Veterinary Parasitology

Parasitology

- study of the phenomenon of parasites and parasitism

or

- multidisciplinary aspects of biochemistry, physiology, biology, immunology etc. of parasite
- Parasite: an animal/organism or a plant which lives in or upon another animal/organism ('host') and draws its nutrition directly from it

Animal associations/ relationships

- **Symbiosis:** close association between two individuals where both the partners are dependent on each other. This relationship is always mutually beneficial. Mutualism and commensalism, both come under it.
- **Mutualism:** association between two organisms where each partner gets benefit from the other. One organism inevitably (physiological dependence) depends on the other organism. One partner cannot live without the other.
- **Commensalism:** one partner of this association benefits from other partner but the other partner neither harms nor benefits the other where from it was benefited.
- **Phoresis:** two partners have no metabolic or nutritional relationship. One organism is simply carried by the other organism. The smaller partner is carried by the larger partner. The smaller partner is called as phoront.
- **Predation:** In this relationship one partner lives by eating other partner.

Animal associations/ relationships

- **Parasitism:** obligatory and intimate association between two different (heterospecific) organisms, the parasite takes the benefit from the host leading to the cause of disease or any harmful effect.
- **Parasitosis:** when parasitic infection produces any disease entity comprising clinical Signs.
- **Parasitiasis:** when parasitic infection does not produce any disease entity comprising clinical signs though the organisms are pathogenic.
  - Theileria annulata does not cause disease entity in the indigenous animals
- **Parasitoidism:** The parasites lay their eggs in other organisms. The larvae feed and destroy the organisms.
- **Hyperparasitism:** It is the condition when one parasite parasitize another parasite.
- **Polyparasitism:** mulitple parasitic infection

Different types of parasites

- **Obligatory parasite**: parasite completely dependent on the host during its whole life cycle or a part of its lifecycle.
- **Facultative parasite**: These are those parasites which can live in host body and also can live freely on the environment i.e. they can have both parasitic and free life.
- **Aberrant parasite**: These are parasites which migrate aberrantly in an unusual location.
- **Ectoparasite**: The parasite lives on the body of the host particularly on the skin.
- **Endoparasite:** The parasites live within the body of the host.
- **Mesoparasite** is one which enters and parasitize external orifices/openings of host's body. Example: Otobius megnini in ears of dogs.

- **Monoxenous parasite:** does not require any intermediate hosts or vectors for completion of their life cycle.
- **Heteroxenous parasite:** requires any intermediate hosts for completion of their life cycle
- **Stenoxenous parasite**: parasites which have narrow host range.
- **Euryxenous parasite**: parasite which has a broad host range.
- **Autoheteroxenous parasite**: Same vertebrate animal acts as both definitive and intermediate host of this parasite. E.g. *Trichinella spiralis*
- **Histozoic parasite**: The parasites which live in tissues are called as histozoic parasite.
- **Coelozoic parasite**: The parasites which live in the lumen of the G.I. tract or other hollow part of the organ are called as coelozoic parasite.

- **Oviparous parasites**:- are those whose female lay egg e.g. Ascaris, Ascridia, Ancylostoma and others.
- **Ovo-viviparous parasites**:- are those whose females lay egg which are containing fully developed larvae to hatch e.g. Habronema etc.
- **Viviparous or Larvaeparous parasites**:- are those parasite in which, the eggs are hatched in the uterus of the female and larvae passed out e.g. Filarid worms .
- **Pupiparous parasites**:- are those parasite in which the egg hatch and larvae developed in the uterus and when passed outside they are ready to pup

Hosts

- Hosts are those organisms which harbour other organisms providing shelter, nutrition and other biological or biochemical factors.
- **Definitive host**: host where the parasites attain their sexual maturity.
- **Intermediate hosts**: in which a part of biological development of the parasite occurs but sexual maturity does not occur.
- **Paratenic host or transport host**: When a parasitic stage is simply sheltered by a host and no biological development occurs in it.
- **Reservoir host:** which harbor the organisms without manifesting any disease.

Vector

- arthropods which harbor the parasitic pathogen without any recognizable disease entity and act as a constant source of infection to other animals
- **Mechanical vector**: Vector in which parasite does not multiply or develop and transmits the parasites in the short period.
- **Biological vector**: Vector in which parasites develop or multiply and make it infective for a susceptible host.

Mode of infection of parasites

- Various modes of transmission of parasites or its infective stage:-
- Ingestion
- Transmammary transmission
- Skin penetration(percutaneous)
- Inoculation
- Direct contact
- Venereal transmission
- Congenital (Intrauterine) transmission
- Auto-infection
- Inhalation

- **Ingestion** – hosts get the infection by ingestion of infective stage of parasites (egg or cyst or oocyst or larva) through the infected feed or fish or meat or colostrum or milk or aquatic vegetation or intermediate host or paratenic host.
- **Transmammary Transmission**: Pup may gets the Toxocara canis infection form mother (bitch) through the colostrum/milk.
- **Skin penetration(Percutaneous)** – 3rd stage larva of hook worms, cercaria of Schistosoma species, egg and larva of myiasis causing flies and Trypanosoma cruzi infections.
- **Inoculation** : through blood sucking arthropod vectors- Trypanosoma evansi, Leishmania spp. etc.

- **Direct contact-** mites, lice, flea etc. infestation.
- **Venereal transmission** – by coitus.

  e.g. Tritrichomonas foetus and Trypanosoma equiperdum.
- **Congenital transmission** (Intrauterine or prenatal or Transplacental transmission) – Parasite are transmitted from infected mother to their foetus through the placenta. e.g. Toxocara canis and Ancylostoma caninum in dog

- Auto-infection: – Infected host is re-infected due to reverse peristalsis movement of intestine and other routes
- e.g. Taenia solium in man, Hymenolepsis nana (Dwarf tapeworm), Cryptosporidium spp. etc.
- Inhalation: – e.g. Cryptosporidium spp.,

- **Prepatent period** : period from the day of first or initial infection of a susceptible host to the day of first discharge or demonstration of presence of egg/larva/ microfilaria/cyst of the parasite from the same infected host. Example: 19-22 days in Eimeria bovis in cattle.
- **Patent period :** It is the time or period of patent infection counted from the day of first to the day of last discharge or demonstration of presence of egg/larva/microfilaria/cyst of the parasite in an infected host.
  - Example : 2-3 weeks after the initial discharge of oocysts in Eimeria bovis infection in cattle;
- **Bionorilics of Parasites** : It is the study of external requirements of parasites like temperature, humidity, and surrounding pH including nutrition essential for survival of their free-living stages.

