning. Replacement of natural vegetation, cropping, and soil cultivation are integrated methods that enable pasture improvement and tick eradication.

• Pasture rotation. It is determined according to the target species and hosts of the successive instars, the period of stay and number of cattle.

• Wild carnivores, as well as other possible hosts of the different instars should be eliminated.

III. Biological control

• Entomopathogens (a group of organisms that attack ticks and insects) either macro- or microorganisms can overcome various arthropods.

• Predators are most effective, especially ants and birds.

IV. Immunization (anti-tick vaccine)

Research into controlling ticks as focused on developing vaccines. Cattle vaccinated with antigens derived from the mid-gut of female ticks were protected from challenge with *Rh. annulatus*. As a result, the number of ticks engorging, their average weight and their ability to lay eggs may all be adversely affected.

Order: Scorpionida (scorpions)

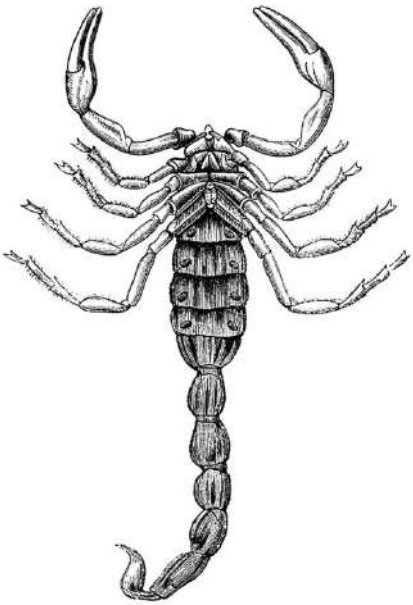


Image at: https://pfharris.com/products/scorpions/

• Large terrestrial arthropods live in warm climates. They are nocturnal, hide away by the day under the stones.

• They are composed of a cephalothorax (prosoma) and abdomen (opisthosoma). Prosoma has mouth parts, 8 legs, small chelicerae and large pedipalps. Opisthosoma consists of 12 segments, anterior broad 7 segments (mesosoma) and posterior narrow 5 ones (metasoma). The last abdominal segment is called sting that carries a poison gland and provided with a sharp spine.

• They only attack when apparently threatened. Most stings occur when they find shelters in shoes or beddings. Their toxins may be fatal causing paralysis of heart failure.

Order: Araneida (spiders)

Image at: https://cyprus-mail.com/2018/11/02/ne spider-species-discovered-in-kyrenia-mountains/

• It is composed of prosoma and non-segmented opisthosoma. Both are connected together by the first abdominal segment (stalk).

• Small pedipalps and chelicerae (the later has poison gland).

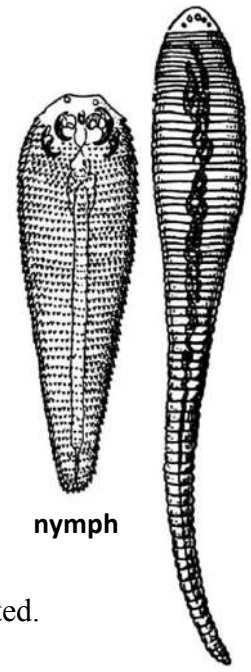
• Most spiders are harmless, otherwise, some large species cause necrotic damage (due to their venom) in humans.

Miscellaneous arthropods

Class: Pentastomida

Genus *Linguatula*

Species *L. serrata* (Tongue-worm)



nymph

Adult female

Host and habitats:

It is a cosmopolitan zoonotic parasite found in the nasal and respiratory passages of dogs, wolves, foxes and humans. They are so named because they have 5 anterior appendages; mouth and 2 pairs of hooks.

Morphology:

• Elongated worm-like, dorsoventrally flattened, colorless and transparent parasite, narrower in the posterior half and resembling vertebrates tongue, so named.

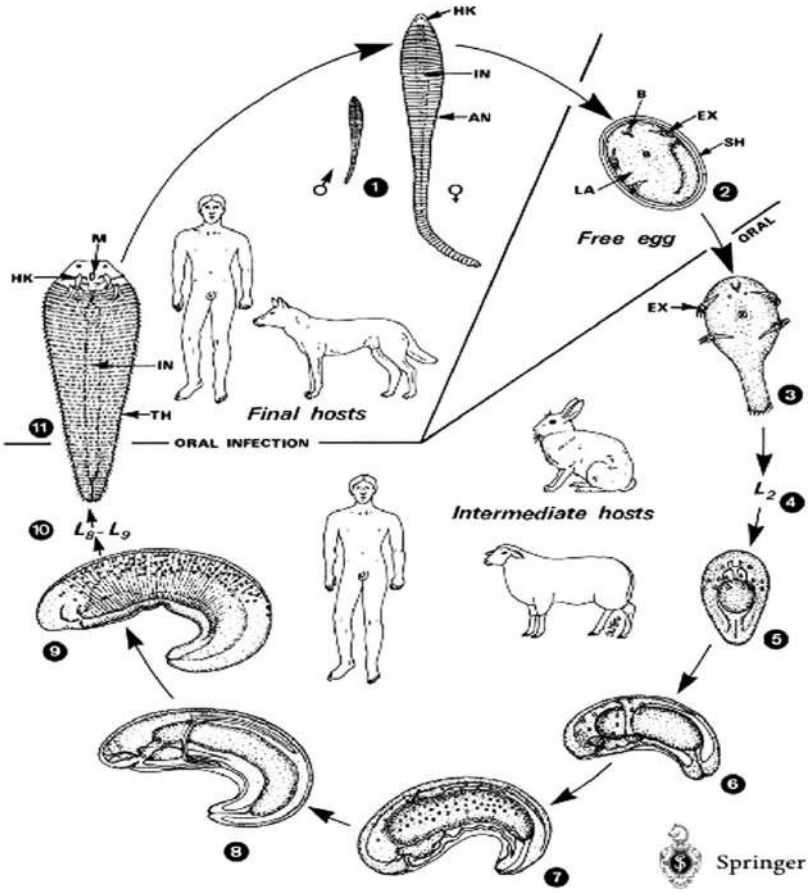
• The female is large, 8-13 x 1 cm, the male is much smaller, 1.8-2 cm x 2 mm.

• The body is covered with a thin cuticle which is annulated i.e. transversely striated.

• Near the mouth, there are two pairs of appendages (hooks), usually interpreted as modified limbs. The anus locates at the posterior end.

Life cycle:

• Adults bury their forebody into the nasopharyngeal mucosa, feeding on blood and fluids. Females live at least two years and produce millions of eggs via sneezing/coughing. Eggs drop off the host in nasal secretion or, if swallowed by the definitive host, with feces.



• When ingested by an appropriate intermediate host (all herbivores including sheep, goats, camels, pigs), the 4-legged larvae (resembling a mite) hatch in the small intestine, penetrate the intestinal wall and lodge in tissues, particularly in **lymph nodes**, lungs, and liver.

• The nymphal stage develops in small cysts (often in lymph nodes). When eaten by a definitive host, infective nymphs either attach in the upper digestive tract or quickly travel reaching the nasopharynx. Females begin egg production in about six months. Humans are accidental definitive host; they are infected via eating raw or semi-raw vertebrate intermediate hosts.

Pathogenesis:

Irritation of the upper nasal passages with sneezing and coughing. In heavy infection, dyspnea with bloody mucoid discharge occurs.

Diagnosis:

It is possible via the presence of eggs in nasal secretions.

Control of arthropods

It is directed towards:

I. Quarantine measures:

To prevent the introduction or spread of new dangerous arthropods, we must:

1) Keep the newly introduced animals in quarantine under veterinary supervision to destruct insects.

2) Limit their multiplication/extension to other districts.

II. Protection of animals from insect attacks:

1) Application of insect repellants as citronella oil.

2) Application of double doors and wire nets on windows.

3) Covering the animals during transportation.

4) Avoiding the use of instruments of infected animals.

III. Reduction of number of arthropods:

1) General sanitary conditions to keep stables and their surroundings clean and free from rubbish, vegetations and accumulated water.

2) Elimination of ponds and swampy areas.

3) Proper animal husbandry.

4) Pasture management to interrupt the life cycle of arthropods.

5) Trapping of insects.

6) Biological control by the use of predators and entomophagous organisms.

7) Chemical control by the use of the proper insecticides.

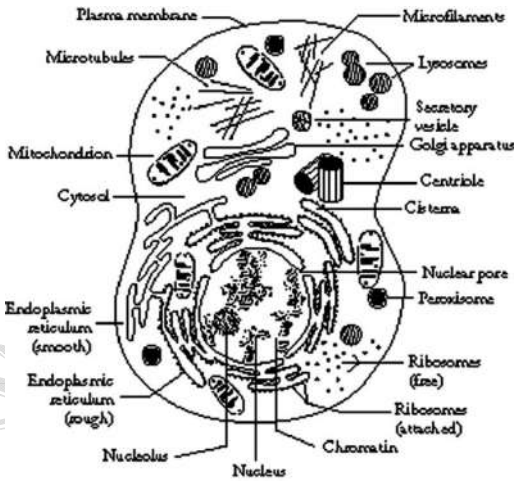
8) Genetic control by the introduction of sterilized males into insect populations.

