

Class cestoda

Family: Anoplocephalidae

This family includes genera *Anoplocephala*, *Paranoplocephala*, *Moniezia* and *Cittotaenia*.

Genus: *Anoplocephala*

sp. *A. magna*

Hosts and habitats: The small intestine particularly jejunum and rarely stomach of horses and donkeys.

Morphology:

- The scolex is large bearing four cup-shaped muscular suckers only.
- Short neck. The mature segment has a single set of genital organs with a unilateral common genital pore. In the gravid segment, all organs undergo atrophy except the uterus, which appears as a transverse sac filled with eggs.
- The adult worm measures 80 x 2 cm with very short segments that overlapping each other.

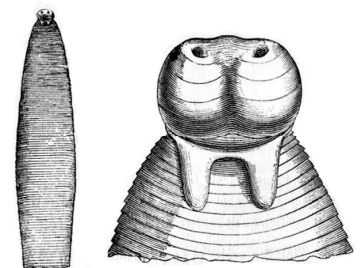


sp.: *A. perfoliata*

The most common tapeworm in equines.

It resembles *Anoplocephala magna* except:

- It habits the small and large intestine of horses and donkeys.
- The scolex is smaller and provided with 4 cup-shaped muscular suckers as well as a **lappet** behind each sucker.
- In the gravid segment, the uterus appears as a transverse sac which is large and lobed.
- Adults measures up to 8 x 1.2 cm.



Genus: *Paranoplocephala*

Spp.: *P. mamillana*

Hosts and habitats: The small intestine and rarely stomach of horses and donkeys.

Morphology: It resembles genus *Anoplocephala* except it is much smaller, up to 60 x 5 mm. The sucker is located dorsally and ventrally in the scolex with a slit-like opening.

Life cycle of *Anoplocephala* spp.

- Equines (final hosts) detach gravid segments or eggs in feces.
- The intermediate host (oribatid mites) ingests eggs and the metacestodes (cysticercoids) develops inside it within 2-4 months after ingestion.

- The final host is infected by ingesting oribatid mites containing cysticercoids which develop to adult worms in the intestine of equines in 4-6 weeks.

Pathogenicity of *Anoplocephala* spp.:

- In common, the light infection is symptomless, however, heavy infection causes ill health or may lead to death. Perforation of the intestine due to infection with *Anoplocephala* spp.
- *A. perfoliata* is frequently found close to the ileocecal orifice attached by its scolices to the cecal wall causing appearance of ulcerative lesions in the form of small, dark, depressed areas associated with oedema and rarely excessive granulation tissues formation leading to a partial occlusion of the ileocecal valve. *A. magna* is the most pathogenic as it produces catarrhal or haemorrhagic enteritis when found in large numbers.
- *Paranoplocephala mamillana* is rarely pathogenic.

Genus: *Moniezia*

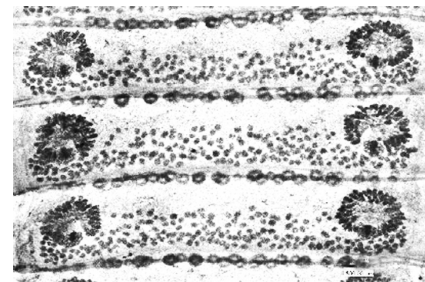
M. expansa

Hosts and habitats:

The small intestine of sheep, goats, cattle and other ruminants.

Morphology:

- The adult worm measured 6 x 1.5 cm.
- The scolex is relatively small bearing 4 prominent suckers.
- The segments are broader than long.
- The mature segment has double sets of genital organs.
- The ovaries and the vitelline glands are found median to the longitudinal excretory canal forming a ring on either side while testes are distributed in the central field of the segment or accumulate towards the sides. Intersegmental glands in the posterior border of the segment in the form of row of small pits.
- In the gravid segment, all organs undergo atrophy except the two uteri form all together a reticular network filled with eggs.
- The eggs are triangular in shape to some extent with a well-developed pyriform apparatus.



Moniezia benedeni

Hosts and habitats: The small intestine of ruminants mainly cattle.

Morphology:

- It is similar to *Moniezia expansa* except:



- It is broader up to 2.6 cm. The intersegmental glands appeared near to the mid-line of the segment as short continuous row.

Moniezia denticulata (Moniezia alba)

Hosts and habitats: The small intestine of cattle, sheep and other ruminants.

Morphology: Similar to *Moniezia expansa* with the **absence** of intersegmental glands.

Moniezia trigonophora

Hosts and habitats:

The small intestine of camels and other ruminants.

Morphology:

Similar to *Moniezia expansa* except:

- Testes appear as two pyramids on either side of the segment medial to the excretory canal.
- Intersegmental glands in the middle of the posterior margin of each segment.

Moniezia palida

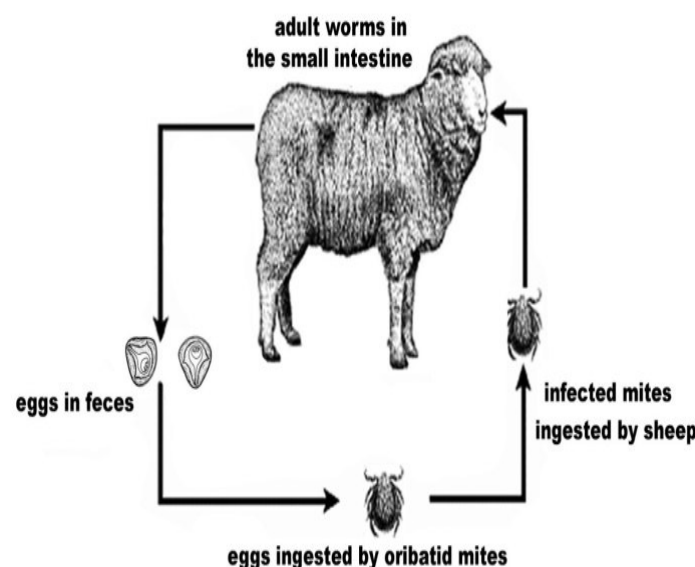
Hosts and habitats: The small intestine of equines.

Morphology:

- The worm measures 140 x 2 cm. The uterus extends lateral to the excretory canals.
- The intersegmental glands are linear and indistinct.

Life cycles of *Moniezia* spp.:

- Final host pass gravid segments and/or eggs in feces.
- The intermediate host (oribatid mites) ingests gravid segments and/or eggs which develop inside oribatid mites to cysticercoids within 4 months.
- The final host can be infected by ingesting oribatid mites with herbage and the pre-patent period is 35-40 days.
- There is a noticeable seasonal prevalence of *Moniezia* infection because of mites over-wintered in pasture. Monieziasis is common in young lambs



and calves through their first summer on the pasture. Lambs become infected very early in life and may pass segment in feces as soon as 6 weeks age. Infection is not common in elderly and is generally light.

Pathogenicity of *Moniezia* species:

- Heavy infection is a common, however, one or few worms can produce disease because of their large size. Lambs, kids and calves under 6 months become infected and show symptoms but the adult animals rarely harbor the parasite.
- Symptoms in young animals appear in the form of vigour, strength, rough coat then animals become anemic and edema may develop. Constipation may occur but in severe cases the intestine may be nearly a solid mass of worms which may cause diarrhea and unthriftiness or leading to an intestinal obstruction.
- Commonly, a chain of segments was found to hang out through the anal opening.
- Decreased wool and meat production is associated with many deaths.
- Monieziasis in lambs is associated with a high prevalence of enterotoxemia.

Family: Thysanosomidae

1- Genus: *Avitellina*

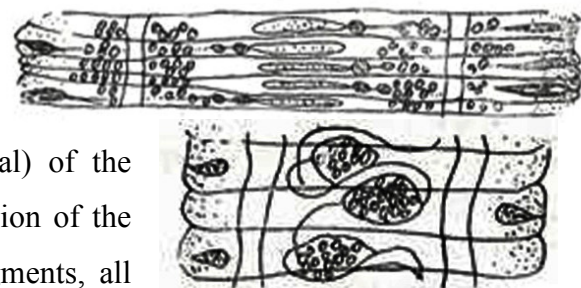
A. centripunctata

Hosts and habitats:

The small intestine of sheep, goats, cattle, and other ruminants.

Morphology:

- The adult tapeworm measured 3 m x 3 mm.
- The scolex has 4 suckers only. The segments are very short with ill-distinct segmentation so the worm appears non-segmented macroscopically. The mature segment has a single set of genital organs with irregularly alternating common genital pore. The ovary is spherical in shape and poral (i.e in the same side of the genital pore). The uterus appeared as a simple transverse sac in the middle of the segment. Testes are collected in 4 groups on either side (medial and lateral) of the excretory canals. Vitelline glands are **absent**. The gravid region of the adult tapeworm is narrow and cylindrical. In the gravid segments, all organs undergo atrophy except uterus, which breaks down into a large thick-walled par-uterine organs, one in each segment. Par-uterine organs appear macroscopically as a median



opaque white line and the wide excretory canals take the shape of transparent lines on either side. Eggs have no pyriform apparatus.

Pathogenicity:

They are not highly pathogenic. Heavy infection produces marked symptoms. They found in adult animals more frequent than the *Moneizia* spp.

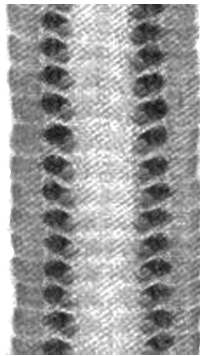
2- Genus: *Stilesia*

S. hepatica

Hosts and habitats: Bile ducts of sheep, goats, cattle and wild ruminants.

Morphology:

- The adult tapeworm measures up to 50 cm x 2 mm.
- The scolex is large has 4 prominent suckers only followed by a broad neck.
- Segments are short although more visible than that of *Avitellina*.
- Mature segment has a single set of genital organs. Testes are present on either side median only (2 groups) to the excretory canals. The uterus consists of 2 portions that connected by the inter-uterine transverse duct in the middle field. No vitelline glands.
- Each gravid segment has two uteri leading to the presence of two par-uterine organs.
- Eggs have no pyriform apparatus.



Pathogenecity:

It is mostly non-pathogenic. The particular significance of this tapeworm is the condemnation of the affected liver at meat inspection as the liver shows slight cirrhosis and thickened wall of bile ducts.

S. globipunctata

Hosts and habitats: Small intestine of sheep and goats.

Morphology:

- The adult tapeworm measures 45-60 cm long and up to 2.5 mm width.
- Testes on either side lateral to the excretory canals and they are from 4-7 in number.

Life cycle of family *Thysanosomidae*:

- The final host passes gravid segments and/or eggs in feces.
- The intermediate host (oribatid mites) ingests these gravid segments and/or eggs.
- Eggs hatch in the intestine of the vector and cysticercoids develop in the body cavity within 2-5 months. The final host can be infected by ingesting oribatid mites with herbage.
- Adult worms develop within 4-6 weeks after ingestion of infected oribatid mites.

Class: Trematoda

Family: Fasciolidae

General characters of the family:

- 1- Large, broad, flat and leaf-like flukes habits in the biliary system and the intestine of mammals particularly herbivores and humans.
- 2- Members have scaly or spiny cuticle. Oral and ventral sucker are close together.
- 3- Intestinal caeca are much branched. Gonads are branched.
- 4- Genital pore is median, directly anterior to the ventral sucker.
- 5- Vitellaria are well developed and much expensive occupying most of the postacetabular space in the lateral fields, and may extend medially.
- 6- Eggs are laid unembryonated, thin-shelled and operculated.

(1) Genus: *Fasciola*

Species of this genus produce a disease called fasciolosis, liver fluke disease, liver rot of liver distomiasis. The most common species are *F. hepatica* and *F. gigantica*.

Fasciola hepatica

Common name: Sheep liver fluke.

Distribution: Cosmopolitan in distribution.

Habitats: Bile ducts, gall bladders and liver.

Hosts: Sheep, cattle, goats, horses, rabbits, hares and humans.