Nomenclature of Parasites

- International Code for Zoological Nomenclature (ICZN), 1904
- The name of the genus of any parasite is uninomial, the species is binomial and the subspecies is trinomial.
- Scientific names are derived from Latin or Greek word.
- The names of the genus and species or subspecies are expressed (printed) in italics or when written are underlined.
- Author of a scientific name of an animal is that who first publishes it. If it is desired to cite the author's name it follows the scientific name. This may be followed, separated by a comma, by the year in which the name was first published.
- Taenia Linnaeus, 1758

Classification of Parasites

- Kingdom
- Subkingdom
- Phylum
- Subphylum
- Class
- Subclass
- Order
- Suborder
- Superfamily
- Family
- Subfamily
- Genus
- Subgenus
- Species
- subspecies

Classification Unit (Taxa)	Suffix to be added in naming	Example
Class	-ea	Sporozoea
Subclass	-ia	Coccidia
Order	-ida	Eucoccidiida
Suborder	-ina	Eimeriina
Superfamily	-oidea	Ancylostomatoidea
Family	-idae	Sarcocystidae
subfamily	-inae	Sarcocystinae

SNOAPAD


SNOAPAD
stands for
Standard Nomenclature of Animal Parasites and Diseases
ABBREVIATIONS

- Guidelines was published in 1988 as the Standardized Nomenclature of Animal Parasitic Disease (SNOAPAD).
- Later, the word ‘ Animal’ was dropped and the ‘SNOAPAD’ is changed to ‘SNOPAD’ to denote all parasitic diseases.

Guideline of SNOPAD is as follows –

- The suffix –**osis (plural= oses)** is to be added to the stem of the names of the parasite taxon by the omission of the last one or two letters-

Taxonomic name of parasite	Addition of suffix	Disease name
Trypanosoma	Trypanosom + osis	Trypanosomosis
Fasciola	Fasciola +osis	Fasciolosis

- By adding –osis in the genitive name where taxa end with –x in the nominative .

Genitive name of parasite	Nominative name of parasite	Addition of suffix	Disease Name
Demodex	Demodicis	Demodic +osis	Demodicosis

- By adding –osis in the full generic name of the parasite.

Generic Name of Parasite	Addition of Suffix	Disease Name
Hepatozoon	**Hepatozoon+ osis**	**Hepatozoonosis**

Methods of dissemination of parasites

- Infective stages of parasite are disseminated by

- Water
- Aquatic vegetation
- Arthropods vectors
- Direct contact
- Animals transport
- Meat export or import
- Natural calamity

Specificity of parasites in tabulated form

Specificity	Name of disease/parasite etc.
Type of host	*Gigantocotyle explanatum* only occurs in buffalo.
Breed specificity	Trypanotolerant animals (N- Dama, Lagune) are resistant against *Trypanosoma spp.* The indigenous breeds are resistant against many parasites however cross breed animals are susceptible to many parasitic diseases. Red masai sheep is resistant against *Haemonchus spp.* However many other sheep are susceptible to *Haemonchus spp.*
Sex specificity	The female cattle suffer more from *Tritrichomonas foetus.* The males suffer less and act as the carriers. *Trichomonas vaginalis* invariably occurs in the female.
System specificity	*Trypanosoma gambiense* and *T. rhodesiense* affect the nervous system.
Organ specificity	Some parasites affect only the organ/organs of the system. The whole system is not affected. *Fasciola spp* affect liver and bile duct.
Cell specificity	*Theileria* schizonts occur in the lymphocytes.
Location specificity	*Eiemria bombayansis* occurs in Bombay.

Parasitic immunity

- Different parts / stages of parasites used as antigen

1. Cuticle or tegument - Outer covering of parasite is used as antigen.
2. Subcellular fraction - Flagellar antigen of Trypanosoma spp
3. Excretory - secretory antigen - Metabolic byproduct and other excretory - secretory material is used as antigen.
4. Eggs - Eggs of parasites are used as antigen.
5. Larva - The antigen can be prepared from the larva of the parasite.
6. The moulting fluid can be used as antigen.

- **Innate immunity** - The immunity or defense which is naturally present in the body is called as innate immunity
- **Acquired immunity** - The immunity which is acquired by natural or artificial means.
- **Active immunity** - Immunity which occurs as a response of administration of an antigen.
- **Passive immunity** - It is passive transfer of immunity from immune individual to unimmune individual.
- **Humoral immunity** - It is antibody mediated immunity. B lymphocytes play predominant role in this immunity.
- **Cell mediated immunity** - It is the immunity which is mediated by lymphocytes, macrophages, N. K. cells and other immune cells and not by antibody.

- Sterilising immunity - The immunity which remains still in absence of organisms after any infection has taken place is called as sterile immunity.
  - infection of coccidiosis, the immunity remains in absence of the organisms
- Premunity - This is a type of immunity which occurs when the parasites are present in the host. In other way, it is called as premunity, which is elicited only in presence of parasite. Immunity wanes in absence of the parasites.
  - Preimmunity is found in Babesia and Theileria infection.

- Cross immunity - The immunity elicited by one organism can also protect other organism is called as cross immunity. Immunity against Fasciola parasite can also protect amphistomes.
- Concomitant immunity - The immunity which occurs against invading larva but not against existing infection.

Veterinary Parasitology

General Harmful Effects of Parasites

- Anorexia, decreased growth rate, poor milk yield, anestrus
- Utilization of host's food- Diphyllobothrium latum absorb Vitamin B12 from the host which result pernicious anaemia
- Feeding on the host materials
- Diarrhoea or Dysentery
- Haemorrhage
- Granuloma formation: Schistosoma nasale caused cauliflower like growth in nasal mucosa of infected host.
- Itching, alopecia, dermatitis
- Anaphylactic reaction: Rupture of Hydatid cyst of Echinococcus granulosus may results anaphylactic reaction.
- Abortion:- Tritrichomonas foetus causes bovine abortion in cattle whereas Toxoplasma gondii causes abortion in sheep and women.
- Flea allergy dermatitis

Specific Tissues lesions Caused by the Parasites

- Submandibular Oedema (Bottle jaw): Fasciola, Amphistomes, Haemonchus contortus, Hook worms etc. infection.
- Pipe stem liver: during fasciolosis, the walls of the bile ducts are generally calcified and protrude markedly from the surface and are difficult to cut with a knife. They resemble the stem of a clay pipe, giving the common name of Pipe stem liver to the infection.
- Cauliflower like Granulomatous lesions: e.g. Schistosoma nasale
- Cholangiocarcinoma: tumor of bile ducts due to Clonorchis sinensis (Chinese liver fluke) infection.
- Pimply gut: due to Oesophagostomum spp. (Nodular worm) infection.

- Milk spot lesions in liver: due to Ascaris suum infection in pig.
- Stenosis of the aorta or malignant tumour in the oesophagus/osteosarcoma (golf ball size lesion) : due to Spirocerca lupi infection in dog.
- Nurse cell: First stage larvae of *Trichinella spiralis* via blood reach to the striated (Skeletal) muscles where they are encapsulated by the host, grow and assume characteristic coiled position. Parasitised cells are called **nurse** cell.



- Chronic dermatitis (hump sore) in cattle : due to *Stephanofilaria assamensis* infection.
- Enlargement of **superficial lymph nodes** (Prescapular lymph nodes) : due to *Theileria* spp. infection.
- Punched necrotic ulcers in abomasum: due to *Theileria annulata* infection.
- Dollar spot: due to *Trypanosoma equiperdum* infection in horse.
- Haemorrhagic typhlitis: due to *Eimeria tenella* infection in poultry.
- Corneal opacity: due to *Trypanosoma evansi* and *Ehrlichila canis* infection in dog.