Veterinary Protozoology

Introduction

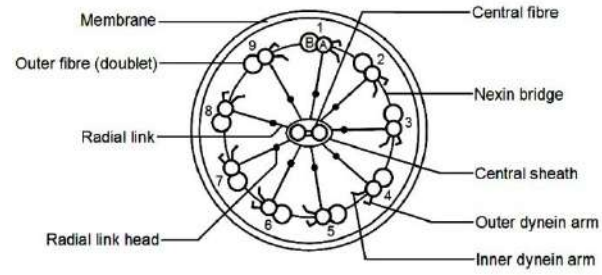
Protozoology is a branch of Parasitology dealing with the study of protozoa, either parasitic or free-living, in both vertebrates and invertebrates. Parasitic protozoa (protists) adapt themselves extremely on the expense of hosts. The **protozoan** is a unicellular organism has the capability to perform all physiological functions of the life. The majority of protozoa are microscopic, otherwise, few species could be visible by the naked eyes (macroscopic). Protozoa habit either singly or in colonies.

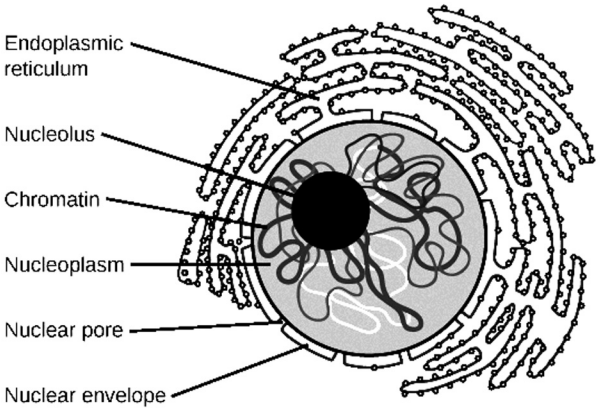
General structure



In general, the protozoan (eukaryotic animal cell) is composed of **cytoplasm** (bounded by a limiting membrane) and a **nucleus** (one or more, often one). The cytoplasm is differentiated into outer peripheral portion, **ectoplasm**, and inner central portion, **endoplasm**. The later contains several organelles, filaments and structures such as nucleus, endoplasmic reticula, mitochondria, Golgi apparatus, chromatoid bodies, vacuoles, fibrils, centrioles, cilia and flagella. Not all these organelles occur in the same organism. The delineation between ecto- and endoplasm greatly varies according to the species.

Item	Ectoplasm	Endoplasm
Location	Outer and peripheral	Inner and medullary
Often, no marked delineation in between		
Consistency	Gelatinous, homogenous, non-granular and hyaline	Fluidy and granular (coarse)
Functions	1- It provides a protection and rigidity of the protozoan. 2- Sometimes, it secretes a cyst wall which protect against unfavorable conditions. 3- Bases of flagella and cilia (organs of locomotion) are embedded in it.	1- Its colloidal status permits the occurrence of organelles. 2- Metabolic functions due to the presence of Golgi apparatus and mitochondria. 3- Secretion of digestive enzymes. 4- Elimination of waste products via chromatoid bodies.



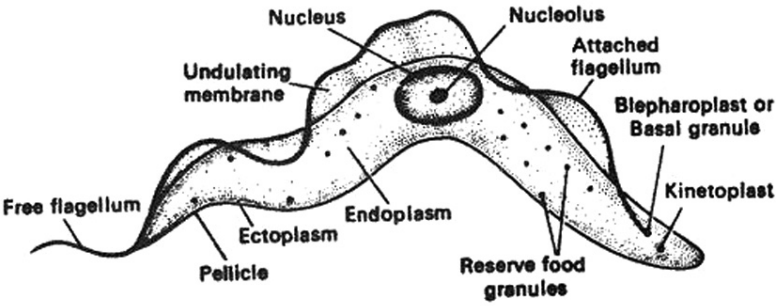


• Protozoa are eukaryotic i.e. with nucleus and a well-defined nuclear membrane. Usually, one (rarely multinucleated) nucleus is present. It is composed of central or eccentric nucleolus (**endosome** or **karyosome**), chromatin granules (DNA + special protein, **histones**) and nuclear fluid (**nucleoplasm** or **nuclear sap**). Two types of nuclei are recognized: 1- Vesicular nucleus; it is pale stained, with small amount of chromatin, large amount of nucleoplasm and it has a reproductive function. 2- Compact nucleus; it is deeply stained, with large amount of chromatin, small amount of nucleoplasm and it has a vegetative function. The most common type of nuclei in protozoa is the vesicular type. The nucleus is responsible for maintaining life and reproduction of the protozoa.

chromatin → chromosomes → genes

• In ciliates (Ciliophora), both types of nuclei are present. In this case, the vesicular nucleus is called **micronucleus** (reproductive functions) and the compact one is termed **macronucleus** (vegetative activities).

• In kinetoplastids (Mastigophora), in the most posterior part, present what is called basal granule (**kinetosome**, **blepharoplast** or **kinetonucleus**) arise from it the **flagellum** (locomotory organ) in a flagellar pocket. Behind it, lies the **kinetoplast** (mitochondrial DNA) which attach to the basal granule by a tripartite attachment complex.



• Flagellum is considered as a **centriole** i.e. microtubules with a central one doublet. It begins as an **axoneme** surrounded by a flagellar membrane.

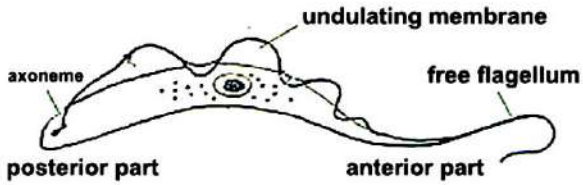
• Moreover, the endoplasm involves food vacuoles containing food particles in various stages of digestion. Such criterion could differentiate pathogenic and non-pathogenic species.

Physiology of protozoa

I. Locomotion:

Four types of locomotory organs are recognized:

1) Pseudopodia (pseudopodia):



Temporary or semi-permanent extensions of the cytoplasm formed in the direction of movement and used for locomotion and feeding. They occur first by a contraction of the cytoplasm followed by a squeezing of the endoplasm and then organelles proceed. They occur as a result of changes in the viscosity of the cytoplasm.

e.g. Sarcodinas (amobae) and some flagellates.

Four types of pseudopodia are known:

a- Lobopodia:

Finger-like and blunt. It is formed of both ecto- and endoplasm.

e.g. Amobae.

b- Filopodia:

Slender and tapering filaments with simple or branched non-anastomosing networks. They are often formed of ectoplasm.

e.g. Some amoebae.

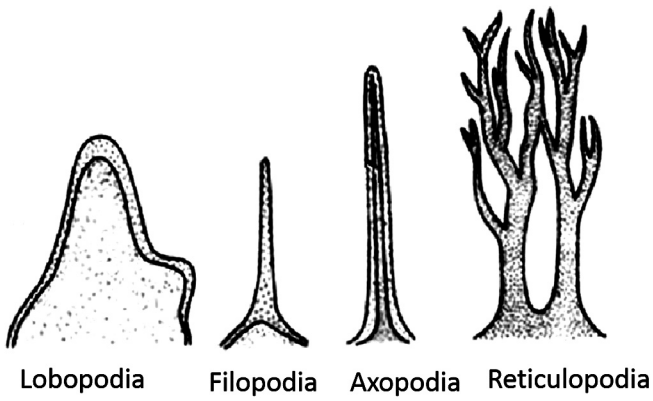
c- Rhizopodia (reticulopodia):

Similar to filopodia but with anastomosing filaments.

e.g. *Foraminifera* spp.

d- Axopodia:

They are semi-permanent and composed of a filament with axial rod (microtubules) and a cytoplasmic envelop. e.g. *Actinosphaerium*.



2) Flagella:

Permanent whip-like filamentous locomotory organelle arises from the blepharoplast in the cytoplasm and located in the posterior part of flagellated protozoa. It consists of a central rod, **axoneme** (it extends from the blepharoplast to the plasma membrane) and outer cytoplasmic sheath. In some species, it passes backwards along the body, being attached to it along the entire length at several points to form undulating membrane. e.g. Flagellates (Mastigophora) and *Tritrichomonas* sp.

Note: The number of flagella in flagellated protozoa not exceed 10 except in order Hypermastigidia.

3) Cilia:

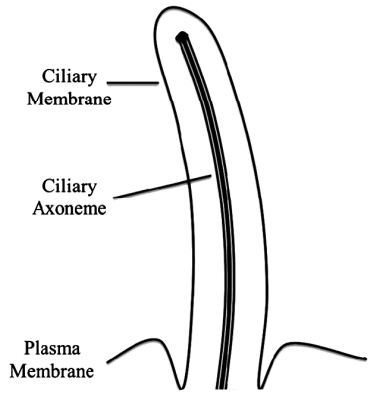
Eyelash-like locomotory organelle resembling flagella in the structure but shorter in length and much greater in number (may be thousands). They often arranged in rows of regular manner and rhythmitically move together followed by the movement of the organism proper.

e.g. Ciliates (Ciliophora) as *Balantidium coli*.

4) Gliding:

A type of movement occurs in certain protozoa with restricted movement and no locomotory organelles. e.g. Phylum Apicomplexa (as *Toxoplasma* sp. and *Sarcocystis* spp.)

II. Nutrition:



Protozoa may be:

1) Holophytic:

Members contain chlorophyll (like plants) that can synthesize carbohydrates.

e.g. *Euglena*.