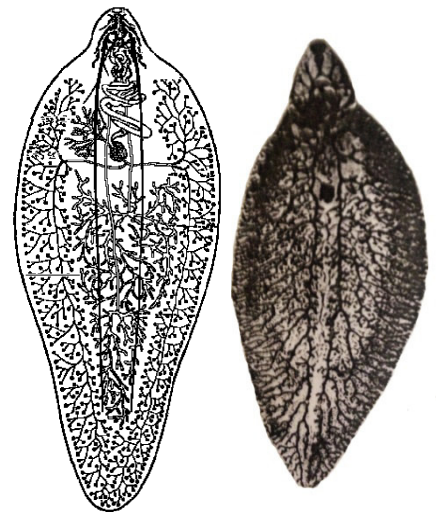
Morphological characters:

i. Grossly:

- Grayish-brown when fresh change to gray-colored fluke on preservation.
- It measures 3.0 x1.3 cm.
- Leaf-shaped, broad anteriorly than posteriorly and the 2 sides of the body are so far apart to make a characteristic V-letter shape. The anterior part has a well-developed cone-shaped projection followed by well distinct broad shoulders.

ii. Microscopically:

- Scaly cuticle.
- The oral sucker is nearly equal to the ventral one.
- The ventral sucker is situated at the level of shoulders.



- A short oesophagus is completely surrounded by a muscular pharynx.
- The intestine bifurcates at the level of shoulders or ventral sucker into 2 blind caeca. The inner wall is branched into small nodules or rudimentary ends.
- Testes are branched, tandem in position occupying the middle field in about the second and third quarters of the body.
- Well-developed cirrus and cirrus sac. The later encloses a prostate gland and a seminal vesicle.
- The ovary is branched, situated anterior to the testes shifted to the right side of the middle.
- The uterus is in the form of convoluted tubules full of eggs lying anterior to the testes.
- Vitellaria are small follicles extending from the level of shoulders to the posterior part of the worm along both lateral fields.
- Common genital pore is situated anterior to the ventral sucker (cirrus and uterus pour into it). Snail intermediate hosts are species of lymnaeids, particularly *Lymnaea truncatula*, *Lymnaea cailliaudi*, *Lymnaea stagnalis*, *Lymnaea tomentosa*.

Fasciola gigantica

Common name: Cattle liver fluke.

Distribution: Africa, Asia, Hawaii, Pakistan.

Habitats: Bile ducts and gall bladders.

Hosts: Cattle, buffaloes, sheep, goats and other herbivores.

Morphological characters:

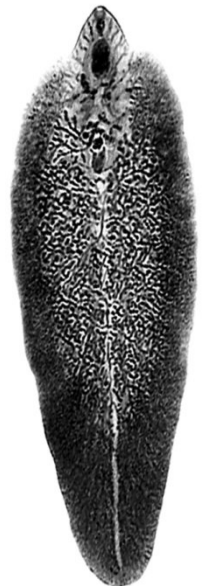
i. Grossly:

- Grayish-brown when fresh change to gray-colored fluke on preservation.
 - It measures 2.5-7.5 x 0.4x1.2 cm.
 - Typical leaf-shaped differs from *F. hepatica* in that:
 - More longer. Smaller cone-shaped projection.
 - Shoulders are less prominent. The two sides of the body are more or less parallel.
- More transparent body.

ii. Microscopically:

It is similar to that of *F. hepatica* except:

- The cuticle is covered with sharp spines. The oral sucker is smaller than the ventral sucker.
- The intestine bifurcates at the level of shoulders or ventral sucker into 2 blind caeca. The inner wall is branched into T-Y shapes.
- Snail intermediate hosts are species of lymnaeids, particularly *Lymnaea stagnalis*, *Lymnaea cailliaudi*, *Lymnaea auricularia*.



Life cycle of *Fasciola* spp.: (*F. hepatica*)

- A two-hosts life cycle.
- It lasts approximately 5 months.
- Eggs pass with bile to the duodenum, then discharge with the feces of infected host to outside. An egg is large-sized (150 x 90 μm), oval, thin-shelled, operculated, golden yellow containing ill-developed embryo consists of one embryonic cell masked by several yolk cells (laid unembryonated).
- The egg hatching occurs at the exterior. Several factors affect such process including temperature and humidity. A high temperature encourages hatching (at 26 °C eggs hatch in approximately 10-12 days while in winter, the process may last for 90 days) although the higher temperature in the hot summer leads to the cessation of the egg development. At lower temperatures, eggs may survive till the environmental conditions will be available for hatching and development.
- Once hatching occurs, the next developmental stage, the miracidium, is released. It is a

triangular-shaped structure with ciliated cuticle, broad anterior part, anterior spine, a pair of eye spots, primitive gut and several germinal balls of actively dividing cells. In water, it swims for few hours searching for the corresponding aquatic snail (the larger the snail size, the larger numbers of

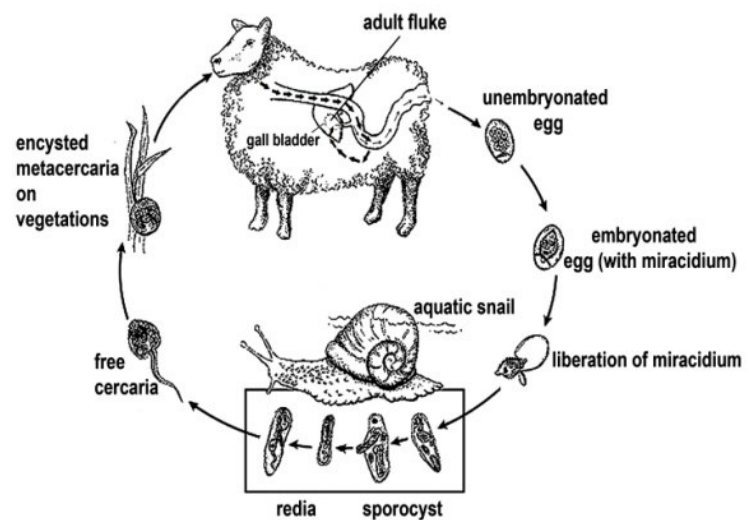


- developmental stages) of lymnaeids (within 24-36 hours, if the snail is not found, the miracidium dies) where it penetrates after casting off cilia and develops into the next stage.
- The sporocyst is elongated sac of undifferentiated mass of actively dividing cells (germinal balls) measuring few millimeters and give rise to the next developmental stage. Each sporocyst produces 5-8 rediae.
 - The redia is located at the hepatopancreas of the snail. It is a cylindrical body, more active than the sporocyst and feed. It measures 1-3 mm in length and consists of a muscular pharynx, simple gut, circular head collar anterior birth pore, 2 caudal processes and several masses of actively dividing germinal balls which further give rise to the next developmental stage.

- The cercaria is leptocercus (with a simple tail) with head: tail is 1:3 (the length of the tail is twice as that of the body), oral and ventral suckers, simple intestinal caeca, dark cytogenous glands and no eye spots. Cercariae get out the snail after spending 4.5-7 weeks from the time of infection.

- Outside the snail, once the cercariae are liberated, within few hours they lost their tails and encysted by a wall secreted by the head cytogenous glands and they are collected on edges of vegetations or below the water surface forming the **infective stage**, encysted metacercariae.

Each of the latter is deep brown and small-sized structure of 0.2 mm in diameter with a thick cyst wall and none of the internal structures could be observed. Encysted metacercariae may survive infective for several months in natural conditions and extended in laboratory conditions. The survival time decreases when the temperatures rises from 10 °C to 35 °C. Hot climates kill the encysted metacercariae. Stagnant water and narrower water canals contain higher numbers of the metacercariae.



- Following the ingestion of the infective stages, excystation occurs in the duodenum (pepsin, trypsin, bile salts and CO₂ facilitate such process) with the liberation of immature flukes, which penetrate into the peritoneal cavity within 24 hours post ingestion of encysted metacercariae.

- On 4-6 days of infection (inside the final host), the majority of immature flukes reach the liver capsule and penetrate into the parenchyma staying for 5-6 weeks.

- On the 7th week, they gain access to the bile duct (predilection site) forming adult worms.

- On the 8th week, eggs are deposited in feces.

- In a less common way, immature flukes may gain access to the liver via the portal circulation.

- For *Fasciola gigantica*, the same life cycle occurs except:

- 1- Lymnaeids are specific for the species.

- 2- The development inside the snails takes a longer time.

Pathogenicity:

It depends on the number of encysted metacercariae ingested, showing pathological lesion in both hepatic parenchyma and bile ducts:

A) Acute fasciolosis:

A less common form and often pass unnoticed in sheep.

- Traumatic hepatitis by simultaneous migration of large numbers of immature flukes.
- Extensive destruction of the liver parenchyma associated with a marked hemorrhage.
- Rupture of the liver capsule with a hemorrhage in the body cavity.
- Accordingly, infected animals may **die** within few days with enlarged, pale and friable liver,
- Hemorrhagic tracts (containing immature flukes) and fibrinous clots on the liver surface.

- Complications:

Flukes predispose to a bacterial disease, Black Disease, caused by an anaerobic bacteria normally inhabitant in sheep (aged 2-4 years), *Clostridium novyii*, but it proliferates in necrotic lesions induced by the flukes.

B) Subacute fasciolosis:

More marked cellular reactions with an immunity to further infection. Early fibrosis is noticed.

C) Chronic fasciolosis:

The most common form (in cattle).

- The main lesion is the **biliary cirrhosis** with fibrotic liver.
- Bile duct walls are greatly thickened with cholangitis.
- Hyperplasia of the bile ducts epithelium (by sharp scales of the flukes) which further completely denuded leaving them as fibrotic tubes.
- Bile ducts are usually calcified, with a blockage of their lumen even protruding from the surface, so as to be difficult to be cut by a knife. This lesion resembles the stem of clay-pipe and the condition is termed **pipe-stem liver**.
- Sometimes, flukes may wander in other organs, as lungs, showing **calcified** flukes with infiltration of purulent gelatinous exudates.

Clinical signs:

A) Acute fasciolosis: (often in sheep)

- Infected animals die suddenly.
- If they survive, they become anorexic with painful to touch abdomen, blood-stained froth from the nostrils and blood discharge from anus.

A) Chronic fasciolosis: (often in cattle)

- Anaemia, off color and vigorous behavior.
- Loss of appetite, depression, emaciation and pale mucous membranes.
- Oedema in the intermandibular space of some animals (sheep) giving rise to a condition termed **bottle-jaw**.
- Dry skin doughy to touch.
- Dry wool, easily to be detached in patches.
- Enteritis, diarrhea or constipation (enteric symptoms usually in cattle).
- Obstructive jaundice due to occlusion of the bile ducts.
- In humans, a condition termed **halzoun-syndrome** is a common due to ingestion of raw liver with an establishment of the whole or a part of the adult fluke in the mucous membrane of the nasopharynx or oesophagus causing inflammatory reactions causing respiratory and regurgitation problems.

Diagnosis:

- In the laboratory, by the detection fasciolid eggs by the use of sedimentation technique.
- In the abattoirs, meat inspection reveals the flukes in hepatic parenchyma and bile ducts.

Treatment: By the use of drugs of choice; triclabendazole, albendazole, levamisole.

Family: Paramphistomatidae

General characters of the family:

- 1- Large, broad and thick flukes appear circular on cross section often parasitize ruminants (**rumen flukes**) as well as fish, reptiles and amphibians.
- 2- The ventral sucker is well-developed lies just in front to the posterior extremity, so called **posterior sucker**. No pharynx. Smooth cuticle. Short oesophagus.
- 3- Simple intestinal caeca reach to the posterior part of the fluke.
- 4- Testes are lobed and usually tandem in position in the middle of the worm, lying anterior to a small ovary which is situated in the posterior third. Uterus is coiled and runs forward anteriorly. Vitellaria are well-developed in the form of compact masses fill along the lateral fields from the level of intestinal bifurcation till the posterior sucker.



(1) Genus: *Paramphistomum*

Species: *P. cervi*

Hosts: Cattle, buffaloes, sheep, goats.

Habitats: rumen and reticulum.

Epidemiology: Cosmopolitan in distribution.