General Control Measures of Parasitic Infections

- Chemotherapy
- Immunological control
- Biological Control
- Intermediate hosts control:
  - CuSO 4 is used to kill the mollusca
  - Gambusia fishes are used to kill the mosquito larvae
- Pasture management
- Managemental control
- Genetic control

- Chemotherapy (Antiparasitic drugs) is still considered as the most important control measures against parasitic infections.
- Anthelmintics
- Insecticides
- Acaricides
- Antiprotozoal drugs

Anthelmintics	Effective against
Fenbendazole	**Usually Nematodes and tapeworms**
Praziquantel	**Tapeworms & Schistosomes**
Oxyclozanide	***Fasciola* spp. (Liver fluke) and Amphistomes**
Triclabendazole	***Fasciola* spp.**

- Insecticides : Act against insects (Flies, lice, ticks , mites etc.) e.g. D.D.T., Cypermethrin, Deltamethrin etc.
- Acaricides : Drugs which act against ticks and mites. e.g. Amitraz, Deltamethrin etc.

Antiprotozoal drugs	Effective against Protozoa
Buparvaquone (Butalex)	*Theileria* spp. (Theileriosis)
Quinapyramine sulphate and Quinapyramine chloride (Triquin)	*Trypanosoma* spp. (Trypanosomosis)
Isometamedium chloride	*Trypanosoma* spp.
Diminazene aceturate	*Babesia* spp. (Babesiosis), *Trypanosoma* spp., *Theileria* spp.
Imidocarb	*Babesia spp.*
Metronodazole	*Entamoeba* spp. (Amoebic dysentery)

Immunoprohylaxis

Commercial available vaccines	Used for the parasitic disease
Raksha vac-T	Theileriosis
Coccivac	Poultry coccidiois
Livacox	Poultry coccidiois
TickGard	*Boophilus microplus* tick
Gavac	*Boophilus microplus* tick
Dictol	*Dictyocaulus viviparous*

Genetic control

- To develop genetically parasite resistance animals.
- Examples-
- N’ Dama cattle is resistance to trypanosomiosis.
- Red Massai sheep is resistance to haemonchosis.
- Garole sheep is resistance to fasciolosis.
- Our Desi breed of cattle i.e. Bos indicus is resistance to Theileriosis

TYPES OF LIFE-CYCLES

- **Simple life-cycle:** parasite simply multiplies by binary fission both in its vertebrate host and its insect vector for its propagation in nature. Example : Trypanosoma spp.
- **Complex life-cycle:** alternation of both asexual and sexual processes of reproduction in the life cycle of a parasite. Example : all helminth parasites; malarial parasites and other parasitic protozoa etc.
- **Direct life-cycle:** does not involve any intermediate host between the parasite and its host. Example: strongylid nematodes.
- **Indirect life-cycle:** involves necessarily one or more intermediate hosts or vector(s) to complete its life cycle. Example: all digenetic trematodes, many other helminths, blood protozoan parasites etc.

- **Direct type of life cycle**: intermediate host or any vector is not required for completion of the life cycle of the parasite. Example: Eimeria sp.
- **Indirect type of life cycle:** one or two intermediate hosts are required for completion of the life cycle.
  - Involvement of one intermediate host This is a type of life cycle whereby one intermediate host is required for completion of the life cycle. Example: Taenia solium requires one intermediate host (pig) for completion of it's life cycle.
  - Involvement of two intermediate hosts: This is a type of life cycle whereby two intermediate hosts are required for completion of the life cycle of the parasite. Example: Diphyllobothrium spp requires two intermediate hosts first is cyclops and second is fish)
- **Homogonic life cycle:** This is a type of life cycle whereby the parasite does not develop to the adult stage in the environment. Example : parasitic cycle of Strongyloides spp

- **Heterogonic life cycle:** This is a type of life cycle whereby the parasite develops to the adult stage (sexually matured parasite) in the environment and the subsequent stages (offsprings) of the parasite infect the host which develops to adult stage later on in the host. Example: Strongyloides sp.
- **Zoonotic life cycle:** In this life cycle, parasites transmit from animals to man or from man to animals. Example: Taenia solium
- **Simple life cycle:** The parasites increase their number by simple propagation or multiplication. Example : Trypanosoma spp.
- **Complex life cycle:** In this life cycle, both sexual and asexual cycles occur. Example: Eimeria spp.

Important parasites and their common names

Name of parasite	Common name
Toxocara canis	Arrow headed worm
Toxascaris leonina	Arrow headed worm
Enterobius vermicularis	Pin worm or Seat worm
Stephanurus dentatus	Kidney worm
Syngamus trachea	Gape worm or Y-shaped worm
Ancylostoma caninum	Hook worm of dog
Ancylostoma tubaeforme	Hook worm of the cat
Ancylostoma braziliense	Hook worm of dog
Aneylostoma duodenale	Hook worm of man
Agriostomum vryburgi	Hook worm of zebu (*Bos indicus*)
Necator americanus	Hook worm of man
Bunostomum trigonocephalum	Hook worm of sheep and goat
Bunostomum phlebotomum	Hook worm of cattle
Gaigeria pachyscelis	Hook worm of sheep and goat
Globocephalus longemucronatus	Hook worm of pig
Bathmostomum sangeri	Hook worm of elephant
Haemonchus contortus	Stomach worm, wire worm, barber's pole worm
Dictyocaulus filaria	Lung worm of sheep and goat
D. viviparus	Lung worm of cattle
D. arnfieldi	Lung worm of horse and donkey
Metastrongylus elongatus	Lung worm of pig
Filaroides osleri	Lung worm of dog
Aelurostrongylus abstrusus	Lung worm of cat
Thelazia rhodesii, T.gulosa,	Eye worm of cattle
T. lacrymalis	Eye worm of horse
T. callipaeda	Eye worm of dog
Oxyspirura mansoni	Eye worm of fowl

Name of parasite	Common name
Dirofilaria immitis	Heart worm
Dracunculus medinensis	Guinea worm, Dragon worm, Medina worm, Serpent worm
Acanthocephala sp	Thorney headed worm
Thysanosoma actinioides	Fringed tape worm
Hymenolepis nana	Dwarf tape worm
Gigantocotyle explanatum	Biliary amphistome
Paragonimus westermanii	Lung fluke
Dicrocoelium dendriticum	Lancet fluke
Prosthogonimus pellucidus	Oviduct fluke
Chlonorchis sinensis	Chinese liver fluke
Fasciola gigantica and F. hepatica	Common liver fluke
Fasciola jacksoni	Liver fluke of elephant
Schistosoma spp	Blood fluke
Menopon gallinae	Shaft louse of poultry
Menacanthus stramineus	Body louse of poultry
Cuclogaster heterographus	Head louse of poultry
Lipeurus caponis	Wing louse of poultry
Goniocotes gallinae	Fluff louse of poultry
Haematopinus eurysternus	Short nosed cattle louse
Linognathus vituli	Long nosed cattle louse
Cimex lectularius	Bed bugs, Cone nosed bugs, Kissing bugs or Assassin bugs
Echidnophaga gallinacea	Sticktight flea of poultry
Tunga penetrans	Jigger or chigoe
Xenopsylla cheopis	Oriental rat flea
Simuliidae	Black fly
Ceratopogonidae	Biting midges, punkies, no see ums
Psychodidae	Sand flies or owl midges