2) Holozoic:

Members ingest food materials (glycogen granules and chromatoid particles) via:

- Temporary mouth:

Food particles are engulfed and contained in food vacuoles with the surrounding fluids. This process is called pinocytosis. e.g. Amoebae.

- Permanent mouth:

A peristome (usually ciliated) leads to cytostome, cytopharynx then to food vacuoles.

e.g. *Balantidium coli*.

3) Saprozoic:

Food materials are absorbed via the body wall. e.g. Trypanosomes.

Note: In *Entamoeba* cysts, stored food is in the form of glycogen vacuoles or chromatoid materials.

III. Respiration:

No organelles for respiration. In parasitic species, the oxygen is obtained from metabolic processes.

IV. Secretion:

Some protozoa secrete proteolytic/hemolytic enzymes to digest food, and others secrete the cyst wall (cystic stage).

V. Excretion:

Waste products are excreted outside via:

- The body wall.
- Contractile vacuoles (osmoregulatory rather than excretory).
- A permanent cytopyge (in ciliates).

VI. Reproduction:

Asexual reproduction

1- Simple binary fission:

The most common form, in which 2 daughter cells are produced from the parent cell. It begins with an organellar and nuclear (**karyokinesis**) cleavage followed by a cytoplasmic (**cytokinesis**) division. It may be longitudinal of transverse.

2- Multiple binary fission (schizogony or merogony):

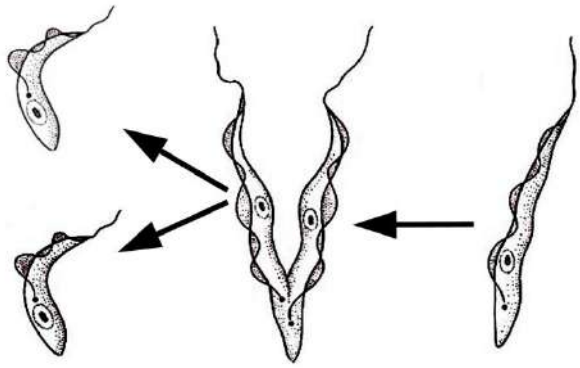
The nucleus divides several times to give small fragments followed by cytokinesis. Each fragmented nucleus with its surrounding cytoplasm is called a **merozoite**. The dividing **Transverse binary fission. e.g. amoebae t)**. e.g. Phylum Apicomplexa.

3- Budding:

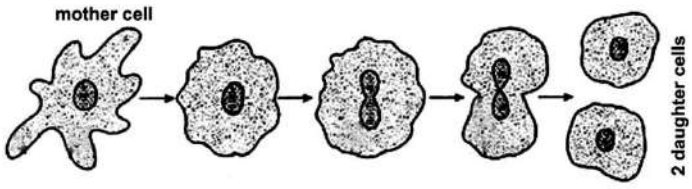
Two or more unequally-sized daughter cells are formed on the surface of the parent cell, then they are separated off and develop to a full size.

• Endodyogony (internal budding):

Daughter cells are formed within the parent cell, then they break out and destroy the mother cell. e.g. *Toxoplasma gondii*.



Longitudinal binary fission. e.g. trypanosomes (flagellates)



Transverse binary fission. e.g. ciliates

4- Sporogony:

It is the process of sporozoites formation by multiple fission of the zygote within the cyst wall. It occurs following the **gametogony (gametes formation)**.

• Sporulation:

It is the process of sporozoites production from the **unsporulated oocyst** (zygote) either:

a) Direct:

The nucleus of the zygote divides several times to produce large numbers of individuals. e.g. Haemosporidia.

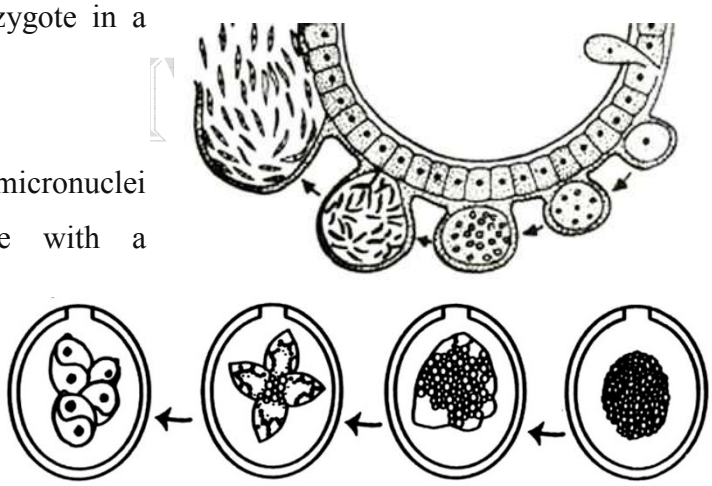
b) Indirect:

The zygote produces two or more **sporocysts** (some species have no sporocysts), each contains two or more sporozoites.

e.g. *Eimeria* spp.

Sexual reproduction:

Sexual cells (gametes) are fused to form a zygote in a process called the fertilization. It includes:

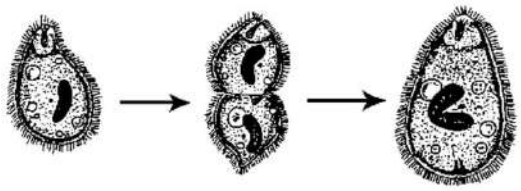


1) Conjugation:

A temporary union of 2 individuals via which micronuclei (reproductive) materials undergo exchange with a degeneration of the macronuclei (vegetative). The formed new individuals are separated with nuclear reorganization takes place. e.g. *Balantidium coli* (ciliates).

2) Syngamy:

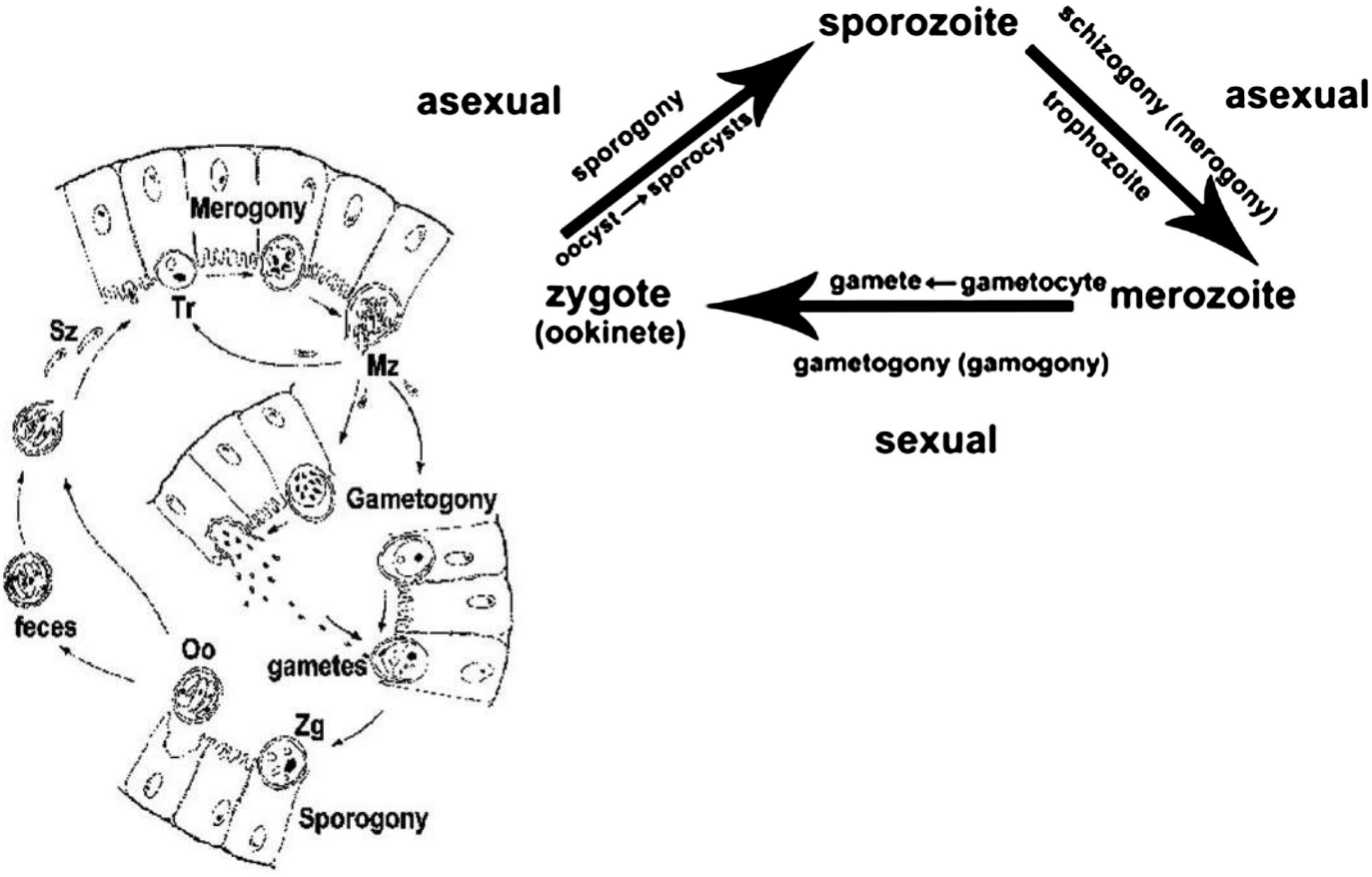
Fusion of microgametes (♂ gametes) (produced from microgametocytes "microgamonts") and macrogametes (♀ gametes) (produced from macrogametocytes "macrogamonts"). The process of gametes formation is called **gametogony (gamogony)**. The resulted individual is called **zygote**, which later divided several times to give sporozoites. In *Plasmodium* spp., the zygote is motile (**ookinete**). When gametes are similar in size, the process is termed **isogamy** (**anisogamy** when dissimilar gametes).