Morphological characters:

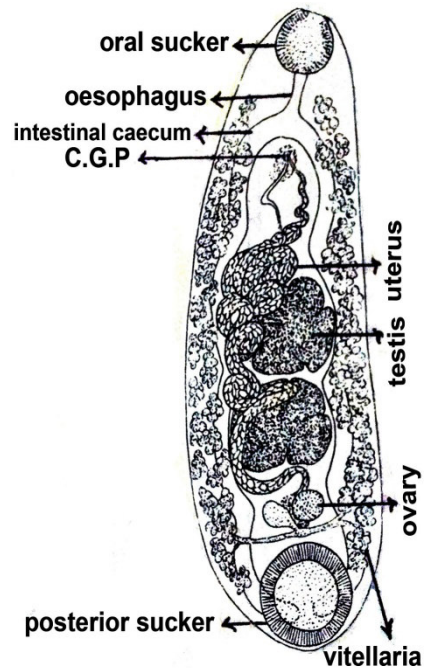
i. Grossly:

Light red when fresh and thick conical or pear-shaped flukes, appear convex anteriorly and more concave posteriorly. It measures 5-12 x 2-5 mm.

ii. Microscopically:

As in general characters of the family with the posterior sucker is large and subterminal.

Intermediate host: Snails, *Bulinus liratus*, *Planorbis planorbis*, *Indoplanorbis exustus* and *Lymnaea bulimoides*.



(2) Genus: *Cotylophoron*

Species: *C. cotylophorum*

Similar in morphological characters, distribution and biology to *P. cervi* except:

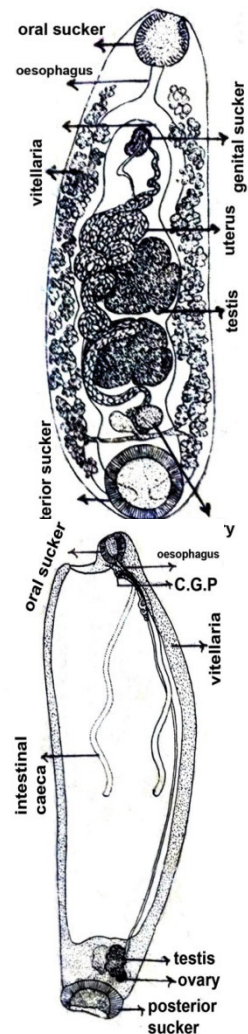
- **Genital sucker** is present surrounding the common genital pore.
- Snail intermediate hosts are *Fossaria parva*, *Bulinus schakoi* and *Indoplanorbis exustus*.

(3) Genus: *Carmyerius*

Species: *C. gregarius*

Similar in morphological characters, distribution and biology to *P. cervi* except:

- It measures 7-10 x 2-3 mm.
- The posterior sucker is relatively smaller and spherical.
- Uniquely, the intestinal caeca reach only to end of the 2nd third of the body (or a short distance behind the middle).
- Testes lie horizontally i.e. opposite to each other at the posterior part of the fluke.
- The ovary is in between the testes.
- Snail intermediate host is *Biomphalaria alexandrina*.



Family: Dicrocoeliidae

Genus: *Dicrocoelium*

Species: *D. dendriticum*

Common names: lancet fluke, little liver fluke.

Host: Sheep, goats, cattle, pigs and may be humans.

Habitats: Bile ducts and gall bladders.

Distribution: Cosmopolitan in distribution.

Morphological characters:

i) Grossly: Medium-sized fluke (6-10 x 2.0 mm) characterized by tapered ends, so the name lancet fluke is derived, with the widest portion at the middle. Uniquely, it is translucent and flattened due to weak musculature and loose parenchyma, therefore, all internal organs could be easily seen even without staining.

ii) Microscopically:

- Smooth cuticle. The ventral sucker is slightly larger, or nearly equal, to the oral one and lies not far apart from it. The oesophagus is partially covered by a pharynx.
- Simple intestinal caeca not reach the posterior end.
- Testes are slightly lobed, tandem in position immediately behind the ventral sucker.
- The ovary lies just posterior to the testes.
- Uterus is in the form of transverse coils full of brown eggs and occupy the central field just behind the ovary till the posterior end. The common genital pore lies just anterior to the ventral sucker. Vitellaria occupy the middle third of lateral fields at the area of the widest part.

Intermediate hosts:

i) 1st intermediate host: Land snails, *Zebrina detrita*, *Helicella ericetorum*.

i) 2nd intermediate host: Field ants or black ants, *Formica fusca*.

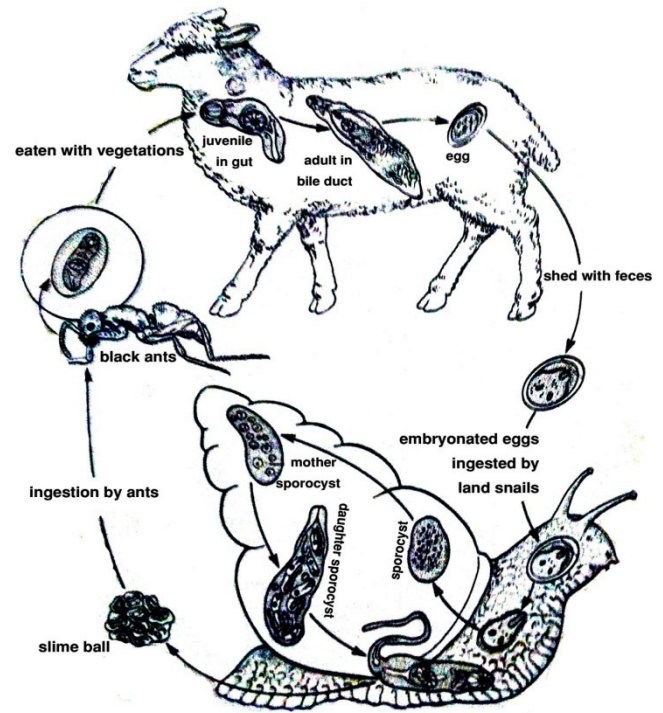
Life cycle: (approximately 5-6 months)

- Embryonated eggs (each is small 45 x 30 µm, oval, thick-shelled, yellowish to dark brown, operculated with no knob and contains fully developed embryo) are ingested by the land snails (1st intermediate host) inside them they hatch and precedes to give miracidia, mother sporocysts and daughter sporocysts (no redial stages). Mother sporocysts have no cuticle, while daughter ones have a cuticle and a birth pore.



- By the 3rd month, leptocercus cercariae, termed **cercariae vitrina**, are released from the mantle cavity of the snails in masses of 200-400 cercariae held together by thick mucoid gelatinous exudates. Each mass is called **slime ball**. The later pass out by the effect of low temperature and drop on vegetations or soil. On the later, black ants (2nd intermediate host), ingest slime balls and encysted metacercariae (infective stages) are developed in the gut of ants.

- Sheep, goats, cattle and other final hosts acquire the infection by grazing on vegetations containing encysted metacercariae. After the excystation in the small intestine, juvenile flukes migrate to the bile ducts via the portal circulation (full growth of adult flukes within 7 weeks post excystation). Four weeks further, eggs are laid.



Pathogenecity:

Similar to that of fasciolids but in lower manner:

- In heavy infections, bile ducts are greatly distended and occluded resulting in jaundice.
- Biliary cirrhosis may occurs associated with proliferation of biliary epithelium.
- Anemia, emaciation, odema and enteritis.

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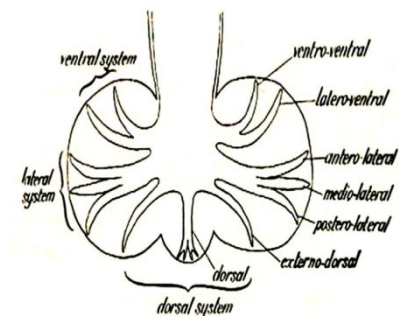
Control of dicrocoelids are difficult as:

- Eggs may survive for months even in low temperatures.
- Land snails are less susceptible to molluscidies than aquatic snails.

**Class: Nematoda
(Roundworms)**

Order: Strongylida (Bursate nematodes)

- Species have **copulatory bursae** at the posterior end of the males.
- There is a buccal capsule (well- or ill-developed) with/without teeth or cutting plates. Some species have a corona radiata (leaf crown) around the buccal capsule. Simple club-shaped-oesophagus, direct life cycle, and the infection occurs by the third stage filariform larvae.



- The copulatory bursa is a cuticular extension at the posterior end of the male worms and consists of 2 lateral lobes and a dorsal one. These lobes are supported by bursal rays (muscle fibers) which arranged into ventral, lateral and dorsal rays. Ventral rays are divided into ventroventral and lateroventral rays. The lateral system consists of 3 rays; anterolateral, mediolateral and posterolateral rays. The dorsal system is composed of two externo-dorsal rays and a dorsal ray (divided). The bursa grasps the female worms during the copulation.

A) Superfamily: Strongyloidea

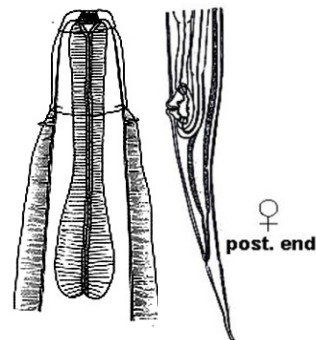
Family: Chabertidae

a) Genus: *Oesophagostomum* (Nodular worm)

spp. *O. columbianum*, *O. venulosum* and *O. radiatum*

Morphology:

- The anterior end has a shallow buccal capsule. There is a large cervical alae and a shallow groove (cervical groove) little behind the anterior of the worm.
- Anterior to the cervical groove, the cuticle is expanded to form a unique cervical vesicle. The copulatory bursa is well-developed and spicules are long. The vulva is near the posterior end of the body.



Hosts and habitats:

The adult worms habit the colon of sheep, goats and cattle.

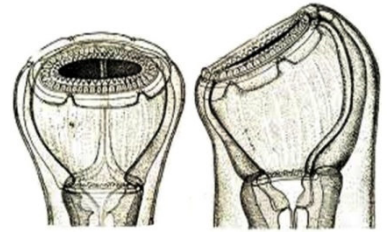
Biology and pathogenesis:

- The embryonal development occurs outside the host.
- The post embryonal development is direct. Eggs develop to the L1 (rhabditiform) on the ground (within 18 hrs) and moult to L2 then to L3 within one week.
- The infective stage is L3. The host is infected by swallowing L3 (sheathed) with the forage. They enter the epithelial mucosa and lie coiled (encyst) next to the muscularis mucosa.
- After 4 days, they undergo the 3rd moulting, changing to L4. The presence of L3 and L4 as well as the presence of discarded cuticular sheaths, result in small gritty lesion (**nodules**).
- Inflammation is localized around larvae. Nodules have small openings through which pus is discharged into the intestine. The intestinal wall shows numerous nodules and tracks.
- Within further 3-4 days, larvae migrate from nodules into the lumen of the intestine, where they moult to L5 and develop to adults.

b) Genus: *Chabertia*

sp. *C. ovina*

- Stout white worms habit colon of sheep, goats and cattle, having a large, bell-shaped and empty buccal capsule which is slightly bent ventrally. The oral opening is surrounded by a double row of small cuticular elements representing the leaf crowns.



- The adult male and female worm measure 1.5 and 2 cm long, respectively. A short transverse cervical groove lies a short distance behind the posterior level of buccal capsule. The male bursa is well developed. Spicules are equal. The vulva opens at the posterior extremity.

Biology and pathogenesis:

- The embryonal development occurs outside the host.
- The post embryonal development is direct. The infective stage is L3.
- Development in the host with extensive histotropic migration in the wall of the small intestine and L3 change to L4 and develop to L5 in the lumen of the caecum, then adults pass to the colon. Adult worms cause parasitic gastroenteritis via ingesting large plugs of mucosa resulting in local hemorrhages and loss of protein through the damaged mucosa. In heavy infections, the wall of the colon becomes oedematous, congested and thickened with small hemorrhages at the sites of worm attachment. Clinical signs are bloody diarrhea, anaemia and loss of weight.