Name of parasite	Common name
Tabaneidae	Horse fly or Breeze fly
Musca domestica	House fly
Stomoxys calcitrans	Stable fly
Haematobia irritans	Horn fly
Glossinidae	Tse tse fly
Calliphoridae	Blow fly
Callitroga hominivorax	Screw worm fly
Callitroga macellaria	
Cordylobia anthropophaga	Tumbu fly
Sarcophaga spp	Flesh fly
Oestrus ovis	Sheep nasal fly
Hypoderma lineatum	Ox warble fly
Hippobosca spp	Forest fly, ked
Melophagus ovinus	Sheep ked or tick fly
Dermanyssus gallinae	Red mite of poultry
Otobius megnini	Spinose ear tick
Ixodes ricinus	Castor bean tick
Ixodes scapularis	Shoulder tick or black legged tick
Boophilus decoloratus	Blue tick
Rhipicephalus appendiculatus	Brown ear tick
R. evertsi	Red legged tick
Haemaphysalis leachi leachi	Yellow dog tick
Dermacentor nitens	Tropical horse tick
Amblyomma hebraeum	Bont tick
A. variegatum	Variegated tick or Tropical bont tick
Trombiculidae	Hervest mite or Chigger mite
Pediculoides ventricosus	Grain itch mite
Cytodites nudus	Tongue worm

Name of pathological conditions / symptoms etc

Name of pathological conditions / symptoms	Brief description
Clay pipe stem liver	It is a condition of bile duct occurring in the chronic fasciolosis. The highly calcified bile duct protrude out from the surface of the liver and are difficult to cut by the knife. The bile duct looks as if, like a hard pipe. This condition is called as clay pipe–stem liver.
Hazel- nut- sized cyst condition	This condition occurs due to aberrant migration of the immature fluke of *Fasciola hepatica* in the lungs. Here they form the hazel-nut-sized cysts filled up with a brownish purulent gelatinous material within which living or dead parasites remains.
Black disease	In normal healthy sheep, *Clostridium oedematiens novyi* occurs. But these organisms produce the disease when the liver is damaged by the acute fasciolosis and the organisms take the advantage of the animals under stress condition. The condition of fasciolosis is further aggravated.
Salmon poisoning or Elokomin fluke fever.	It is caused by the rickettsial agent named *Neorickettsia helminthosa* transmitted by *Nanophytes salmincola.*
Snoring disease	Granulomatous growth in the nasal cavity and proliferation of nasal epithelium leads to cauliflower-like appearance which occurs due to deposition of granulamatous tissues and the deposition of the tissue is initiated by the eggs which release some kind of soluble antigen which are the enzymes present in the miracidium.
Clam digger's itch / Hunter's itch / gale des nageurus / badedermatitis / rice paddy itch / lake side disease	This is a condition which is occurred due to allergic reaction caused by the penetration by the cercariae of non-human schistosomes into the human skin. There is severe dermatitis associated with pruritus. This situation does not occur when the individual gets first exposure of cercariae but in the subsequent events different anomalies comprising dermatitis occur.

Name of pathological conditions / symptoms	Brief description
Gid or staggers	A condition which occurs due to development of coenurus cyst in the brain of sheep and goat. There is pressure atrophy of skull and the skull becomes thiner and thinner with the advancement of the condition which may even lead to perforation of the skull. There is hyperaesthetic condition of the animals. The animals move in a circle and and show jerky or staggering gait.
Pernicious anaemia	It is caused due to deficiency of Vit B-12 in human beings resulting from competition between the parasite and hosts. In other words it could be told that the parasites assimilate the host's Vit B -12 and cause the hosts deficient from this vitamin.
Cerebral cysticercosis or neurocysticercosis	Human being is the definitive host of *Taenia solium*. But sometimes, man may act as an intermediate host and formation of cysticercus occurs in the brain. The infection occurs by ingestion of eggs of *Taenia solium* along with the food or by autoinfection.
Hump sore	It is a chronic verminous dermatitis in hump region of cattle caused by *Stephanofilaria assamensis* in the Indian Subcontinent.
Milk - spot	Due to infection of *Ascaris suum*, white spots appear in the liver and these spots are formed by varying degrees of fibrosis which is stimulated by the migrating larvae.
Husk or hoose disease	This is mainly caused by *Dictyocaulus viviparus* infection in cattle. Extensive damage occurs in lung and the animals exhibit the clinical signs of coughing, dyspnoea. Harsh respiratory sound is heard due to emphysematous crackling in lungs.

Name of pathological conditions / symptoms	Brief description
Cutaneous habronemiasis / Granular dermatitis / Summer sore / Bursati.	This condition is caused by deposition of larvae of *Habronema sp* and *Draschia sp* in existing wound by the infected flies. Eye region is mainly affected. Wort-like lesions are found mainly in the nictating membrane or surrounding tissue.
Sore head	It is a filarial dermatitis occurring in sheep by *Elaeophora schneideri*.
Hump sore	It is a chronic verminous dermatitis in cattle caused by *Stephanofilaria assamensis* in the Indian Subcontinent. This parasitic condition is highly prevalent in West Bengal, Assam and other north-eastern states of India.
Enzootic cerebrospinal nematodiosis	It is caused due to migration of larvae of *Setaria digitata* and other *Setaria* sp. in the brain resulting in acute focal encephalomyelomalacia and other associated pathognomoic condition like meningitis, encephalitis and meningoencephalitis.
Ocular onchocercosis or river blindness	It is the pathological condition of eye of man characterized by keratitis, conjunctivitis and periodic opthalmia etc caused by *Onchocerca volvulus*.
Miliary dermatitis	This condition occurs in cats due to hypersensitive reaction caused by flea. The clinical conditions are associated with formation of small papules. The condition is further aggravated by scratching to alleviate pruritus.
Sweet itch, Sweat itch or Summer dermatitis, Queensland itch	In warm summer climate horses and ponies suffer from a condition of seasonal dermatitis. It is caused by the bite of *Culicoides* flies leading to an allergic reaction.

Name of pathological conditions / symptoms	Brief description
Strike	Strike is a myiasis condition which occurs on the skin of sheep due to deposition of larvae. In the sheep, in some areas of the body surface, skin-folds are found. In this fold, water is trapped which acts as a good medium for growth of bacteria. Due to this bacterial growth a typical smell is produced which attracts the blow flies. The blow flies deposit larvae and aggravate the condition further which is called as strike.
Tail strike	Strike which occurs on the tail.
Breech strike	The strike which occurs on the breech region.
Pizzle strike	This is a srike condition which occurs in the rams and wethers of sheep. The sheath of the ram is affected and the area is soiled by urine.
Poll strike	This situation occurs in the region of horn close to the head.
Body strike	The strike which occurs in the body of the animal is called body strike.
Cutaneous myiasis	This myiasis occurs in the skin of the back region of the animal due to ox warble fly, *Hypoderma lineatum* and *H. bovis.*
Opthalmomyiasis	This myiasis occurs in the eye region caused by *Rhinoestrus purpurensis.*
False gid	This condition is caused by larval stage of *Oestrus ovis* in nasal cavity. The clinical signs are associated with restlessness, in coordination, high stepping gait and circling movement or interrupted straight movement.

Parasites in Definitive Hosts.