Note:

Trophozoite: A vegetative motile stage of the protozoan.

Cyst: An encysted sessile stage of the protozoan that can resist adverse environmental conditions.



Classification of protozoa (protists)

Kingdom Protozoa

Phylum Sarcomastigophora

Subphylum Mastigophora

Class Zoomastigophora

Order Kinetoplastorida

Family Trypanosomatidae

Genera *Trypanosoma*, *Leishmania*

Order Diplomonadorida

Family Hexamitidae

Genera *Giardia*, *Hexamita*

Order Trichomonadorida

Family Monocercomonadidae

Genus *Histomonas*

Family Trichomonadidae

Genera *Trichomonas*, *Tritrichomonas*, *Tetratrichomonas*, *Pentatrichomonas*

Subphylum Sarcodina

Class Lobosea

Order Amoebida

Family Endamoebidae

Genera *Entamoeba*, *Dientamoeba*, *Iodomoeba*, *Endolimax*

Phylum Apicomplaexa

Class Sporozoa

Order Eucoccidia

Family Eimeriidae

Genera *Eimeria*, *Isospora*, *Tyzzeria*, *Wenyonella*

Family Sarcocystidae

Genera *Sarcocystis*, *Toxoplasma*, *Besnoitia*, *Frenikelia*, *Hammondia*

Family Cryptosporidiidae

Genus *Cryptosporidium*

Family Plasmodiidae

Genus *Plasmodium*

Genus *Haemoproteus*

Genus *Leucocytozoon*

Family Haemogregarinidae

Genus *Hepatozoon*

Family Babesiidae

Genus *Babesia*

Family Theilieriidae

Genus *Theileria*

Phylum Ciliophora

Family Balantidiidae

Genus *Balantidium*

Phylum Microspora

Family Nosematidae

Genus *Encephalitozoon*

Phylum: Sarcomastigophora

• Single nucleus.

• They have flagella and/or pseuodopodia.

• Sexual reproduction, if present, by syngamy.

Subph. Mastigophora Subph. Sarcodina

A) Subphylum: Mastigophora

• They are elongate with one or more flagella.

• Asexual reproduction by longitudinal binary fission.

• Sexual reproduction may occur in some species.

• Parasitic species occur in vertebrates and invertebrates, often in digestive system, circulatory system, genital system and tissues.

Cl. Zoomastigophora Cl. Phytomastigophora

Parasitic with no chloroblasts non-parasitic with chloroblasts

Haemoflagellates other flagellates

(O. Kinetoplastorida)

O. Diplomonadorida O. Trichomonadorida O. Retromonadorida

Order: Kinetoplastorida

General characters:

• They often have kinetoplasts which usually relatively small, terminal/subterminal and compact.

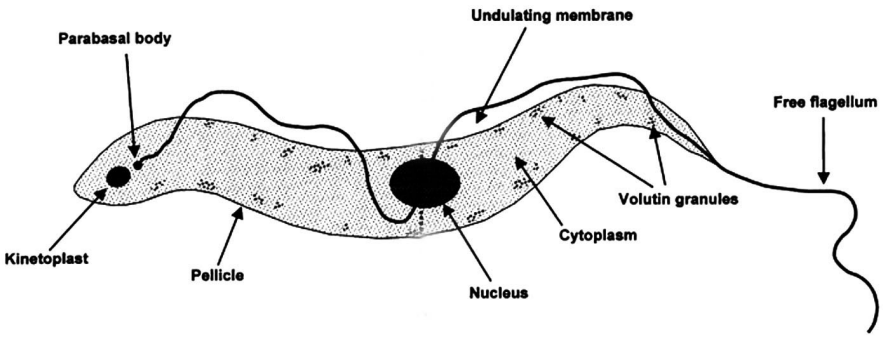
• Flagellates with a single well developed flagellum and may be an undulating membrane.

• Haemoflagellates need an arthropod vector to complete their life cycle.

Family: Trypanosomatidae

• They are initially parasites of invertebrates (insects), however, trypanosomes and leishmanias parasitized vertebrates.

• Elongated leaf-like (tapered at both ends) or sometimes rounded and measured 8 to over 50 μm long.



• Single flagellum arises posteriorly from basal body (basal granule, blepharoplast or kinetosome) situated in a flagellar pocket and pinch up as undulating membrane (absent in *Leishmania* and leptomand form) and extends anteriorly as a whip-like free flagellum.

• Posterior to the kinetosome, present a rod or spherical-shaped **kinetoplast** containing DNA.

• Cytoplasm (limiting membrane is called **pellicle**) contains a single large rounded or oval nucleus, mitochondria, lysosomes, endoplasmic reticulum, ribosomes and small granules (formerly called "volutin granules") can sometimes be seen in the cytoplasm.

Differential morphology:

1) The presence/absence of trypanosomes in different forms. If all individual trypanosomes are like, the infection is called **monomorphic** (of one form); if there are distinctly different types it can be either a **polymorphic** (= pleiomorphic) species, or a mixed infection of different species.

2) The presence/absence of a free flagellum. In certain species, there may be some trypanosomes with, and some without, a free flagellum.

3) Size of the trypanosome (expressed in μm).

4) The size and position of the kinetoplast. The position is related to proximity to the posterior extremity of the organism.

5) The degree of development of the undulating membrane. It may be conspicuous or inconspicuous.

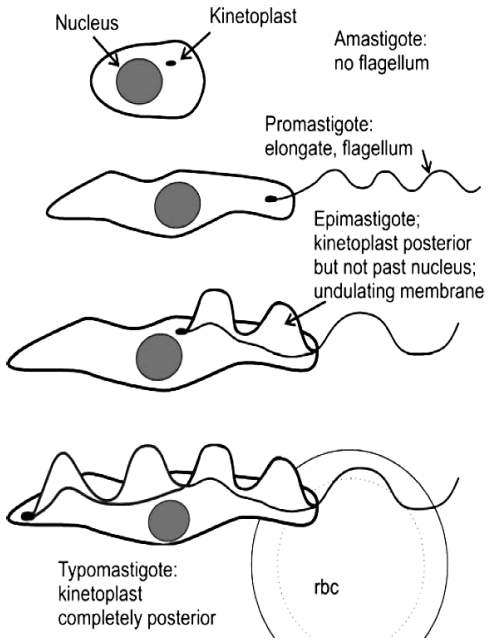
6) The shape of the parasite, particularly the shape of the posterior part. The posterior extremity may vary from blunt to pointed.

7) The movement pattern in fresh blood preparation can be of some help in identifying the species involved, particular for *Trypanosoma vivax*, which moves **rapidly** forward between the blood cells, whereas other species often just wriggle around without showing much forward progress.

• During the life cycle, they have to pass in one or more of the following developmental stages:

1- Trypomastigote form:

A blade-like and found in vertebrate hosts (and in invertebrate intermediate hosts). Kinetoplast is **posterior** to the nucleus often near the posterior end. A free **flagellum** and a well-developed undulating membrane



2- Epimastigote (crithidial) form:

Kinetoplast and kinetosome are **anterior** to the central nucleus with **short** undulating membrane. Parasites of invertebrates (insects).

3- Promastigote (leptomonad) form:

Central nucleus, kinetoplast and kinetosome are at the **anterior tip** with **no** undulating membrane. Parasites of invertebrates (insects).

4- Amastigote (leishmanial) form:

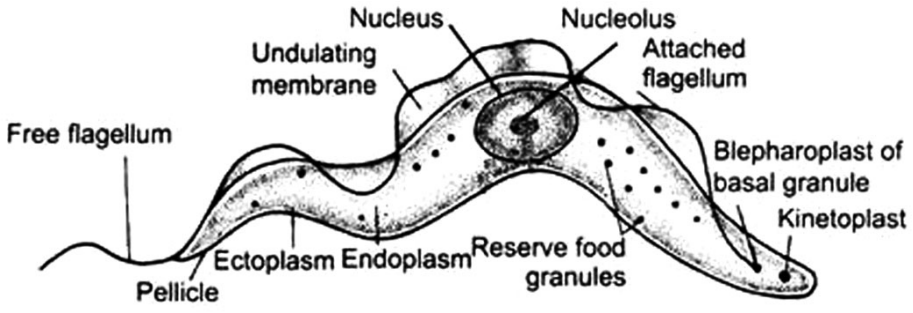
Rounded body and found in vertebrates (humans, dogs). Kinetoplast is present without flagellum that replaced by a short fibril (axoneme).

• This family includes the genera *Trypanosoma* and *Leishmania*.

(1) Genus *Trypanosoma*

General characters:

• They habit the circulatory system and tissue fluids of vertebrates (humans, domestic animals, birds), however, some spp., as *T. cruzi*, invade cells and transmitted by blood sucking insects.