B) Superfamily: Trichostrongyloidea

(1) Family: Trichostrongylidae

a- Genus: *Trichostrongylus* (Black scour worm)

Small, thin (thread) and hair-like worms (males 4-6 mm and females 5-7 mm long). They are difficult to be seen by naked eyes. Ill-defined buccal capsule. The excretory notch is in the oesophageal region (unique feature). They have prominent excretory pore. No cervical papillae. The male posterior end has a well-developed bursa (large lateral lobes and a small symmetrical dorsal one) with short and stout spicules and a gubernaculum. In females, the vulva is short distance behind the middle of the body with a prominent lip (no vulvar flap).



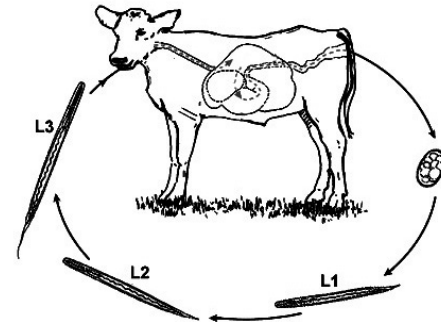
Hosts and habitats:

Trichostrongylus spp. habit the small intestine except *T. axei* (abomasum) and *T. tenuis* (cecum of game birds).

- 1- *T. axei*: in abomasum of sheep, cattle, camels and in the pyloric region of stomach of horses, pigs and humans.
- 2- *T. colubriformis*: in the duodenum of sheep, cattle and other ruminants.
- 3- *T. capricola*: in sheep and goats.
- 4- *T. retortaeformis*: in the intestine of rabbits.
- 5- *T. tenuis*: in the caecum of chicken and other domesticated birds.

Biology and pathogenesis:

- The life cycle is direct and non-migratory. Embryonal development occurs outside the host. Post embryonal development is direct.
- The infective stage is L3 (within 1-2 weeks).
- Infection occurs by ingestion of the infective (sheathed) L3. They exsheathed in the abomasums, then penetrate (histotropic phase of migration) deeply between the intestinal villi (for intestinal species) or abomasal glands (for gastric species), where they moult to L4 and L5. Then, young adults emerge onto the mucosal surface where they become mature and copulate. The prepatent period in animals is about 3 weeks.
- *Trichostrongylus* spp. is the most common cause of parasitic gastroenteritis in tropics. Infected animals shed large numbers of eggs/gram.



b- Genus: *Ostertagia*

(Small brown stomach worms)

- Adult worms habit the abomasum of cattle (*O. ostertagi*), sheep and goats (*O. circumcincta* and *O. trifurcata*). Worms are recognized, in clear abomasal debris, by their reddish-brown color. They are up to 1 cm long and difficult to be grossly seen.
- Ill-defined buccal capsule with small lateral cervical papillae.
- In male, the bursa has an accessory bursal membrane, short and stout spicules with bifid tips and prebursal papillae. Gubernaculum is present. In females, the vulva is usually covered by a vulvar flap.

Biology and pathogenesis:

- The life cycle is direct and non-migratory.
- Embryonal development occurs outside the host.

- Post embryonal development is direct. • The infective stage is L3 (within 2 weeks).
- The infection occurs per os.
- Development inside the definitive host occurs with histotropic phase of migration in the abomasal mucosa (The entire parasitic life cycle usually completed in 3 weeks).
- *Ostertagia* spp. cause anorexia, severe diarrhea of green color, necrosis in abomasal wall and loss of appetite. Hyperplasia of gastric glands and mucosa forming coalesced nodules (Morocco leather or Cobblestone appearance).

c- Genus: *Haemonchus*

(Wire worms, large stomach worms, Barber's pole worms)

• *Haemonchus* is a blood-sucking abomasal nematode which may be responsible for extensive losses in sheep (*Haemonchus contortus*) and cattle (*Haemonchus placei*), especially in tropical and subtropical areas.

• Adults are easily identified because of their specific location in the abomasum, bright red color, and their large size (2.0–3.0 cm).

• In fresh female specimens, the pink (blood-filled) intestine of the worm twisted around the paler reproductive tract (ovaries) (**Barber's pole worm**).

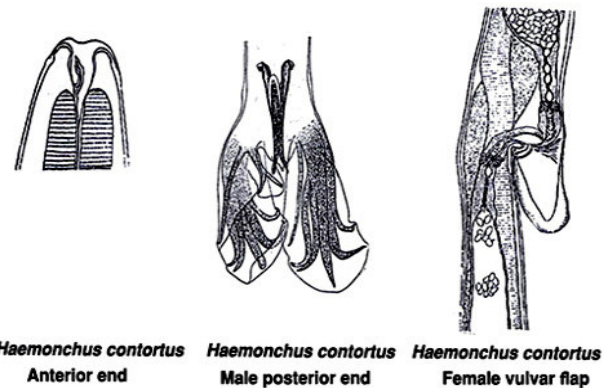
• Anteriorly, both sexes have a very small buccal capsule containing a dorsal tiny lancet which is used for piercing the small blood vessels during feeding. In *H. contortus*, anterior prominent lateral cervical papillae are present.

• In males, the bursa has large lateral lobes with a small asymmetrical dorsal one (the later has a unique inverted Y-shaped dorsal ray). Gubernaculum is present.

• In females, the vulva is usually protected by a cuticular large and linguiform flap.

Biology and pathogenesis:

- The life cycle is direct and non-migratory.
- Embryonal development occurs outside the host.
- Post embryonal development is direct.
- The infective stage is L3.
- The infection occurs per os.
- Development inside the definitive host occurs with histotropic phase of migration in the abomasal mucosa. The prepatent period is approximately 3 weeks in sheep and 4 weeks in cattle. In severe haemonchosis, animals suffer from **anaemia**, dark colored feces and sudden



death (in acute infection), severe gastric haemorrhage in hyperacute stage, weakness, unthriftiness, emaciation and bottle-jaw.

d- Genus: *Cooperia*

Adult worms habit the small intestine of cattle (*C. oncophora*, *C. punctata*, and *C. pectinata*) sheep and goats (*Cooperia curticei*).

Morphology:

- Relatively small worms (less than 9 mm long), light red-colored and coiled when fresh. The main common features are the small cephalic vesicle (inflated anterior end) and the marked anterior transverse cuticular striations. Cervical papillae may be present.
- The male bursa is relatively large. It has a small dorsal lobe with the dorsal ray bifid for half its length. Spicules are brown-colored, short and stout with distinct wing-like expansions in the middle region. Gubernaculum may be present.
- The females have a long tapering tail and a vulvar flap may be present.

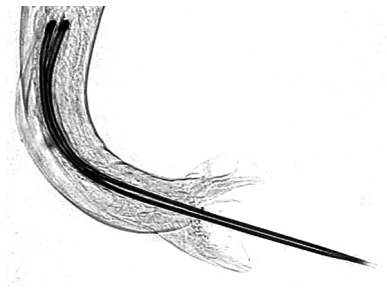


Biology and pathogenesis:

Typical life cycle of Trichostrongyloids. The prepatent period is up to 3 weeks. Diarrhea, dehydration, loss of condition, weakness, loss of appetite and loss of weight are common clinical signs.

e- Genus: *Nematodirus* (Thin-necked worm)

- Adult worms habit the small intestine of sheep, goats (*Nematodirus filicollis*, *Nematodirus spathiger*, and *Nematodirus battus*) cattle (*Nematodirus helvitanus*) and camels (*Nematodirus cameli*).
- Adults are slender, about 2 cm long. The body is always much twisted and a group of worms give the appearance similar to that of the cotton wool. The anterior end has a distinct cephalic vesicle (inflated) which is transversely striated with no cervical papillae.
- Spicules of the male are long, slender with fused tips. No gubernaculum. The female tail is short, truncate with a small spine (It possesses a vulvar flap).



- The egg is ovoid, colorless and large, measuring twice the size of the typical trichostrongyle egg. Female of *N. battus* is exceptionally has a long pointed tail and its large egg is brownish with parallel sides.

Biology and pathogenesis:

- Unlike other trichostrongyloids, the development to L₃ occurs within the egg (post embryonal development is inside the egg).
- Infection occurs by ingestion of L₃ which enter the mucosa of the small intestine where the two parasitic moults take place between the villi within 4-10 days post-infection.
- The prepatent period is approximately 15 days. *Nematodirus* causes parasitic gastroenteritis, diarrhea, loss of body weight and dehydration.

Genus: *Dictyocaulus*

(Lungworms)

- The taxonomic position of these worms in trichostrongylids rather than metastrongylids is referred to being that they are geohelminths, while metastrongylids are biohelminths.
- Adult worms habit the trachea and bronchi (unique feature) of cattle (*Dictyocaulus viviparus*), sheep, goats, (*Dictyocaulus filaria*) horses and donkeys (*Dictyocaulus arnfieldi*). They are the major causes of parasitic bronchitis in their hosts.



Morphology:

- The adults are slender, thread-like, milk-white-colored and up to 8.0–10 cm (males 3.5-4.5 cm and females 4.5-6.5 cm) long.
- Small and shallow buccal capsule.
- In the male bursa, the medio- and posteriolateral rays are fused except at their tips. Spicules are stout, dark brown and **boot-shaped**. Female vulva lies behind the middle of the body. The egg measures 120 x 80 µm and contains a fully developed larva when freshly laid.

Biology:

- Ovoviviparous females produce eggs which hatch immediately while they are in the air passages or in the gut after passing up the trachea and being swallowed. However, in *D. arnfieldi*, hatching does not occur until soon after the egg being passed in the feces.
- L1 migrate up the trachea and swallowed, then pass out in feces. The preparasitic stages do not require feeding. L3 is reached within 5 days, then, they leave feces to reach the herbage.

- Infection is by ingestion of L3 which then penetrate the intestinal mucosa and pass to the mesenteric lymph nodes where they moult to L4 which then travel via the lymph and blood to the lungs (lymphatic migration) and break out of capillaries into the alveoli about one week after infection. The final moult occurs in bronchioles few days later, and young adults then move up the bronchi and develop to maturity.
- The prepatent period is about 3- 4 weeks.

Pathogenicity:

They produce a disease called dictyocaulosis (verminous bronchitis or lung verminosis). Almost respiratory signs: intermittent coughing, particularly during exercises. In severely affected animals, dyspnea is obvious. Catarrhal bronchitis and pneumonia are frequent. Other clinical symptoms such as foaming around the mouth, loss of appetite, diarrhea and fever due to secondary bacterial infection and even death may occur.

C) Superfamily: Metastrongyloidea

- They are very slender, long and thread-like. The male bursa is much reduced with two spicules.
- The typical life cycle is indirect (intermediate hosts are usually molluscs or insects).
- Most of them habit air spaces of lungs or blood vessels adjacent to lungs. They may be conveniently divided into four groups according to host: those occurring in pigs (Metastrongylidae: *Metastrongylus*), sheep and goats (Protostrongylidae: *Muellerius*, *Protostrongylus*, *Cystocaulus*, *Spiculocaulus*, *Neostrongylus* and *Varestrongylus*), deer (*Elaphostrongylus*, *Parelaphostrongylus*) and domestic and wild carnivores (Filaroididae: *Oslerus*, *Filaroides*, *Aelurostrongylus*, Angiostrongylidae: *Angiostrongylus* and Crenosomidae: *Crenosoma*)

Family: Metastrongylidae

a- Genus: *Metastrongylus*

sp. *M. apri*

- They are slender, white-colored, up to 6.0 cm long and found in pigs.
- They have two lateral trilobed lips. Individual species are differentiated on the basis of size and shape of the male spicules. The bursal dorsal ray is small. The life cycle is indirect involving earthworms as intermediate host.