MODES OF INFECTION	NAMES OF INFECTIVE STAGES (For Definitive Hosts)	EXAMPLES (Names of Parasites)
1. Through ingestion of (with food and water)		
a. Direct from the environ!llent	**a. Metacercariae** (encysted on vegetation near _water collections)	-*Fascia/a* spp., Amphistome flukes etc.
	b. Cysticercoids (including self-infection and also auto-infection in man)	*Hymenolepis nana*
	c. Infective nematode eggs (having L_2 stage larva in each egg)	*Ascaris* spp. and other ascarid and trichurid nematodes etc.
	d. Infective L3 stage namatode larvae (during grazing on infected pastures)	*Haemonchus contortus* and other strongylid nematodes etc.
	e. Infective sporozoites (inside sporulated oocysts/ sporocysts of coccidian parasites)	Coccidia including *Sarcocystis* spp. and *Toxoplasma gondii* etc.

	f. Infective cysts	Parasitic amoebae, *Balantidium coli*
b. Invertebrate Intermediate Hosts (IH)	**a. Metacercariae** (encysted in IH viz. ants, grass hoppers, snails, fish etc.)	*Dicrocoelium dendriticum*, *Eurytrema pancreaticum*, *Echinostoma* spp., *Opisthorchis* spp. etc.
	b. Cysticercoids (develop in IH viz. grass mites, beetles, louse, house flies, earthworms etc.)	Tapeworms classified under Orders Anoplocephalidea and Davaineidea
	c. Infective L3 stage nematode larvae (develop in IH viz. beetles, house flies, stable flies, cockroaches, fish etc.)	*Spirocerca lupi* and other spirurid nematodes etc.
c. Invertebrate Vector	**Sporozoites** (develop in nymphs and adults of hard tick - *Rhipicephalus sanguineus*)	*Hepatozoon canis*
d. Vertebrate Intermediate Hosts	**a. Metacestodes** i. Cysticercus, Strobilocercus, Coenurus, Hydatid cysts (develop in striated muscles, tissues and organs of cattle, pig, sheep, goat, rodents, wild ruminants, lagomorphs etc.)	*Taenia* spp., *Echinococcus* spp.
	ii Tetrathyridium (pl.-dia) (develop mostly free in peritoneal cavity of dogs, cats, mice, birds, reptiles, amphibia etc.)	*Mesocestoides* spp.

	iii. Plerocercoids (dev lop in body of fish) (develop in water snakes, birds, mice, and mammal)	*Diphyllobothridium latum* *Spirometra* spp.
	b. L_1 **stage nematode larvae** (encapsulated in skeletal muscles of pig, wild bar, deer etc.)	*Trichinella spiralis*
	c. Infective bradyzoites (develop inside sarcocysts/tissue cysts in muscles, tissues, organs of cattle, sheep, goat, pig, horse etc.)	*Sarcoci;stis* spp., *Toxoplasma gondii*
	d. Infective **Nymphal stage** (develop in viscera of herbivore animals, rodents etc.)	*Linguatula serrata* (Tongue worm)
e. Paratenic/ Transport Hosts	**Infective nematode larvae** (migrating/settled)	*Toxascaris leonina, Stephanurus dentatus, Syngamus trachea* etc,
2. Through Skin Penetration (Percutaneous)	**a. Furco-cercous cercariae**	a. Blood-flukes of Family Schistosomatidae
	b. Infective L_3 stage nematode larvae	b. Hookworms of Family Ancylostomatidae and *Strongyloides* spp.
3. Through inoculation of Infective stages by blood sucking arthropods (Vectors)	**a. Infective L_3 stage nematode larvae** **b. Trypomastigotes** **c. Promastigotes** **d. Sporozoites**	a. All filarial nematodes b. *Trypanosoma* spp. c. *Leishmania* spp. d. All haemosporozoan parasites (species of *Plasmodium, Babesia, Theileria, Leucoci;tozoon, Haemoproteus* etc.)
4. Through Inhalation	**Infective sporozoites** inside sporulated oocysts	*Cryptosporidium baileyi* in chicken, turkey etc.
5. Trans-uterine/ Intra-uterine/ Prenata"l	**a. Migrating L_2 stage nematode larvae** **b. Migrating L_3 stage nematode larvae** **c. Tachyzoites** in pseudocysts	a. *Toxocara canis* b. *Ancylostoma caninum* c. *Toxoplasma gondii*
6. Trans-mammary/ Trans-colostral	**a. Migrating L_2 stage nematode larvae** **b. Migrating I3 stage nematode larvae**	a. *Toxocara canis, T. cati, T. vitulorum* b. *Ancylostoma caninum*
7. Through sexual coitus	**a. Trophozoites** **b. Trypomastigotes**	a. *Tritrichomonas foetus* b. *Trypanosoma equiperdum*
8. Through direct body contact and migration of parasitic stages to the animal body from the surrounding habitats	Developmental stages and adults	Lice, Sheep ked, ticks, and mange mites

Different important systems of parasites

- Digestive system: tape worms digestive system is completely absent. Takes nutrition from whole body surface
- Treamtodes: oral sucker, pharynx, oesophagus and two blind caecae.
- Nematodes: mouth, buccal capsule, oesophagus, intestine and anus
- Amoeba: food material is taken into the food vacoule and the excreta is excreted through one opening which is called as cytopyge.
- Respiratory system Respiratory system is absent in cestodes, trematodes, nematodes and protozoa.
- Excretory system: Excretion is performed by flame cells in cestodes, trematodes and by pored osmoregulatory system in nematodes.
- Nervous system Very simple type of nervous system is present in cestodes, trematodes and nematodes.

Reproductive system

- Cestodes: Hermaphrodite or bisexual or 'Monoecious parasites' because of both sex organs (male and female) are in the same individual
- Treamtodes: Hermaphrodite except Schistosoma spp which are unisexual. **Female parasite is carried by the male parasite during the time of copulation.**
- Nematodes: Unisexual or 'Dioecious parasites'

Description of different intermediate stages of parasites

- Trematodes:

- E-M-S-R-C-M

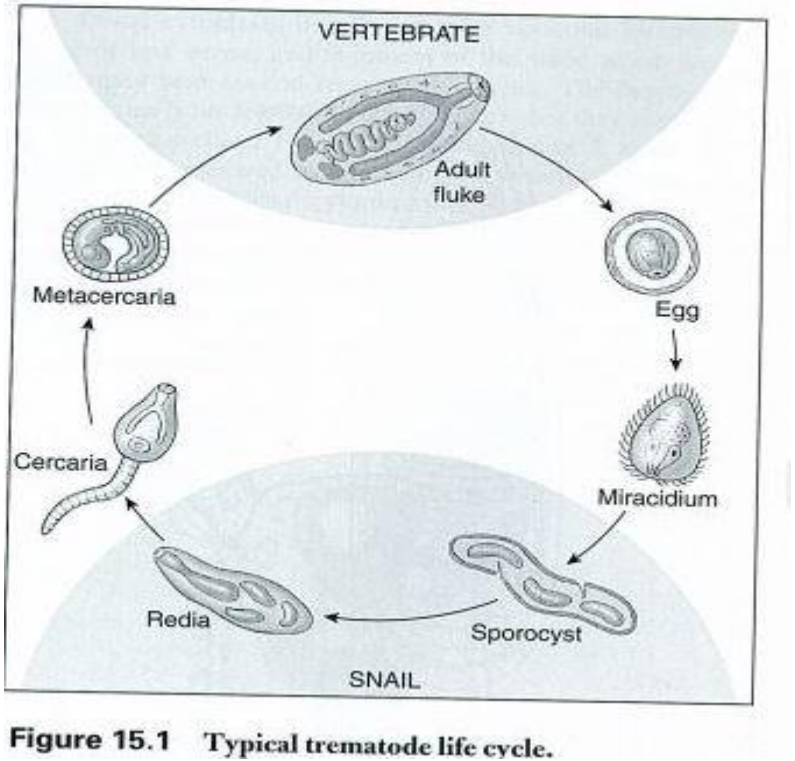


Figure 15.1 Typical trematode life cycle.