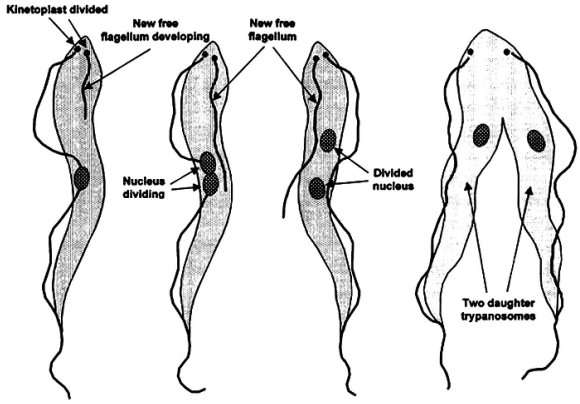


• Typical trypanosome morphology i.e. elongated blade-like with pointed ends, centrally located oval nucleus, a kinetoplast is located posterior to the nucleus (near the posterior end either terminal or subterminal) from it the flagellum arise and passes towards the anterior end attached to the body by an undulating membrane. At the anterior end, flagellum extends forwards as a free flagellum.

• They either monomorphic or polymorphic showing several forms in blood of vertebrate hosts; long slender, intermediate and short stumpy.

• Reproduction by longitudinal binary fission:

Two daughter cells are produced as follows: The kinetoplast divides, then, the parabasal body develops, from which a flagellum arises. The nucleus divides followed by the rest of body organelles duplicating them. The body then divides into two daughter cells. The process is rapid giving a large parasite population within a short period of time.



• All trypanosome species are transmitted mechanically/biologically by blood sucking arthropods except *T. equiperdum* (via coitus). Two hosts (a vertebrate host and a blood sucking invertebrate host) are required. Blood sucking arthropods ingest host blood containing trypomastigote forms that change into epimastigote forms which multiply and finally give **infective** metacyclic trypanosomes in about 3-4 weeks.

• Based on characteristics of the development in invertebrate hosts, trypanosomes are classified into:

I. Anterior station group (salivaria group)-African trypanosomes

Development occurs at the anterior part of digestive tract and the usual mode of transmission is inoculative, through the biting mouthparts of the vector. Infective stages (metatrypanosomes or metacyclic forma) are released in saliva.

Subgenus	Species/Group	Development/transmission
Duttonella	***Vivax* group** *T. vivax* (ruminants, equines) *T. uniforme* (cattle, sheep, goats) *T. viennei* (cattle) *T. caprae* (goats)	In tsetse flies: development in proboscis only. - It can persist by mechanical transmission. - Monomorphic with free flagellum. - Large and terminal kinetoplast.
Nannomonas	***Congolense* group** *T. congolense* (ruminants, equines) *T. simiae* (pigs, monkeys) *T. suis* (pigs)	In tsetse flies: development in midgut and proboscis. - Small without free flagellum. - Medium and terminal kinetoplast.
Trypanozoon	***Brucei* group** *T. brucei brucei* (all animals) *T. brucei rhodesiense* (humans) *T. brucei gambiense* (humans)	In tsetse flies: development in midgut and salivary glands. - Oral transmission in carnivores. - Pleomorphic (slender, intermediate, short stumpy) with/without free flagellum. - Small and subterminal kinetoplast.
	***Evansi* group** *T. evansi* (camels, equines) *T. equiperdum* (equines) *T. equinum* (equines)	Mechanical transmission (by tabanids). In *T. equiperdum* venereal transmission occurs.

II. Posterior station group (stercoraria group)-American trypanosomes (*Cruzi* group)

Development occurs at the posterior part of digestive tract of insects. Infective stages (metatrypanosomes or metacyclic forma) are released through the feces of the insect.

Subgenus	Species/group	Development/transmission
Megatrypanum	*T. melophagium* (sheep) *T. theileri* (cattle, antelopes)	- Large mammalian tryoanosomes with typical kinetoplast near the nucleus. - Vectors are hippoboscids or tabanids.
Herpetsoma	*T. lewisi* (rats) *T. rangeli* (humans, dogs, monkeys)	
Schizotrypanum	*T. cruzi* (humans, dogs, cats)	

Evansi group

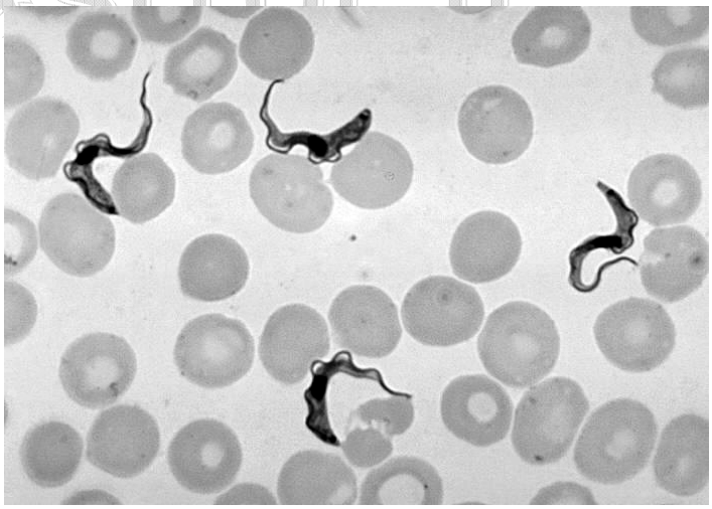
1) *Trypanosoma evansi*

Hosts and habitats:

Intererythrocytic trypanosome of camels, horses, buffaloes, dogs and pigs (all domestic and wild animals as well as laboratory animals can be experimentally infected).

Distribution:

North Africa, Asia, South and Central America.



Morphology:

- Often monomorphic, but polymorphic individuals may occur.
- Typical trypomastigote form measured 15-35 um in length.
- Terminal kinetoplast, well developed undulating membrane and free flagellum.
- Stumpy forms and individuals lacking kinetoplasts may appear occasionally particularly post treatment.

Life cycle:

It is transmitted mechanically by blood sucking flies. No cyclical development in vectors and trypanosomes remain in proboscis. The usual vector is *Tabanus* sp. which transmit the disease by picking up the infection from infected vertebrate host. Dogs are infected mostly by ingesting infected flies rather than biting.

Diseases:

i) Horses

The disease in India is called **Surra** disease which is fatal in acute form, particularly in the first few hours, emaciation and oedema of legs and lower parts of the body as well as areas of necrosis and hemorrhages at the junctions of skin and mucous membranes (nostrils, eyes and anus). Intermittent fever, enlargement of L.Ns. and splenomegaly could be detected.

ii) Camels

In Egypt, the disease is chronic and called **El-Dabab** (**Gufar** in Sudan) during which animals become weak and emaciated.

iii) Cattle and buffaloes

The disease is less severe and animals act as reservoir.

iv) Dogs:

The disease is chronic with a high mortality rate.

Diagnosis (in camels):

1- Clinical history.

2- Direct blood smear, to:

a) Prove the motility of the trypanosomes.

b) Thick blood film. …… with large blood drop and dehaemoglobinization.

c) Thin blood film…… with small blood drop and no dehaemoglobinization.

3- Xenodiagnosis:

Laboratory animals were inoculated I/P and examined daily for the detection of intererythrocytic trypanosomes.

4) Chemical tests:

- **Mercuric chloride test**:

One drop blood serum of suspected animal + 1 ml mercuric chloride (1:30000) = turbidity in min.

- **Formol gel test**:

1 ml blood serum of suspected animal + 1 drop 40% formaldehyde+ incubation at 37ºC for 2 h= gel formation.

5) Serological tests.

Control: 1- Treatment of infected animals. e.g. Naganol.

2- Eradication of insects and elimination of rodents.

2) *Trypanosoma equiperdum*

Hosts and habitats: Mucous membranes of genital organs of horses and donkeys.

Distribution: Africa, Asia, Southern and eastern Europe.

Morphology: It is typically similar to *T. evansi*, monomorphic and measured 25 um long.

Disease:

The infection is transmitted mechanically by **coitus**.

The trypanosome causes a **venereal disease, Dourine,** in equines. The disease appears in 3 forms:

1) Stage of oedema: Mucoid vaginal or urethral discharge, oedema in genitalia and mild fever. Mares exhibited hyperaemic mucosa.

2) Stage of urticaria: Subcutaneous oedematous plaques particularly in flanks. They may persist for 3-4 days and disappear with the incidence of recurrency.

3) Stage of paralysis: It begins in muscles of neck and nostrils, then affect hind limbs and all body muscles followed by recumbency and death.

Diagnosis:

Clinical symptoms as well as the detection of trypanosomes in smears from vaginal or preputeal discharge, or from serous fluids of urticarial swellings.

3) *Trypanosoma equinum*

Hosts and habitats:

Blood of equines, particularly horses and mules. Dogs are occasionally infected.

Morphology:

Large monomorphic, measured 23 µm long, **no** kinetoplast, small blepharoplast.

Transmission and disease:

It is transmitted mechanically by blood sucking flies (*Tabanus* and *Stomoxys*).

It causes a chronic disease in **equines** called **Mal de Caderas** which characterized by emaciation, weakness of hind quarters, conjunctivitis, keratitis, oedema of eyelids, temporary cutaneous plaques on the neck.