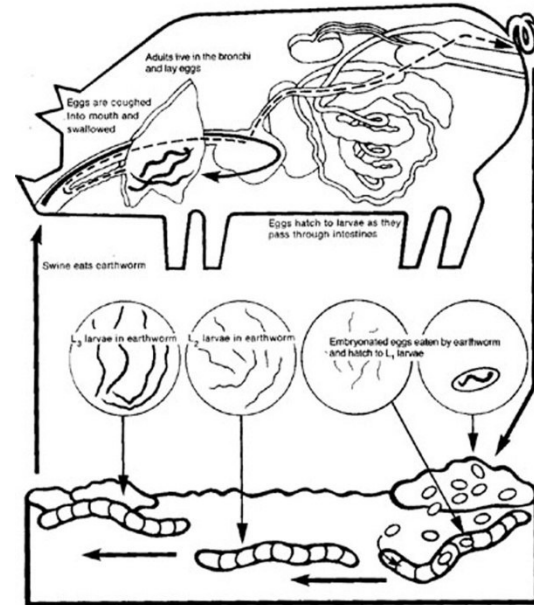
Biology and pathogenesis:

- Laid eggs, in bronchioles and bronchi, are coughed up, swallowed and pass with feces and further swallowed by earthworms.

- In the gut of the later, L1 hatch and they penetrate the wall of the crop. Two moults occur and the ensheathed L3 appear in 10-30 days. Swine become infected via **ingesting earthworms containing the infective larvae**.

- Larvae liberated, exsheathed and penetrate the intestinal mucosa of pigs. They reach lymph vessels, heart, and pulmonary artery to lungs, then to air sacs, where the L4 occur and continue to bronchioles and bronchi (lymphatic migration).

- The prepatent period is 4 weeks. Infected pigs suffer from petechial haemorrhage produced in lung tissues and adult worms occlude bronchioles causing verminous pneumonia.



b) Genus: *Protostrongylus*

sp. *P. rufescens*

Morphology:

- They are slender, hair-like and **reddish** worms in small bronchioles of lungs of sheep and goats. Male worms are up to 4.5 cm and females up to 6.5 cm long.
- In males, the bursa is small and reinforced by two chitinous plates. The tubular spicules are almost straight; the distal ends bear two membranous alae. The gubernaculum has two boot-shaped prolongations bearing several knobs posteriorly.
- In females, the vulva is close to the conoid tail.

Biology and pathogenesis:

- Embryonal development occurs during passage of eggs inside the body of final hosts.
- Post embryonal development is indirect.
- Infective stage is L3.
- The infection occurs per os.
- The adults are ovoviviparous. L1 pass in feces and they penetrate the foot of the molluscan (*Zebrina* and *Helicella* snails) intermediate host, and develop to L3 in a minimum period of 2–3 weeks. The final host is infected by ingesting the infected molluscs. On ingestion of the

later, L3 liberate, travel to lungs via the lymphatic-vascular route. The parasitic larvae occur in mesenteric lymph nodes and lungs.

- The prepatent period of *Protostrongylus* is 2-3 months. The patent period exceeds 2 years. Animals showing bronchitis and respiratory manifestation.

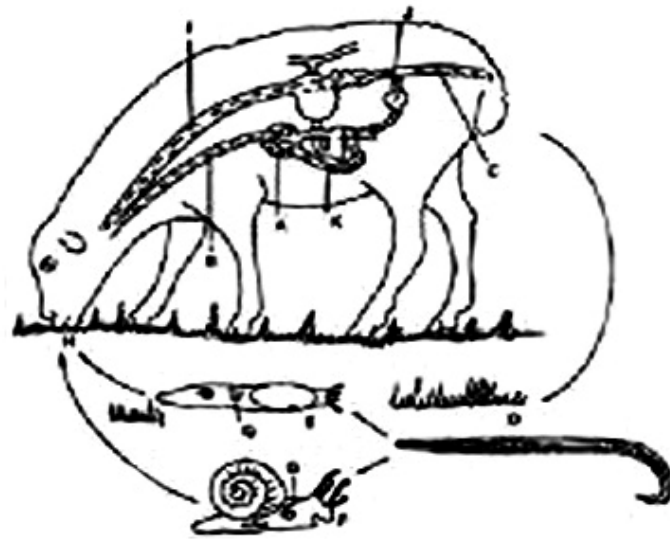
c- Genus: *Muellerius*
sp. *M. capillaris*
(Hair lungworms)

Morphology:

- These are grey-reddish, slender hair-like worms about 1.0-4.0 cm long. Although being large, they are often difficult to see with naked eyes as they are embedded in lung tissues.
- The adult males have pointed non-bursate spirally coiled posterior end. The spicules are curved with sharp points. The vulva has a small swelling at the posterior margin and is located close to the anus.

Biology and pathogenesis:

- The life cycle is indirect and involves a molluscs (snails/slugs) intermediate host. First, the parasite infects the intermediate host, which is subsequently ingested by a goats or sheep while grazing. Larvae migrate to lungs by the lymphatic system and cross into the alveoli or bronchioles. In alveoli, larvae mature to adults (ovoviviparous females), which lay eggs in the lung tissues. Eggs rapidly hatch, and larvae are coughed up/ swallowed. Larvae are expelled into the environment in the sputum or feces and reinfect a snail or slug to complete the life cycle.



- The prepatent period of *Muellerius* is 6-10 weeks. The patent period is more than 2 years.

Pathogenicity (in goats): Similar to that of dictyocaulosis.

Order: Ascaridida
Superfamily: Ascaroidea
Family: Ascaridae
Genus: *Ascaris*
sp. *Ascaris (Toxocara) vitulorum*

Common name and hosts: Ascarids of cattle and buffaloes, particularly calves.

Distribution: Tropical and subtropical areas.

Habitat: Small intestine.

Morphology:

- The largest worms infecting cattle (♂ 25 cm and ♀ 30 cm long and 7 mm thick).
- It is a whitish-colored and translucent, so internal organs could be easily seen by naked eyes.
- A narrow anterior end, so it appears **smaller** than the succeeding parts. Laterally, 2 characteristic wing-like projections (alae) are present. Club-shaped oesophagus.
- Eggs are subglobular, grayish, 70x80 µm, having a thick shell with finely pitted albuminous layer and contain a single cell.

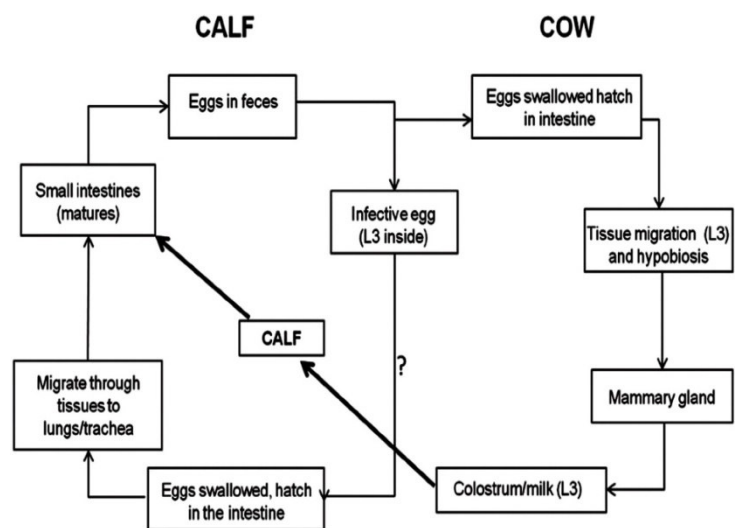
Life cycle:

- Embryonal development occurs at the exterior.
- Post embryonal development is direct.
- The infective stage is the egg containing L2.
- The route of infection per os.
- The development inside the final host occurs with hepatopulmonary migration (see page 137).
- The prenatal and transmammary infections are the main sources of infections to calves. Larvae have somatic migration then they become dormant. In pregnancy, dormant larvae mobilized from the tissues in the 8th month of pregnancy, reach the blood stream then to the fetus through the placenta (prenatal infection). Other larvae reach mammary glands and the newly born calves get the infection via dam's milk (transmammary infection).

- The prepatent period in calves is 3-4 weeks. In adult cows, it is longer, depending on the migration and dormancy periods.

Pathogenesis and clinical signs:

- It is usually non-pathogenic for adult cows. Otherwise, it is harmful to calves (characteristic butyric acid or acetone odor on breath and/or urine is common) if untreated.
- Migrating larvae in adults, particularly in lungs, are often associated with secondary bacteria and subsequent pneumonia. In calves, adult worms (in the small intestine) absorb nutrients of



the host causing diarrhea (often putrid), colic, enteritis, loss of appetite and weight. Due to the large size of the worms, massive infections may obstruct the gut and even perforate.

- Occasionally, worms could migrate via the bile duct causing cholangitis.

Diagnosis:

- Detection of eggs in feces of calves.

Prevention and control:

- Avoid grazing of cows in pastures contaminated by *T. vitulorum* eggs.
- Treatment with broad spectrum [anthelmintics](#) e.g. [benzimidazoles](#)

sp. *A. suum*

Common name: Large intestinal nematode.

Distribution: Cosmopolitan.

Host and habitat: Small intestine of pigs.

Morphology and general characters:

- Males are up to 25 cm and females up to 40 cm long, whitish in color, and **quite** thick.

- Anteriorly, 3 lips with the diameter is **more or less equal** to the succeeding parts. It has a club-shaped oesophagus.

- The male tail is ventrally curved, with a pair of equal spicules and numerous pre- and post-cloacal papillae.

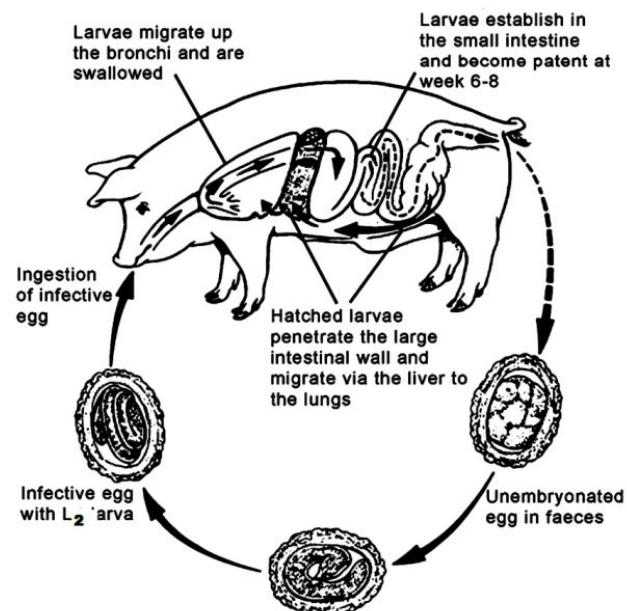
The vulva opens in the first third of the body. Eggs are oval/ovoid-shaped, golden brown/dark greenish brown in color, thick-shelled with mammillated albuminous layer (prominent projections) and 50-70×40-60 µm. The freshly deposited egg contains one cell.

- It is worthy to mention that *A. suum* is zoonotic. Visceral larva migrans due to larvae migration has been described.

Life cycle:

- One adult female produces 200,000 to one million eggs daily. Eggs can develop to the infective stage in 3-4 weeks. Under optimal conditions, eggs may survive for years, but they are highly resistant to chemical agents.

- The pattern of the life cycle is similar to *T. vitulorum*.



Pathogenesis and clinical findings:

- It may significantly reduce the growth rate of young pigs. Rarely, the intestinal mechanical obstruction may occur.
- Hepatic hemorrhage and fibrosis are due to larval migration through the liver leads to accumulation of lymphocytes seen as white spots (**milk spots**) under the capsule. Lesions become visible 7-10 days post infection and disappear within 1-4 weeks.
- In heavy infections, migratory larvae may cause pulmonary edema. Susceptible pigs show abdominal breathing (**thumps**). Unthriftiness and weight loss may be noticed.
- The previous infection generally induces development of acquired resistance to reinfection.

Diagnosis: Detection of eggs/worms in feces. As pigs are coprophagic, a low egg count (<200 eggs/g) may indicate coprophagy rather than an actual infection.

Treatment: Benzimidazoles and probenzimidazoles, dichlorvos, ivermectin, levamisole, and pyrantel are effective.

Superfamily: Filarioidea**i) Family: Onchocercidae****filarial worms****1- Genus: *Onchocerca***

Common name: Filaria of ligaments.

Distribution: Tropical areas.

Hosts and habitats: Fibrous tissues of equines and cattle particularly ligaments and intermuscular connective tissues.