- Trematode
- Egg: mostly oval. The colour may be yellowish Fasciola spp) , transparent or colourless(amphistomes), grayish or brownish(Dicrocoelium spp).
- The eggs of some trematodes are operculated.
- The eggs may be elongated (Schistosome)

- Miracidium: embryo within egg develop to miracidium.
- either may hatch out in the environment or hatching occurs after the egg has been ingested by intermediate host (aquatic snail).
- The miracidium is actively motile. It has one prominent anterior spine and the body is ciliated.

- Sporocysts: third stage of biological development of trematode.
- Redia: develops in the sporocyst in many numbers. The redia has several birth pores through which many cercariae are released.

- Cercaria: Most of these are tailed. The shape of cercaria and length of tail are variable. Tail may be short, long or bifurcated(Schistosoma spp). In some cercariae, pigment is present which are called as Cercaria pigmentata.
- Metacercaria: Metacercaria is the encysted form of cercaria. Cercaria looses its tail and encyst either on grass blades, aquatic vegetation or in the intermediate host.

Cestodes

- Egg: Eggs have got several coverings like outer envelope, inner envelope and oncospheral membrane. In some species (Taenia spp) there is another one protective covering which is called as embryophore.
- Embryophore is striated in Taenia spp. In the oncosphere there are presence of six hooklets remaining in three pairs. That's why embryo of cestode is called as hexacanth embryo.
- Most of the eggs are round.
- After hatching the oncosphere comes out. migrate into different organs like lung, liver, heart and diaphragms where these lead to form different cysts. These cysts are also called as bladder worms or metacestodes.

Different bladder worms/cysts/ metacestode

- Cysticercoid
- Cysticercus
- Hydatid cyst
- Coenurus
- Strobillocercus
- Procercoid
- Plerocercoid