Brucei group

1) *Trypanosoma brucei*

Hosts and habitats:

Blood, lymph and CSF of horses, mules, donkeys, ox, sheep, goats, camels, pigs, wild animals. Dogs and cats could be infected by eating goats with subclinical infection. Antelopes are the natural and reservoir host.

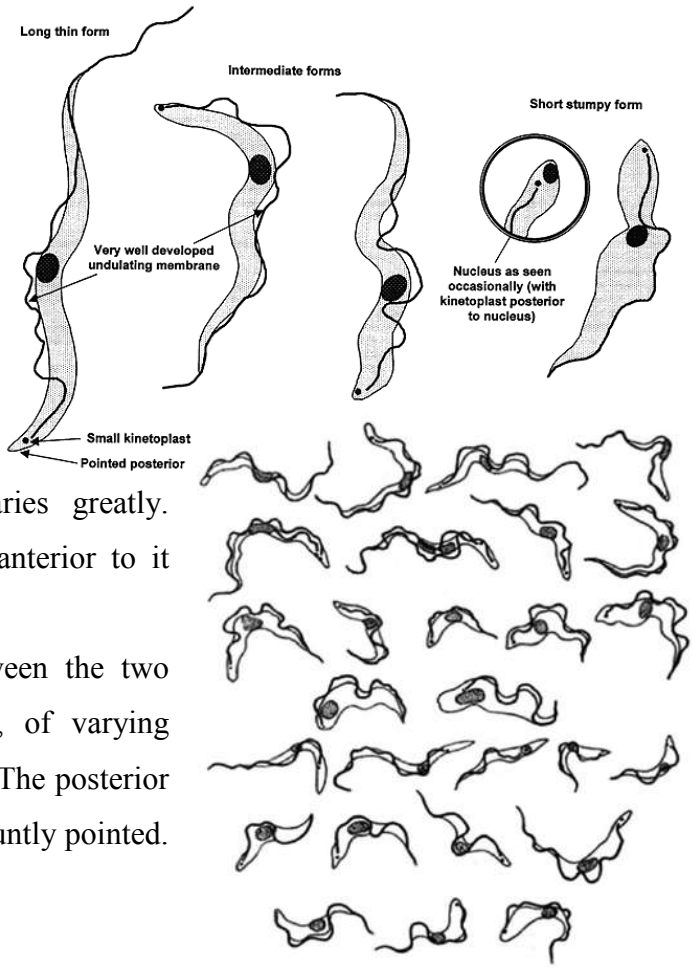
Distribution:

Tropical Africa, where the vectors, tsetse flies, are found.

Morphology:

Polymorphic with long slender, intermediate and short stumpy forms. Small and subterminal kinetoplast and distinct undulating membrane.

1. <u>Long slender forms</u> (23–30 μm in length) with a **long free flagellum**, which may be up to one half of the length of the organism. The posterior end is pointed and the nucleus is central.



2. <u>Short stumpy forms</u> (17–22 μm in length) normally **without a free flagellum**. Occasionally individuals may have a short free flagellum. The kinetoplast is usually subterminal. The position of the nucleus varies greatly. Sometimes, it is so far that the kinetoplast is anterior to it (**<u>postero-nuclear forms</u>**).

3. <u>Intermediate forms</u> varying in length between the two previously mentioned types. A **free flagellum**, of varying length, is always present. The nucleus is central. The posterior end is somewhat variable in shape, but usually bluntly pointed. The kinetoplast is close to the posterior extremity.

<u>Life cycle</u>: (15-35 days)

• It is transmitted by the blood sucking flies, *Glossina* sp.

• When the trypanosome (trypomasigote form) is ingested by the vector, it is localized in the posterior part of the midgut and multiplies for 10 days. They are somewhat broad.

• At the 10-12 days, slender forms appear and migrate slowly to the proventriculus (12-20 days).

• They migrate forward to oesophagus, pharynx and then to the salivary glands. In the later, they changed into epimastigote forms.

• Further multiplication occurs changing into metacyclic trypanosomes (**infective stages**) which are small and stumpy with or without short free flagellum.

• When infected vectors attack the final host, metacyclic trypanosomes change to trypomastigote forms and multiply in lymph and blood by longitudinal binary fission to be localized in lymph nodes.

• Trypanosomes pass the blood brain barrier (bbb) into CSF multiplying into it and brain cells.

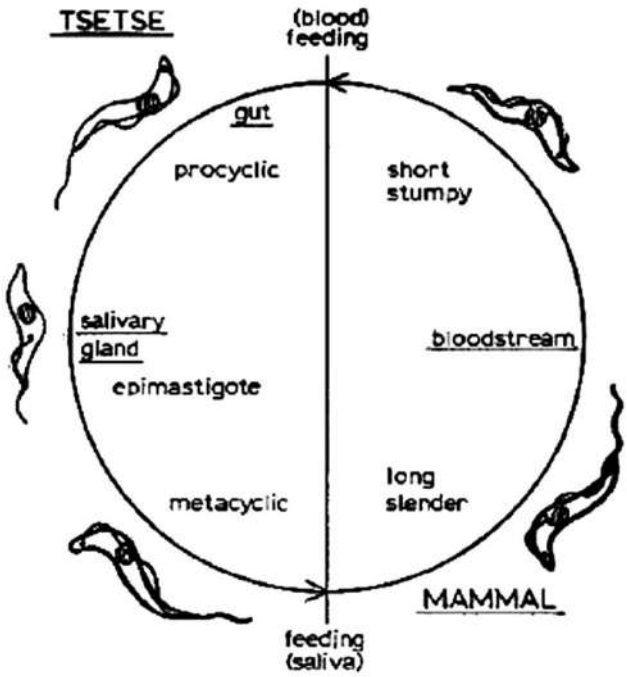


Image at: https://www.deduveinstitute.be/~opperd/parasites/afr_sl_siickness.html

Diseases:

• Equines are the most susceptible showing fever and oedematous swelling of the belly, genitalia and legs, emaciation (although a good appetite), muscular atrophy, incoordination, lumbar paralysis and death.

• The disease is chronic in cattle showing fever, anemia, emaciation and ocular discharge. Symptoms are severe in sheep, goats, camels and dogs.

Diagnosis:

Clinical symptoms. Thick blood films. Detection of trypanosomes in lymph and CSF.

2) *Trypanosoma gambiense* (Central and West Africa)

3) *Trypanosoma rhodesiense* (Central and middle Africa)

African human trypanosomes (African sleeping sickness in man)

Morphology and life cycle:

Similar to *T. brucei* (vector is tsetse flies).

T. gambiense causes domestic type of the disease transmitted by the vector from one human to another, while in *T. rhodesiense*, it causes infection among people away from their village. In the later species, wild animals act as reservoir.

Disease:

• At the biting site, nodules are formed followed by fever, enlargement of liver, spleen and lymph nodes (especially those of posterior cervical region, **Winterbottoms's sign**).

• In the brain, cerebral capillaries show pathological lesions consisted of perivascular cuffing, cellular infiltration, degeneration of neurons leading to dullness and sleeping, so the disease name derived. Death may occur due to meningitis and other complications.

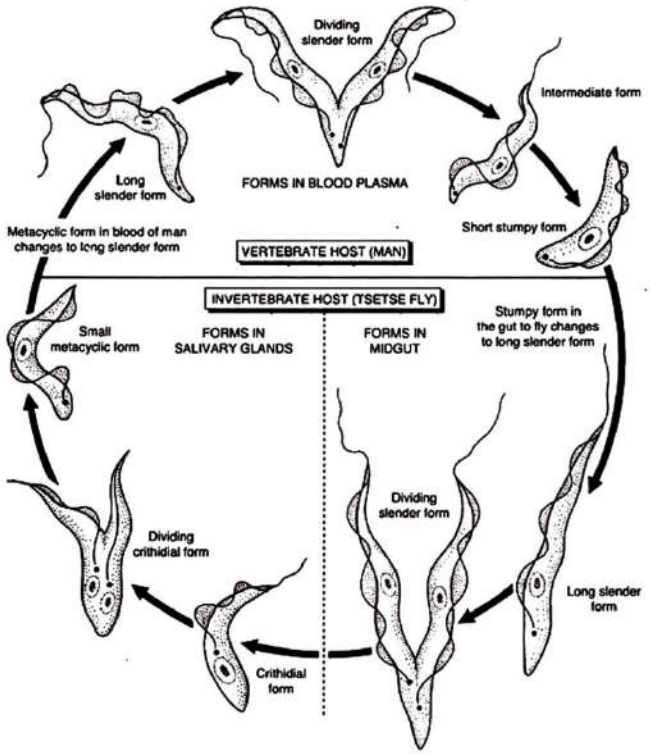


Image at: http://www.biologydiscussion.com/parasitology/parasitic-protozoa/life-cycle-of-trypanosoma-gambiense-with-

Diagnosis:

Clinical symptoms and the detection of trypanosomes in blood, lymph and CSF.

Congolense group

1) *Trypanosoma congolense*

Hosts and habitats:

Blood of cattle, equines, sheep, goats, camels, dogs.

Morphology:

Small (8-20 µm), monomorphic, blunt posterior end, marginal kinetoplast, **no** free flagellum and ill-distinct undulating membrane.