The common species are *O. reticulata* and *O. cervicalis* in the ligamentum nuchae, cervical ligaments and flexor tendons of limbs of equines, *O. gibsoni* and *O. gutturosa* in subcutaneous tissues and ligamentum nuchae of cattle and *O. armillata* in aorta of cattle.

Life cycle:

- Microfilariae are found in the dermal lymph space and vessels.
- *Culicoides* act as I.H for *O. reticulata* and *O. gibsoni* and *Simulium* sp. for *O. guttuosa*; suck the body fluid containing L1.
- Inside I.H, larvae change to L2 then L3. The final host is infected during feeding of the I.Hs.
- The adult worms are developed in a year.

Pathogenicity:

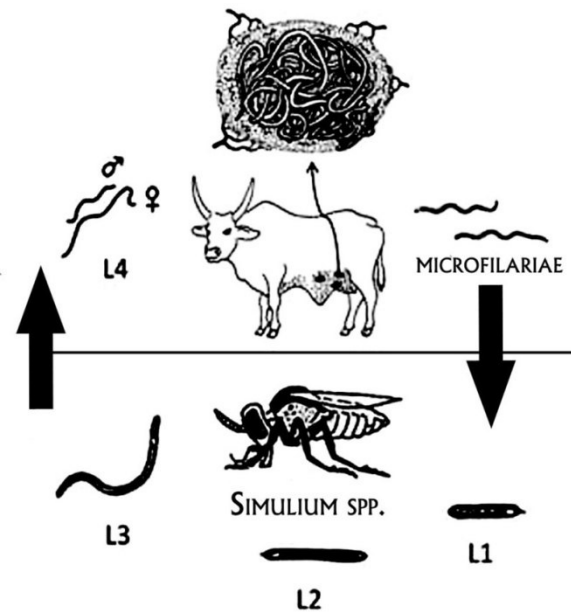
O. cervicalis has been associated with fistulous withers, poll evil, dermatitis, and uveitis in horses. Adults in the ligamentum nuchae induce edematous necrosis to chronic granulomatous changes due to the inflammatory reactions, these resulting in marked fibrosis and mineralization.

Diagnosis:

Skin biopsy is preferable. Microfilariae are concentrated and stained with new methylene blue.

Treatment:

Ivermectin (200 mcg/kg) and moxidectin (400 mcg/kg) are efficacious (>99%) against microfilariae.



3- Genus: *Dipetalonema*

(Syn. *Acanthocheilonema*)

- Adult males are slender and up to 9 cm long and female are up to 21 cm long.
- They are transmitted by *Aedes* and ticks.
- *D. evansi* (*Acanthocheilonema evansi*) infects spermatic arteries of camels.
- *D. reconditum* habits the body cavity of dogs. It causes orchitis, subcutaneous abscesses and arteriosclerosis.

4- Genus: *Setaria*

- Adult worms habit the peritoneal cavity, the peritoneal surface and less common in the pleural cavity.

- Common species are *Setaria equina* in horses and donkeys and *Setaria labiato-papillosa* in cattle and wild ruminants. It is long slender worms up to 13 cm.
- The life cycle is indirect and species of mosquitoes are intermediate hosts. The adult stage reaches the peritoneal cavity in 8-10 months (pre-patent period).

ii) Family: Filariidae

Genus: *Parafilaria*

- Adult worms live under the skin and intermuscular connective tissues of equines and cattle.
- Common species are *P. multipapillosa* in equines and *P. bovicola* in cattle.
- Adults are white small slender, worms up to 6 cm long.
- Numerous papillae and circular ridges in the cuticle of the anterior extremity are characteristics.
- The female tail is also blunt without papillae. It is oviviparous giving small embryonated eggs then hatch to release the microfilariae (L₁).
- The insect vectors are *Musca* species for *P. bovicola* and *Haematobia* species for *P. multipapillosa*.
- The infective L₃ pass to the final host when infected flies feed on lachrymal secretions or skin wounds, migrate and develop to adult stages.
- It induces hemorrhagic exudate or “**bleeding points**” when it deposits their eggs in the skin leads to streaks the surrounding hairs and attract flies.

Order: Enoplida

Suborder: Trichuroidea (Trichinelloidea)

Family: Trichinellidae

Genus: *Trichinella*

sp. *T. spiralis*

Common name: Spiral worm.

Distribution: Cosmopolitan.

Hosts and habitats: It is the smallest nematode of humans and the largest intracellular parasite of the small intestine. Pigs, humans and rats are the main hosts.

Morphology:

- The males measure 1.5 mm in length by 36 µm in diameter. No spicules.
- The size of females are approximately twice than that of males (measuring 3 mm in length by 36 µm in diameter).

Life cycle:

- Adult worms live around the columnar epithelial cells of the small intestine and the larvae live in striated muscle cells of the same mammal.

- The worm can infect species of mammals that consumes encysted larval stages.

- For completion of the life cycle, an infected host must die and ingested by another.

- When an animal ingests meat containing infective *Trichinella* cysts, the gastric acid dissolves the hard covering of the cyst and releases larvae. The later pass into the columnar epithelium of the small intestine and, in 1-2 days, become mature (molts about 4 times). After

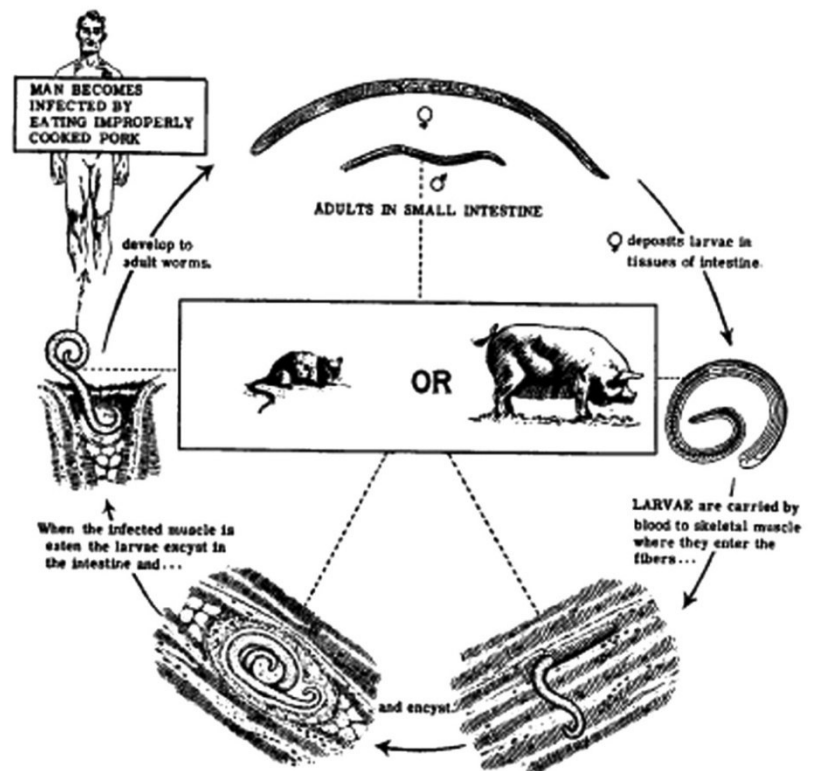


Image at: <https://www.slideshare.net/rajud521/trichurids>

become mature (molts about 4 times). After copulation, males die and adult females produce larvae.

- The female is larviparous, laying her living larvae within the small intestine (5-6 days after infection).

- Larvae penetrate the intestinal wall and wander through the lymphatic system to the circulatory system, then to survive in skeletal muscles (as masseters, intercostals, diaphragm). Within the muscle cell, worms curl up and the cell is now called a **nurse cell complex**. Soon, a net of blood vessels surrounding the nurse cell, providing nutrition for the larva inside. The **nurse cell-parasite complex** may survive for as long as the host remains alive. The cyst measures 0.5 x 0.25 mm with the longitudinal axis is parallel to that of muscle fibers. Ingesting raw or undercooked meat that contains the parasite is the source of infection.



Image at: http://www.isradiology.org/tropical_diseases/tmcr/chapter14/differential2.htm

Clinical signs: (trichinellosis)

Migrating juveniles cause pain as they invade muscle tissue. Oedema, cardiac and pulmonary difficulty, pneumonia, nervous disorders, deafness and delayed or lost reflexes may occur. Adult worms may induce dysentery.

Diagnosis: Muscle biopsy or blood examination could identify trichinosis.

Treatment:

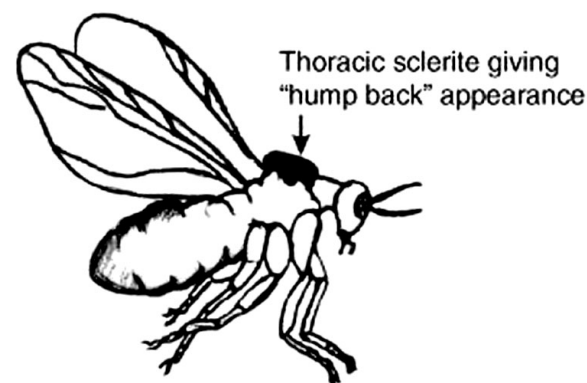
Symptoms could be relieved with aspirin and corticosteroids. Thiabendazole may kill adult worms, however, there is no treatment against larvae.

Control:

- Thoroughly cooking of pork. Proper freezing is effective.
- Proper meat handling as the ordinary curing and salting of pork products will not kill encysted juveniles.

Arthropoda**Nematocera****Family Simuliidae****Genus *Simulium*****Species *S. venustum* (Black flies, Buffalo gnats)****General characters:**

- Small-sized insect of approximately 2-5 mm long and the body is covered with short golden or silvery hairs.
- Only females are hematophagous.
- **Not-hairy** antennae of 11 segments (they lack the property of being plumose or pilose).
- Maxillary palps are 5-segmented.
- **Humped** shiny black or grey thorax.
- Wings are broad, not spotted, not scaly and not hairy (except some bristles on the thick anterior veins).

**Life cycle:**

- Complete metamorphosis.
- Eggs are laid on stones, plants just beneath the surface of running water.
- Larvae are produced within a one week.
- After 6 moultings, triangular pupae are produced.

Medical importance:

- Painful bites for humans and animals with a great annoyance followed by intense itching and ulcerative lesions. This allergic reaction is termed **black fly fever**.
- Biological transmission of *Onchocerca* spp. in cattle and humans and *Leucocytozoon* sp. in ducks and turkeys.

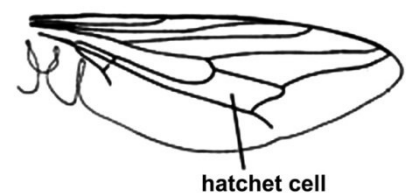
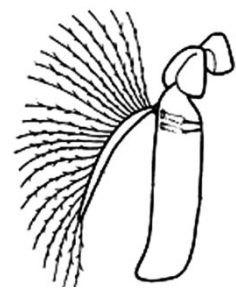
Cyclorrhapha

Genus *Glossina* (Tse tse flies)

Species *G. morsitans*

General characters:

- Large blood sucking flies restricted to tropical Africa and tropical areas in Asia and America.
- They are yellowish to dark brown and approximately as twice as size of *Musca*.
- **Both** sexes are hematophagous and **both** have dichoptic eyes (ocelli are also present).
- Proboscis is adapted for piercing and sucking, elongated prominently and horizontally directed. Maxillary palps are as long as labium.
- Aristate antennae with dorsal **compound** spinulae.
- The thorax is dull-greenish with inconspicuous stripes. At rest, wings are held over the back crossing each other as folded scissor-like (completely overlapping each other) and extend a short distance beyond the end of the abdomen. Each wing is characterized by the presence of **hatchet-shape (cleaver) discal cell** (between 4th and 5th longitudinal veins). A narrowly-opened 1st posterior cell is found between 3rd and 4th veins.
- Abdomen is triangular, light to dark brown composed of 6 visible segments dorsally.