Nematodes

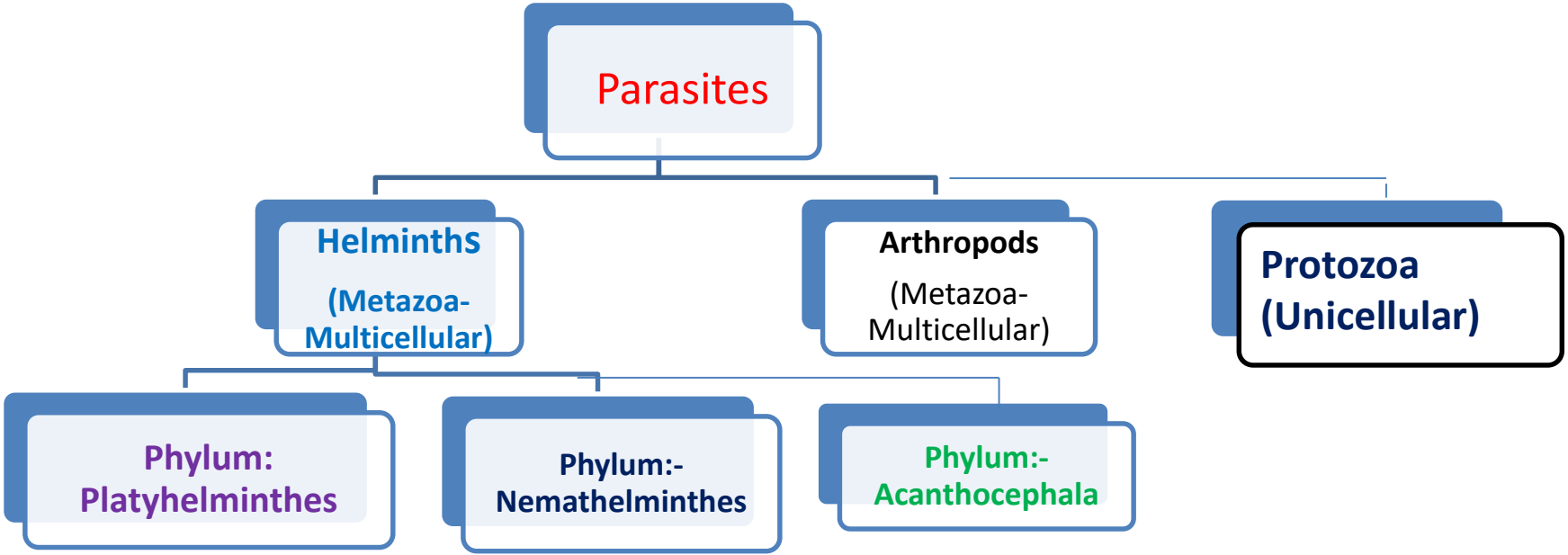
- Egg
- Larva
- Adult

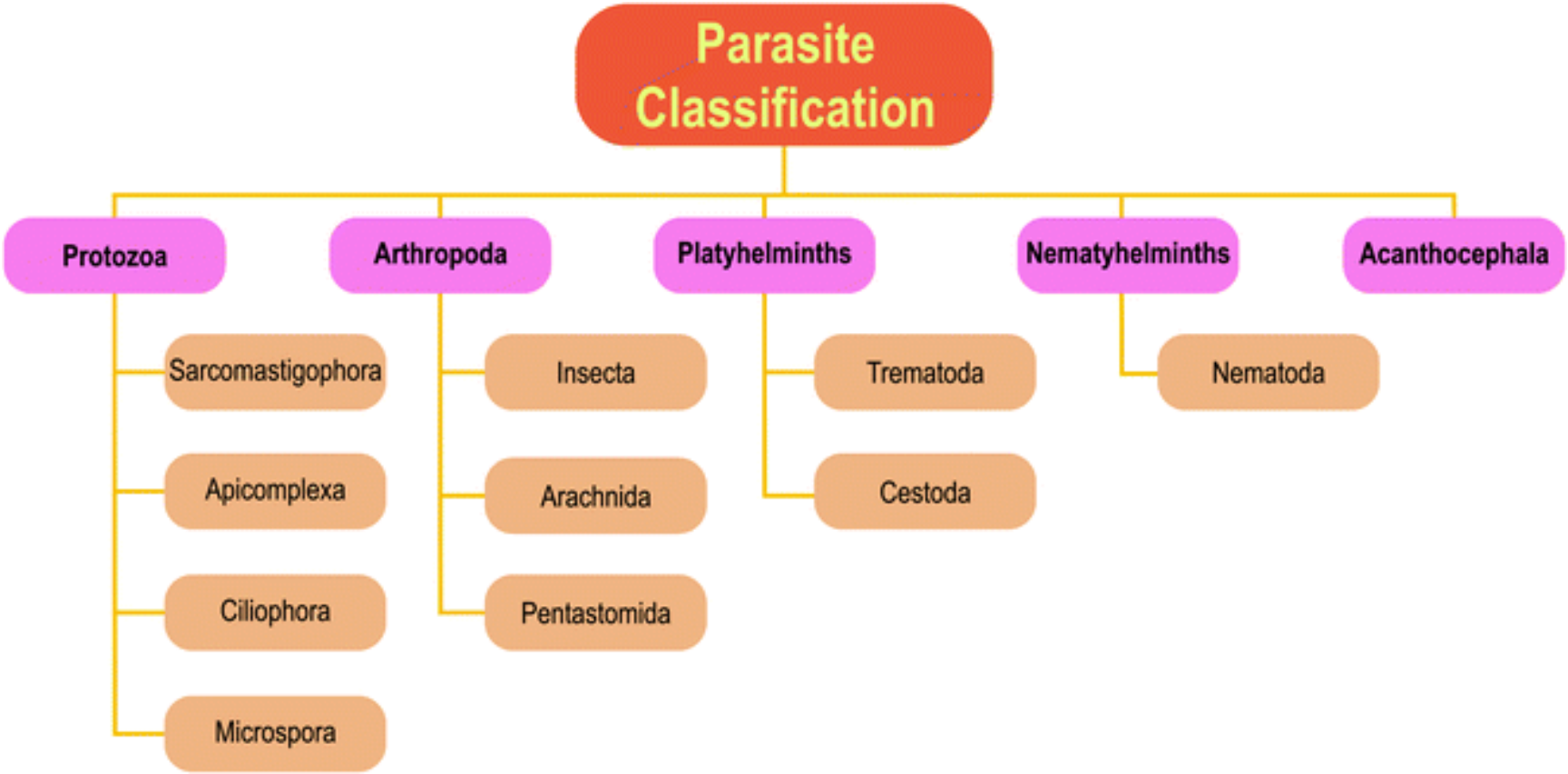
Protozoa

- Oocysts /Cysts: In some protozoa sporulated oocysts (coccidian parasites) and cysts (Amoeba) are the infective stages. The oocysts contain two or four sporocysts. Each sporocyst contains two or four sporozoites.
- When the sporulated oocysts are ingested by the host, these are affected by enzyme (trypsin), bile, C02 and some other biochemical factors and the sporozoites come out.

- Sporozoites: elongated organisms which are motile and can penetrate through the cell membrane and enter within it
- Trophozoites: rounded up sporozoites
- Schizonts The nucleus of the trophozoite split up into several particles. Each particle takes a part of cytoplasm and ultimately becomes individual organism. Thus a number of organisms are produced in the cell from a single trophozoites. This is called schizont.
- Merozoites: The organisms present in the schizont are called merozoites. Schizont bursts and merozoites come out.
- Gametes: After formation of second generation schizonts the merozoites are transformed into macrogametes
- Tachyzoites /Bradyzoites These are developmental stages which are found in Toxoplasma and Sarcocystis spp.

- **Parasites are eukaryotic organisms.**



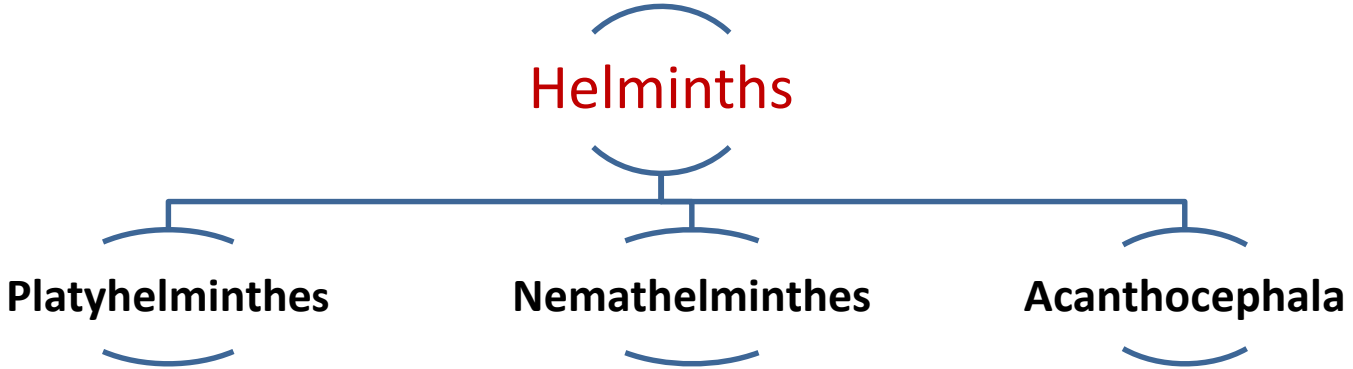

Parasite Classification
Protozoa
Arthropoda
Platyhelminths
Nematyhelminths
Acanthocephala
Sarcomastigophora
Apicomplexa
Ciliophora
Microspora
Insecta
Arachnida
Pentastomida
Trematoda
Cestoda
Nematoda

GENERAL CLASSIFICATION OF PARASITES

- Parasites, in general,are grouped as
  - Metazoans (multicellular) and Protozoans (unicellular).
  - Metazoan parasites are (1) Helminth parasites and (2) Arthropod parasites,
  - protozoan parasites are classified under the sub-kingdom protozoa.

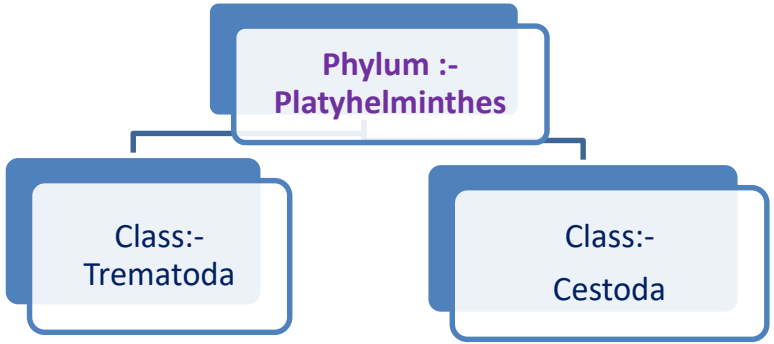
Salient Characters of Phylum: Platyhelminthes

- ✓ Helminth word has been derived from a Greek word helmins or helminthos which means a worm.
- ✓ Helminths (worms) are mainly endoparasites.



Helminth Parasites

- Platyhelminths and nematohelminths
- Phylum : Platyhelminthes The worms are usually dorso-ventrally flattened and commonly called flatworms .
- These are either leaf-like or oval/globular (fluke parasites) grouped under a Class – Trematoda
- or are very elongate tape-like (tapeworms) grouped under two Classes - Eucestoda (true tapeworms} and Cotyloda (fish tapeworms).
- All flat worms are hermaphrodite. Flat worms are also called 'Monoecious parasites' because of both sex organs (male and female) are in the same individual except for blood flukes
- Solid bodies without a body cavity (acoelomate)



	Trematodes	Cestodes
Common name	Flukes	Tape worms
Body segmentation	Absent	Present
Alimentary canal	Present	Absent
Operculum in egg	Usually operculated egg	Usually non- operculated egg

Platyhelminthes are hermaphrodite. These include:

(a) Trematodes

(b) Cestodes

Nemathelminthes includes:

(a) Nematodes

Nematode	**Trematode**	**Cestode**
Round worm	Flat worms	Tapeworms
Spindle shaped	Leaf shaped	Ribbon shaped
No segment	No segment	Segmented
Unisexual	Hermaphrodite	Hermaphrodite
Alimentary canal present	Present	Absent