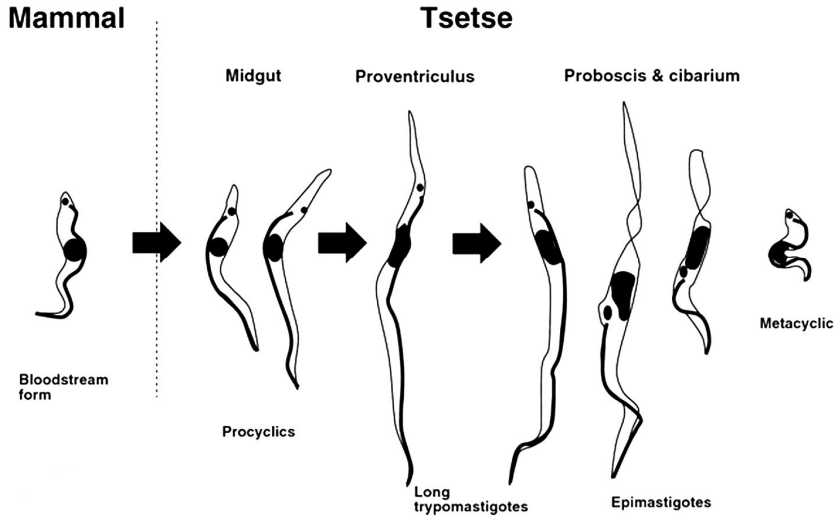


Image at: file:///C:/Users/dell/Downloads/Trypanocidal drugs and the problem of drug resista.pdf

Life cycle:

• Biologically transmitted by tsetse flies.

• After ingestion, trypanosomes develop in the midgut of the vector into trypomastigote forms with no free flagellum. Then, they migrate to the proventriculus and to proboscis where they assume the epimastigote forms with no free flagellum. In proboscis, they attached to the wall, then to the hypopharynx changing into the infective stages (metacyclic trypanosomes). In vector, life cycle is 15-20 days during which, salivary glands are **never** infected.

Disease:

The trypanosome causes an acute disease called **Nagana**. Cattle, sheep, goats, horses, and camels may be affected. In acute form, lymph nodes are swollen, oedomatous with congested liver and hemorrhages in the heart muscle. The condition is fatal in cattle. Chronic cases may occur in about one year with signs of emaciation, enlargement of lymph nodes, but **CNS is not involved**.

Diagnosis: Clinical symptoms and detection of trypanosomes in blood smears.

2) *Trypanosoma simiae*

Hosts and habitats:

Blood of pigs and camels, slightly pathogenic for sheep and goats and non-pathogenic for cattle, horses and dogs. Monkeys act as reservoir.

Morphology:

Polymorphic with long slender and short stumpy forms. Usually absent free flagellum.

Life cycle, disease and diagnosis:

Similar to *T. congolense* (the disease is acute in pigs and mild in sheep and goats).

3) *Trypanosoma suis*

Monomorphic (14-19 μm), with short free flagellum and infect pigs inducing a chronic disease.

Vivax group

1) *Trypanosoma vivax*

Hosts and habitats:

Blood and lymph in all animals except dogs and pigs (CNS involvement in sheep is possible).

Morphology:

Monomorphic (20-27 μm long). Broad posterior end with a large and terminal kinetoplast. Short free flagellum and small undulating membrane.

Life cycle:

It is biologically transmitted by tsetse flies. Development occurs only in **proboscis**. Trypomastigote forms changed into epimastigotes which multiply and change into metacyclic trypanosomes and pass to the hypopharynx ready to infect a new host by insect biting. Life cycle in insect is 6 days.

Disease:

Often mild to moderate in the form of moderate anemia, weakness, emaciation and oedema of subcutis (moderate infection in sheep and chronic in horses).

Diagnosis: Smears from lymph nodes.

2) *Trypanosoma uniforme*

Similar to *T. vivax* but smaller, and infect cattle, sheep and goats.

3) *Trypanosoma caprae*

Similar to *T. vivax* and infect goats, sheep and cattle.

Cruzi group

1) *Trypanosoma cruzi*

(American human trypanosomes, Chagas disease)

Hosts and habitats:

Humans (particularly children) and many species of wild and domestic animals are susceptible. Trypanosomes are found in blood at the early infection. Later, they invade cells of RES, heart, striated muscles and other tissues (in CNS, neuroglial cells are affected). Trypomastigote forms are found in both blood and cells while amastigote and epimastigote forms are found only in cells.

Distribution: South America.

Morphology:

Monomorphic, curved/crescent in shape with stumpy body (16-20 µm long). Pointed posterior end. Large and subterminal kinetoplast which appear bulged outside the body or fill the distance at that point. It is the **largest kinetoplast** among other trypanosomes. Moderately long free flagellum and narrow undulating membrane with 2-3 undulations. Amastigote forms occur in groups in heart, muscles and other cells.

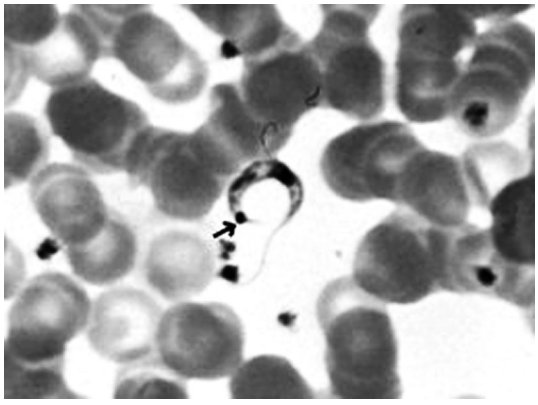


Image at: https://msu.edu/course/zol/316/tcruscope.htm

Life cycle:

• The trypanosome is transmitted biologically by the winged bugs (*Triatoma megista*) and soft ticks (*Ornithodros* sp.).

• Trypomastigote forms cannot multiply in blood, but invade cells of RES and striated muscles especially heart, where they rounded up and assume the amastigote (lesihmanial) forms which multiply by binary fission, destroying host cells and forming nests of the parasite. Leishmanial forms changed into trypomastigoe forms which re-enter blood.

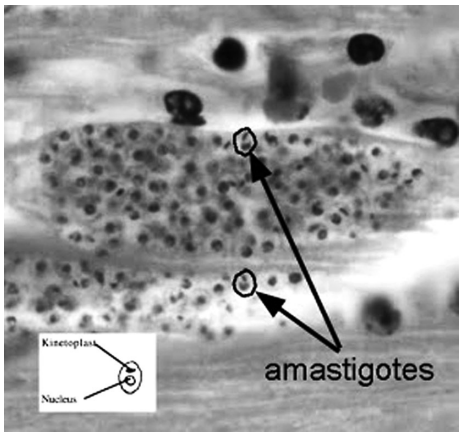


Image at: https://parasitewonders.blogspot.com/2011/02/answer-to-case-150.html?m=1

• Vectors such blood containing trypomastigote forms which pass into the midgut and change into amastigote forms that multiply by binary fission turning into metacyclic trypomastigotes or epimastigotes. The later further multiply by binary fission and extend to the rectum of the vector, changing into metacyclic trypomastigotes which pass out in **feces**.

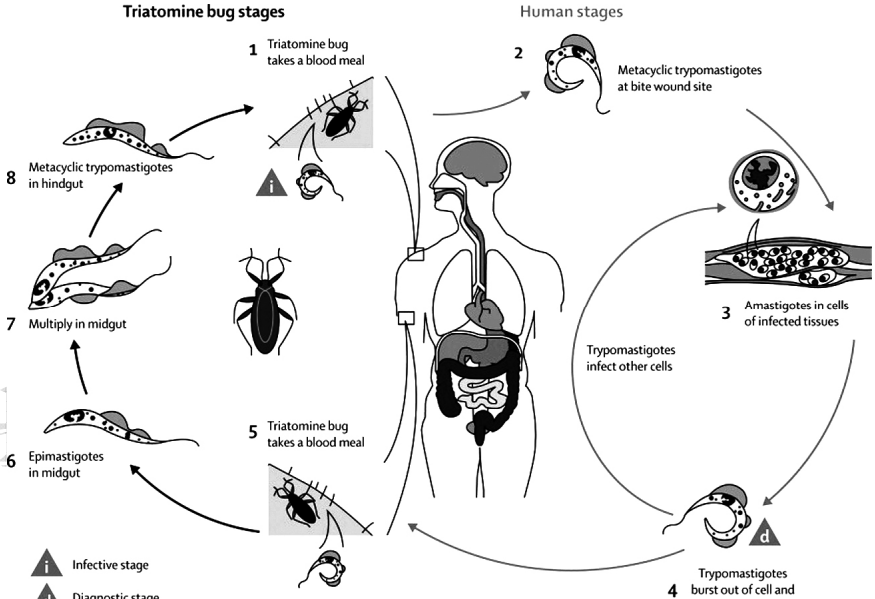


Image at: https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(08)70230-5/fulltext

• Life cycle is about 15-16 days in vector. The most of human infections occurs when feces are rubbed into mucous membranes following bites of vectors (usually triatoms defecate after feeding).

Disease:

The trypanosome causes **African human trypanosomiasis** (**Chagas disease**). The disease is acute or chronic, and often children assume the acute form. It is characterized by swelling of eyes and conjunctiva (**Romana sign**), anemia, fever and headache. If the patient survives, he assumes a chronic infection which may persist along his life. Enlarged liver and spleen with swollen lymph nodes. Death due to affected hearts increased in endemic areas.