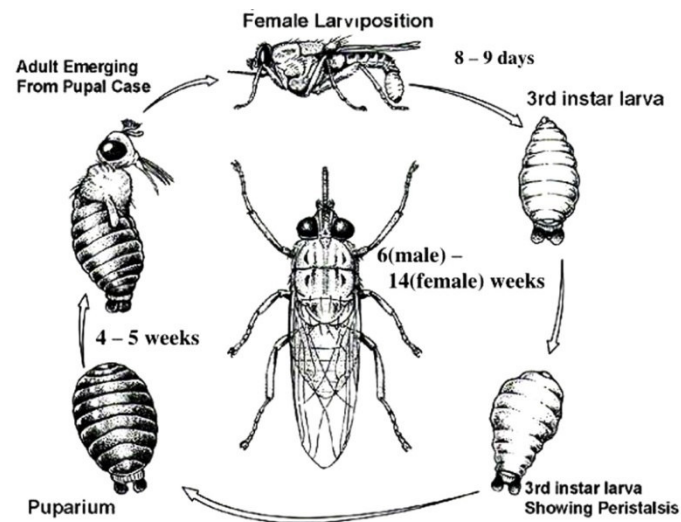
Habitats:

They are diurnal flies found in all places where domesticated animals are reared.

Life cycle:

- The adult female gives rise to a fully grown larva (cylindrical and creamy-white to pale yellow) which hide itself in the soil in depth of 2 cm.

- Immediately, the larva pupates within 1-1.5 hours. The pupa is olive-shaped, Mahogany-brown in color and provided with 2 posterior knobs. The pupal period lasts for 17-90 days (average 35 days) according to temperature and humidity. Then, adult emerges.
- The adult female gives one larva every 10-14 days, and it gives 12 larvae during its life span.



Medical importance:

Biological transmission of various trypanosomes:

- 1- *T. congolense*, *T. vivax*, *T. brucei* (Nagana disease in animals).
- 2- *T. gambiense*, *T. rhodesiense* (African Sleeping Sickness in humans).

Genus *Lyperosia* (*Siphona* or *Haematobia*)

L. stimulans (*S. irritans* or *H. irritans*) (Horn fly)

General characters:

- Blood sucking flies causing annoyance of animals.
- It resembles *Musca domestica* in color with about its half-length.
- Wing venation, antennae and proboscis are similar to those of *Stomoxys* sp. (except that maxillary palps are as long as proboscis). Life cycle resembles that of *Musca domestica*.
- Adult flies are found as clusters around the base of cattle or sheep horns, and eggs are laid in fresh dung of those animals. It causes a great annoyance resulting in decreased milk production. Biologically, it transmits *Stephanofilaria stilesi* and *T. congolense* in cattle and *T. rhodesiense* in humans.

Flies-producing myiasis

Genus: *Hypoderma*

Species *H. bovis* (Heel fly, Ox-Warble fly, cattle grubs), *H. lineatum*

Host: Cattle.

Habitats: S/C tissues of the back.

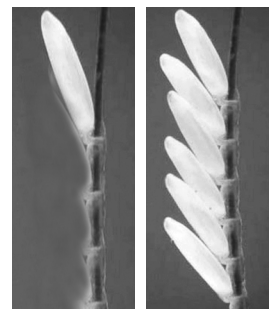
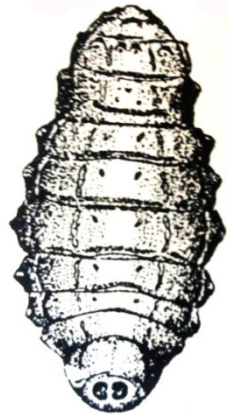
Season: Summer (June, July)

Morphology:

Similar to a bee with one pair of wings. The abdomen is covered with yellow to orange hairs with a broad band of black hairs around the middle. Females are **oviparous**.

Life cycle: (10 months)

- Eggs are laid (particularly in sunny weathers) at the basal parts of hairs at the region of the heel (also in lower legs and ventral belly) either singly (*H. bovis*) or in row of 6 or more (*H. lineatum*) per one hair.
- Within 4 days, hatching occurs (by the body temperature), and L₁ crawl down hairs, penetrate the skin and wander in the S/C tissue up the leg and then towards the diaphragm.
- In *H. lineatum*, larvae find their way in the submucosal C.T and muscles of the oesophageal wall.
- In *H. bovis*, larvae find their way to the dorsal aspect of the body to reach the S/C tissue of the back and enter the spinal cord and leave it again to return the S/C tissue of the back (hence, it is L₂) causing inflammation, oedema and a local swelling (so the term **warble** is derived).
- Within 3 days, L₂ perforate (by oral hooks) a small hole in the back skin with the posterior spiracles are directed towards the pore for respiration. Then the swelling subsides. Larvae feed on inflammatory exudates.
- Within 15-50 days, the fully developed L₃ is formed. It is 2.5-3 cm long, dark gray to black, broad oval with the maximum thickness at the middle. Short spines are found on the ventral aspect. Posterior spiracles are **kidney-shaped** (fully-developed L₃ is formed in 30 days).
- Mature L₃ leave their fibrous sac (warble) and force themselves out the hole and fall on the ground to pupate.
- Pupae are coarctate and dark brown or black.
- Adults emerge 35 days after the pupation.



Medical importance:

1- It induces a specific myiasis.

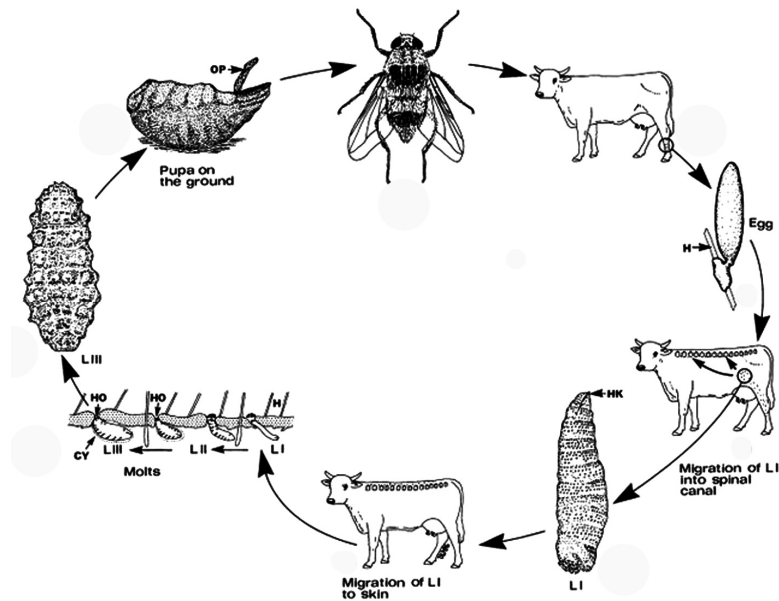
2- Effects of adults:

Due to a persistent approaching of flies to lay eggs, cattle become straggled and restless by continuous irritation, so, they try to avoid flies either by running away even in water or by dragging themselves against any object injuring themselves. This galloping is called gadding.

A continuous irritation causes animals not to feed properly leading to a loss of weight and decreased milk yield.

3- Effects of larvae:

- Economic losses of meat in all regions where larvae pass via them as muscles of back, oesophagus, legs and diaphragm. This occurs as larvae irritate tissue around them and flesh become infiltrated with greenish-yellow gelatinous exudates especially along all tracks where larvae wandered. These areas are called **butcher's jelly** as it could be detected by inspection in abattoirs.



- As a result of skin perforation by larvae, skin becomes of low quality rendering it unsuitable for manufacturing purposes.
- Wounds caused by skin perforation may predispose for secondary bacterial infections.
- Larvae have toxic effects to the hosts.

Order Acarina

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.	- Host specific.

<ul style="list-style-type: none"> - 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. 	<ul style="list-style-type: none"> - 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	
<ul style="list-style-type: none"> - 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 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 <i>Notoedres</i>). - The posterior margin of males is not bilobed. 	<ul style="list-style-type: none"> - 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 <i>Psoroptes</i> only) stalks. - Leg 4 of males is shorter ending with hairs. - Leg 3 of females bears 2 long terminal bristles (in <i>Otodectes</i>, leg 4 ends with hairs). - In males, the posterior part of the body has 2 adanal suckers and is bilobed. - Anterior legs are distinctly stronger than posterior ones.

Common species	
1- Genus <i>Sarcoptes</i> . 2- Genus <i>Notoedres</i> . 3- Genus <i>Cnemidocoptes</i> .	1- Genus <i>Psoroptes</i> . 2- Genus <i>Otodectes</i> . 3- Genus <i>Chorioptes</i> .
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 locate a female's burrow and mate. Transmission occurs primarily by the transfer of the impregnated females during skin-to-skin contact.	The development from eggs through the larval and nymphal stages to mature adults occurs entirely on the skin and takes about 10 days.

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 4 th coxa	Anterolateral to the 4 th coxa
Pulvilli	Always present	Rudimentary or absent
Sexual dimorphism	Easy and marked	Difficult
Examples	<i>Boophilus annulatus</i> , <i>Rhipicephalus sanguineus</i> , <i>Hyalomma</i> species	<i>Ornithodoros moubata</i> , <i>Argas persicus</i>

Veterinary Protozoology

Order: Kinetoplastorida

Genus *Trypanosoma*

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

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

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

(*Cruzi* group)

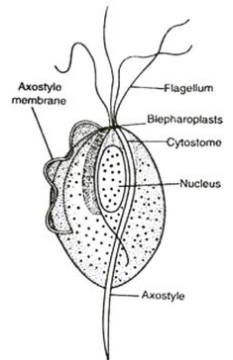
Subgenus	Species/group	Development/transmission
<i>Megatrypanum</i>	<i>T. melophagium</i> (sheep) <i>T. theileri</i> (cattle, antelopes)	- Large mammalian trypanosomes with typical kinetoplast near the nucleus. - Vectors are hippoboscids or tabanids.
<i>Herpertsoma</i>	<i>T. lewisi</i> (rats) <i>T. rangeli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

Genus *Trichomonas*

Species *T. vaginalis*

Morphology:

- Ovoid/pear-shaped organism with 4 anterior flagella and no posterior free flagellum.
- Large anterior nucleus.
- The undulating membrane extends from the base of flagella posteriorly to about half-length of the parasite.



Hosts and habitats: Vagina, prostate gland and urethra of humans.

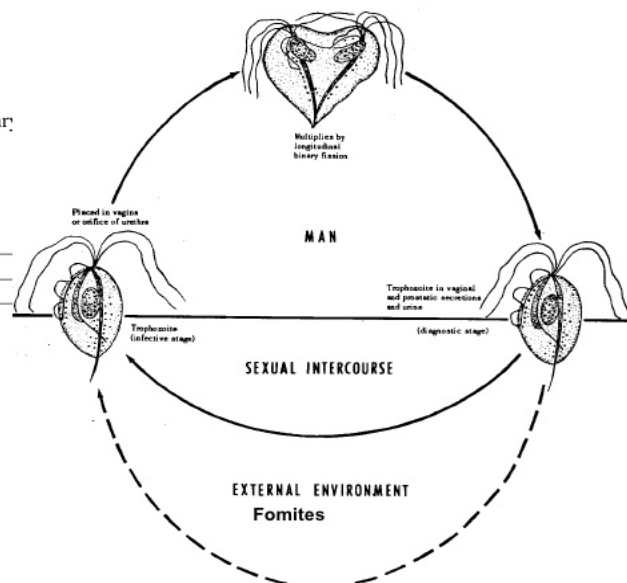
Pathogenesis: Males are usually carriers (symptomless except urethritis in rare cases). Females suffer from burning micturition.

Treatment: Hygienic conditions, iodine solutions and antibiotics.

Life Cycle of *Trichomonas vaginalis*

1. Trophozoites occur in the urogenital system.
2. Trophozoites multiply by binary fission.
3. Trophozoites are transmitted from one person to another by _____

_____ (washcloths, towels, etc.).



Phylum: Apicomplexa (syn. Sporozoa)

Genus *Sarcocystis* (syn. *Sarcosporidia*)

General characters:

It resembles *Toxoplasma* but:

- It is obligatory heteroxenous tissue cyst-forming coccidian parasites with a prey animals (herbivores) serving as the intermediate host and a predator (carnivores) serving as the definitive host. Humans act as incidental intermediate hosts.
- Sporulation occurs **within** the definitive host.
- The infective stage is **disporocystic tetrazoic oocyst**.

Life cycle:

- Infected cat sheds sporulated oocyst. The cyst wall is very thin (fragile) and easily to undergoes rupture, so, sporocysts, rather than oocysts, are often seen in feces. Moreover, sporocystic walls may rupture releasing sporozoites.
- Sporocysts/sporozoites are ingested by the proper intermediate host inside which sporozoites

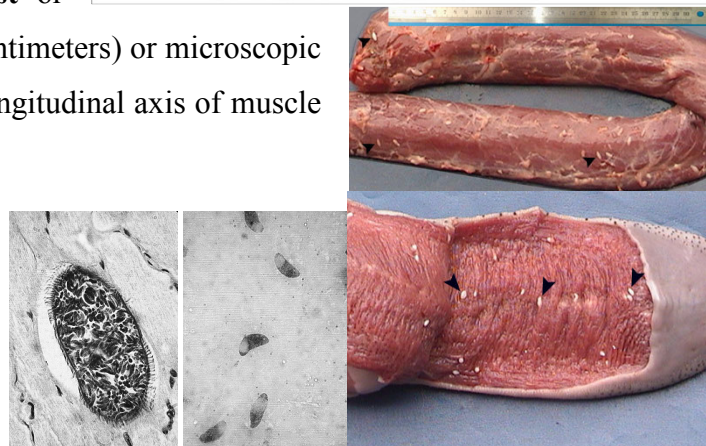
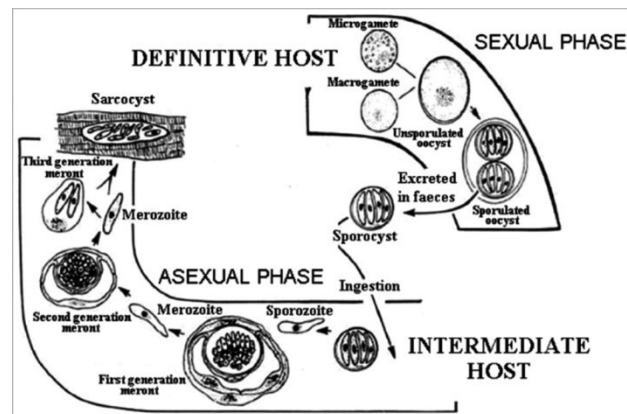
penetrate the intestinal wall with the formation of 2 or more schizont generations, then merozoites circulate in blood reaching the endothelial lining of blood vessels of internal organs forming tachyzoites (**endopolygony**).

- Tachyzoites circulate to the skeletal muscles, particularly oesophagus, heart and diaphragm and multiply by **endodyogony** and change to bradyzoites. A mass of the later is called a true cyst (**sarcocyst** or

Miescher's tubule). It is either macroscopic (few centimeters) or microscopic (few micrometers), spindle-shaped, parallel to the longitudinal axis of muscle

fibers. The covering is either thin or thick wall consisting of an outer homogenous layer and inner nucleated layer. From the later, a number of septa (trabeculae) derived to divide the internal cavity into several compartments of different sizes.

Metrocytes (mother cells of bradyzoites) derived from the nucleated layer and give rise to bradyzoites (merozoites). The number of the later decreases towards the center. Each bradyzoite (**Rainey's corpuscle**) is banana-shaped, the anterior end is more pointed



containing granules surrounding a vacuole, the posterior end is broader and the nucleus is either centrally located or shifted posteriorly. A mature cyst is formed within 4 months. The tissue of intermediate host containing infective sarcocyst is ingested by the appropriate definitive host, within which the sarcocyst ruptures with liberation of bradyzoites that penetrate the **lamina propria** of the small intestine and form gametes (**no schizonts**). Fertilization between macrogametes and flagellated microgametes occurs with the production of zygote forming unsporulated oocysts which soon sporulate (infective stage) endogenously followed by shedding of sporocysts in feces.

Commons species:

Cattle

- *S. bovicanis* (*S. cruzi*).
- *S. bovis* (*S. hirsuta*).
- *S. bovis* (*S. hirsuta*).
- *S. bovis* (*S. hirsuta*).

Buffaloes

- *S. fusiformis* (cats-buffaloes). Macroscopic.
- *S. levinei* (dogs-buffaloes). Microscopic.

Equines • *S. equicanis*.

Sheep *S. ovicanis*. *S. ovifelis* (*S. tenella*).

Family: Babesiidae

Genus *Babesia*

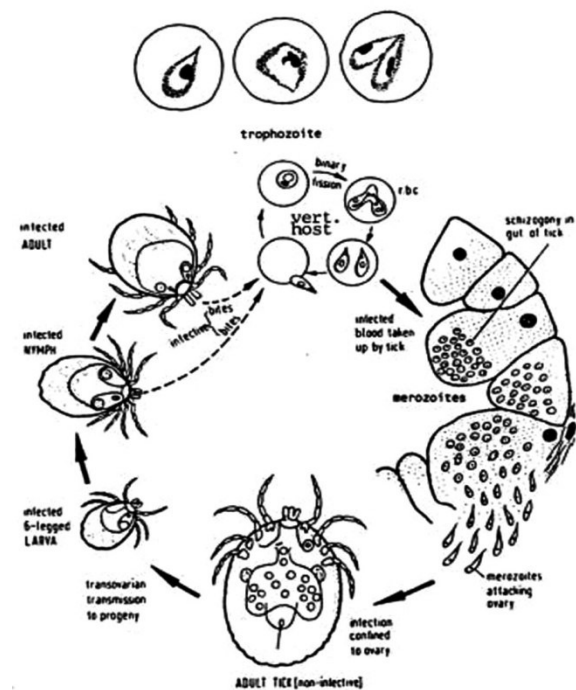
Species	Host	Morphology	Vector
<i>B. bigemina</i>	Cattle, buffaloes	Trophozoite is large (4-5 μm), pyriform, rounded, oval or irregular. Pyriform members occur in pairs with an acute angle. They are highly pathogenic.	<i>Boophilus microplus</i> <i>B. annulatus</i> <i>B. decoloratus</i>
<i>B. bovis</i>	Cattle	Similar to <i>B. bigemina</i> but smaller, in the center of RBCs. Vacuolated (signet-ring shape) forms are common.	<i>B. annulatus</i> <i>B. decoloratus</i>
<i>B. divergens</i>		Similar to <i>B. bovis</i> but smaller, tend to locate at the periphery with a relatively large angle. European sp.	<i>Ixodes ricinus</i> <i>Haemaphysalis longicornis</i>
<i>B. major</i>		Similar to <i>B. bovis</i> but larger.	<i>H. punctata</i>

<i>B. motasi</i>	Sheep, goats	Similar to <i>B. bigemina</i> . Paired pyriform trophozoites are common. Highly pathogenic in sheep.	<i>H. punctata</i> <i>Rhipicephalus</i> spp.
<i>B. ovis</i>	Sheep	Small babesiae. The majority are rounded and tend to be at the periphery. Less pathogenic.	<i>Rh. bursa</i>
<i>B. caprae</i>	Goats	Similar to <i>B. ovis</i> .	<i>Rhipicephalus</i> spp.
<i>B. caballi</i>	Equines	Large-sized, resembling <i>B. bigemina</i> with an acute angle	<i>Dermacentor</i> spp. <i>Rh. bursa</i>
<i>B. equi</i> (<i>N. equi</i>)		Small-sized, mostly are rounded. Pyriform shapes found in tetrads forming maltese-cross shape.	
<i>B. canis</i> - <i>B. canis canis</i> - <i>B. canis rossi</i> - <i>B. canis vogeli</i>	Dogs	Large -sized, usually pyriform/amoeboid containing vacuole. Multiple infections of up to 16 merozoites are found.	<i>Rh. sanguineus</i>
<i>B. gibsoni</i>		Small -sized and pleomorphic (mostly rounded).	<i>Rh. sanguineus</i> <i>Haemaphysalis</i> spp.
<i>B. felis</i>	Cats	Small-sized, mostly rounded/irregular (rarely pyriform).	<i>H. leachi</i>
<i>B. microti</i>	Rodents	Similar to <i>B. equi</i> .	<i>Ixodes</i> spp.

Life cycle: (*B. bigemina*)

- Following inoculation by ticks vector (*Boophilus* spp.), released **sporozoites** (often in transovarian species) penetrate the cell membrane of erythrocytes.
- Once inside, they become **trophozoites** which undergo binary fission to give 2-4 **merozoites**.
- The later break out RBCs wall and immediately invade another intact cells with repeated schizogony and consequently multiple merozoites. This asexual cycle occurs indefinitely until the host dies or eliminates the parasites.

- Some merozoites remain unchanged except taking an unusual shape and act as **gamonts** (gamont precursors). They are called ray bodies (**Strahlenkorper** in dogs). They produce gametes often in the gut lumen of tick vector.
- During the passage from the host to the midgut, 2 populations of ray bodies develop from the gamonts. Ray bodies undergo further multiplication to form large aggregations of multinucleated cells. Once the division is completed, uninucleated ray bodies with thorn-like structure are differentiated into micro- and macrogametes.
- After tick engorgement (within 2-4 days), gametes fuse together in pairs (initial syngamy) forming a spherical zygote that will be motile, **ookinete** or **primary kinete**.
- The later invades the gut epithelium with further multiplication (asexually) to form more club-shaped ookinetes (**vermicules, sporokinetes or large merozoites**) which escape into the hemolymph and invade a variety of tissues (**including uterus, ovaries and oocytes**) where successive series of secondary schizogony occur to form more vermicules. These cycles continue till the infected tick **dies**.
- Kinetes invade salivary glands and acini and undergo asexual division (**sporogony**) to form multinucleated stages (**sporozoites or small merozoites**) which are released in the salivary gland lumen mixed with saliva. Thousands of sporozoites (broad anteriorly and narrow posteriorly) are formed and become active within 5 days after taking the blood meal.



Family: Theileriidae
Genus Theileria

Item	(1) <i>Th. parva</i>	(2) <i>Th. annulata</i>
Disease	East Coast fever, African Coast fever, bovine theileriosis	Egyptian fever, Mediterranean Coast fever, tropical theileriosis
Hosts	Cattle, water buffaloes	Cattle, water buffaloes, sheep, goats
Distribution	Eastern, central and southern Africa	North Africa, South Africa
Location	Lymphocytes and RBCs	

<p>Structure</p>	<ul style="list-style-type: none"> • Rod/comma-shaped are usually inside RBCs. Rounded forms may be found. • Multiplying forms in lymphocytes and cells of RES (spleen, L.Ns) are called Koch's blue bodies (Koch's bodies). Each is circular or irregular with blue cytoplasm and numerous nuclei appear as red chromatin granules on staining with Romanowsky stain. Two types of schizonts: macroshizonts (macromerozoites) and microshizonts (micromerozoites). Inside RBCs, parasites multiply by binary fission forming 2 merozoites. 	<ul style="list-style-type: none"> • Rounded/oval forms are often found inside RBCs. Rod/comma-shaped organisms may be found. • Multiplying forms in lymphocytes of L.Ns and spleen produce Koch's blue bodies either intracellular or in their lumen. • Inside RBCs, parasite multiplication produces 2-4 daughter merozoites.
<p>Vectors</p>	<p><i>Rh. appendiculatus, Hyalomma excavatum</i></p>	<p><i>Hyalomma excavatum</i></p>
<p>Pathogenesis</p>	<p>It is highly pathogenic for cattle (particularly imported species). Adults are more affected showing enlargement of L.Ns and spleen, hemorrhages on mucous and serous membranes (due to release of toxic metabolic products) with ulcers on the abomasal wall and red streaks on the intestinal walls.</p>	<ul style="list-style-type: none"> • Mortality rate of 10-90%. • Enlargement of of L.Ns, spleen and liver. • Marked anemia, bloody diarrhea and icteric mucous membranes. • The disease may appear in: <ul style="list-style-type: none"> - Peracute form: death within 2-4 days. - Acute form: weakness, decreased milk production and enlargement of L.Ns. - Chronic form: irregular fever, anemia, icterus and severe emaciation.