Diagnosis:

Thick blood smears in acute stages. In chronic stages, xenodiagnosis or cultivation on NNN media may be used. Biopsy from examined lymph nodes. Serological tests.

2) *Trypanosoma lewisi*

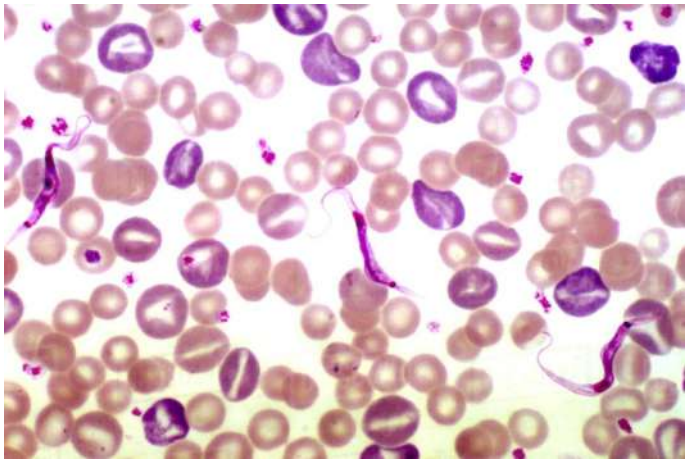


Image at: https://dissolve.com/stock-photo/Trypanosoma-lewisi-royalty-free-image/101-D943-144-10666

• Elongated S-shaped with long tapered posterior end and measures 26-34 um.

• Nucleus anteriorly located with long free flagellum

• Kinetoplast is either rod-shaped or oval and far away from the posterior end being transversely located.

• It infects rats (often non-pathogenic) and transmitted by eating rat fleas (*Ceratophyllus fasciatus*). Infective stages pass with feces of fleas and enter the biting wound.

3) *Trypanosoma theileri*

• Trypanosomes of blood (trypomastigotes and epimastigotes) of cattle and distributed worldwide. Large trypanosome (60-70 µm) with long and pointed posterior end.

• Kinetoplast lying some distance from the posterior end. Well-developed undulating membrane and well defined free flagellum.

• Epimastigotes multiply by binary fission in lymph nodes.

• Tabanids and *Stomoxys* are vectors.

• Cattle are infected by contaminating mucous membranes with infective stages developed in the hindgut.

4) *Trypanosoma melophagium*

Similar to *T. theileri*, common in sheep. It is non-pathogenic and the vector is *Melophagus ovinus*.

(2) Genus *Leishmania*

General characters:

• Haemoflagellates of reticuloendothelial cells.

• There are two forms of the parasite, leishmanial form (amastigote form) in humans and other mammalian hosts and the leptomonad form in the insect vectors.

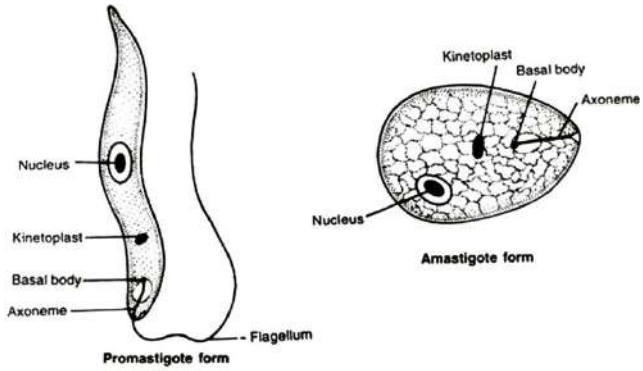
• All species are morphologically similar and only distinguishable by diseases producing, clinical signs, geographical distribution and species of vectors

• The leishmanial stage is non-motile ovoid/round (2-5 µm long), nucleus (central) and kinetoplast (they are only visible in stained preparations) with no free flagellum (a short axoneme could be seen internally) and undulating membrane. The leptomonad form is motile spindle-shaped with free flagellum (both the body and the flagellum measures 20 µm long) and terminal/subterminal kinetoplast.

• Species are transmitted via the insect vector, sand flies (*Phlebotomus* spp.)

Hosts and habitats:

Leishmanial bodies (amastigote forms) are intracellular parasites of macrophages in humans, dogs, pigs and various rodents, while leptomonad forms (promastigote forms) are found in the gut of sand flies.



Amastigote and promastigote forms

Image at: http://www.yourarticlelibrary.com/zoology/parasite-leishmania-donovani-life-cycle-mode-of-infection-and-treatment/24263

Life cycle:

• Inside the body of humans, the parasite occurs as amastigote form (leishmanial bodies) and engulfed by macrophages (of reticuloendothelial system in the skin, spleen, liver, lymph nodes, mucosa and leucocytes). They resist the phagocytic activity of lysosomal enzymes.

• Inside macrophages, amastigote forms multiply by binary fission, and when macrophages die, they invade another intact ones with more cells are infected.

• When the adult female sand fly attacks a human feeding on blood, amastigote forms turned into a large number of small-sized promastigotes in the insect's gut within 3 days.

• Promastigotes multiply by longitudinal fission and migrate anteriorly to the pharynx and mouth cavity. At the 5th day, most of them reach the proboscis ready to infect another host.

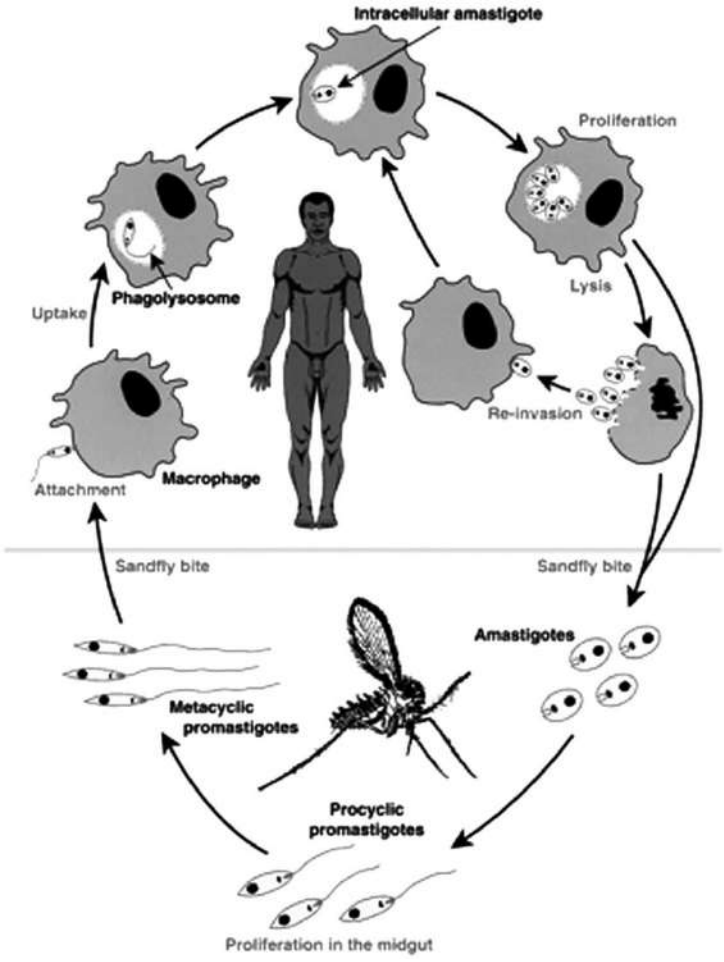


Image at: Emanuela Handman Clin. Microbiol. Rev. (2001). Doi 10.1128/CMR.14.2.229-243.2001

Common species:

1- *Leishmania tropica*: In the middle East and countries with hot day climate.

2- *Leishmania donovani*: In India, central Africa and South America.

3- *Leishmania brasiliensis*: In South America.

Pathogenesis:

Leishmania spp. cause a complex disease in the form of:

(1) Cutaneous leishmaniasis: (Oriental sore, Aleppo button or Baghdad boil)

It is caused by *Leishmania tropica*. The lesion appears as nodules, **sores**, (2-4 cm in diameter) on the skin and further ulcerate. These sores have hard elevated edges with a surrounding red zone. Secondary bacterial infections may complicate the condition. Parasites could be detected at the sores edges. The condition is often chronic. If occurs in the face, it will be incurable.

(2) Visceral leishmaniasis: (Kala Azar, Dum-Dum fever or black fever)

It is caused by *Leishmania donovani*. Inside the human body, the parasite invades the reticuloendothelial cells where it multiplies until the cells rupture. Blood-forming organs are congested with marked emaciation, anemia and a distended abdomen. The pathogenesis is mainly due to the blockage of the RECs all over the body.

(3) Muco-cutaneous leishmaniasis: (American leishmaniasis, Epsundia)

It is caused by *Leishmania brasiliensis*. The parasite causes a great destruction of the skin and the lesions extend to the nasopharyngeal mucosa persisting for many years. Further lesions develop in the nose, pharynx and palate with the end result of deformity of the face.

Diagnosis:

• Detection of the parasites in Giemsa-stained smears from lesions.

• Intraperitoneal inoculation of laboratory animals with the parasite.

• Examination of the insect's gut to detect the promastigotes.

Control:

The use of antileishmanial drugs (e.g. Miltefosine), antibiotics and insecticides.