Class: Trematoda

Order:- Digenea

Family:-

Family	Genus
Dicrocoelidae	***Dicrocoelium*** **(Lancet Fluke)**
Fasciolidae	***Fasciola*** **(Liver fluke) ,** ***Fasciolopsis***
Paramhistomatidae	***Paramhistomum, Cotylophoron, Gigantocotyle, Gastrothylax, Gastrodiscus*** **etc.**
Paragonimidae	***Paragonimus*** **(Lung fluke)**
Prosthogonimidae	***Prosthogonimus*** **(Oviduct fluke)**
Opisthorchidae	***Opisthorchis***
Schistosomatidae	***Schistosoma*** **(Blood fluke)**
Notocotylidae	***Notocotylus, Ogmocotyle***

Class Trematoda

- There is only one sub-class Digenea of veterinary importance
- Most fluke parasites are hermaphrodite but blood flukes, classified under the family Schistosomatidae, are unisexual and elongate.
- Life-cycle of all trematodes is indirect involving one or more intermediate hosts.
- In all cases, the first or the only one intermediate host is a species of snail. The second intermediate host, if any, may be an ant, grasshopper, fish, dragon fly, snail, frog or some crustaceans.

Sucker

- There are generally two suckers (Oral & ventral suckers) which serve as organ of attachment.
- flukes have a ventral sucker near middle or in upper half of the body - distomes (e.g. Fasciola gigantica)
- muscular sucker towards the posterior end known as acetabulum - amphistomes (e.g. Paramphistomum cervi).
- There are also few other types of flukes which do not have any secondary sucker but for an oral sucker. These are called monostomes (e.g. Notocotylus attenuatus)

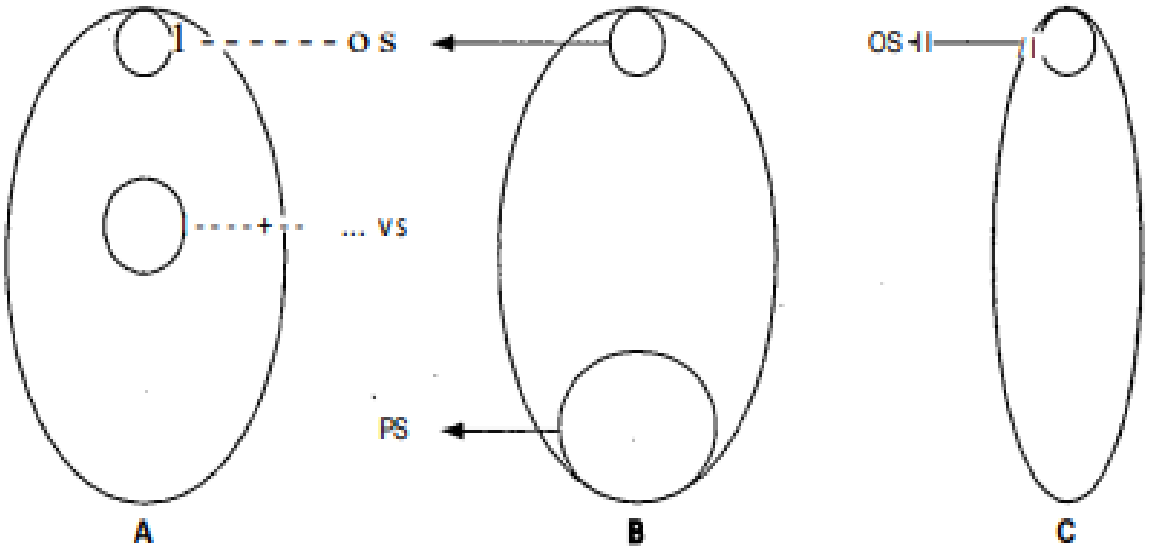
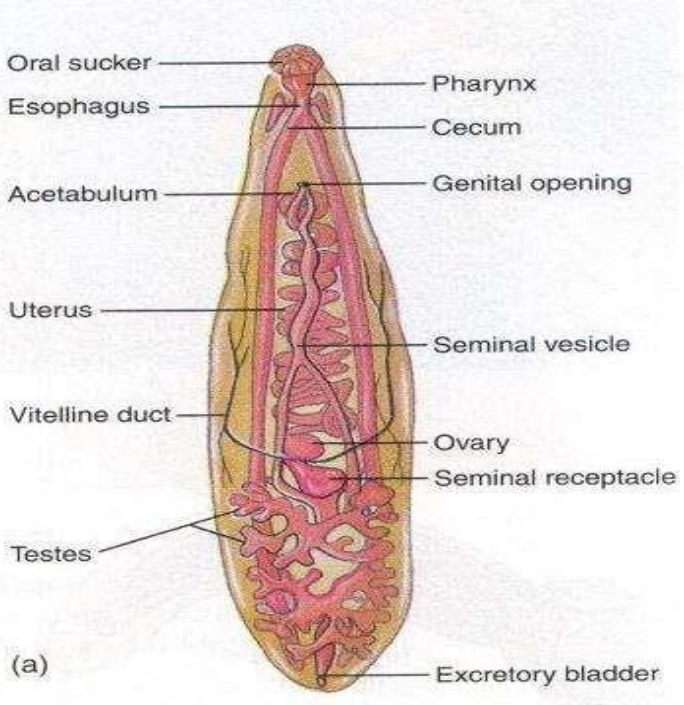
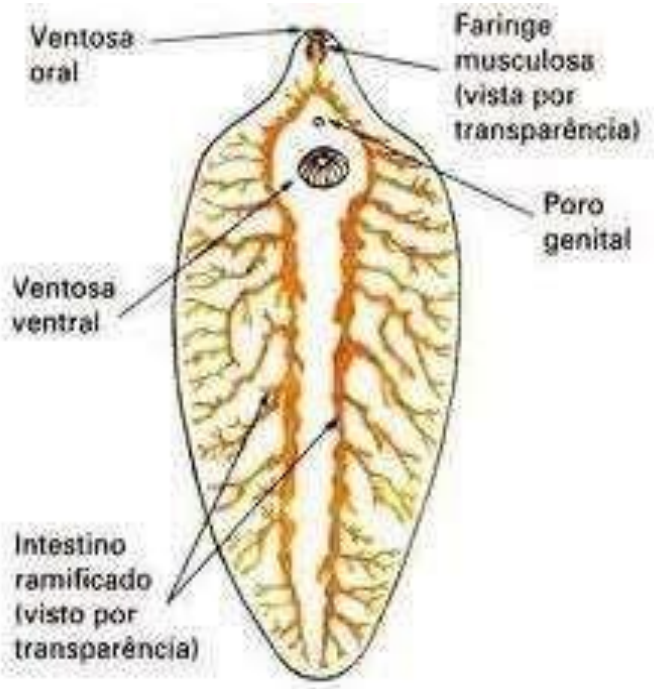


Fig. 1. Types of digenetic trematodes. A. Distome ; B. Amphistome ; C. Monostome.OS = Oral sucker; VS= Ventral sucker; PS= Posterior sucker (aceiabulum)

Body Systems

- The body surface of trematodes comprises a tough syncitial tegument.
- There are no respiratory organs.
- The mouth opens into a muscular, pumping pharynx, connects via a short oesophagus.
- There is no anus, and waste material must be egested through the mouth.
- The excretion occurs mostly through the tegument, Some of the species of trematodes possess an excretory system, which consists of two or more protonephridia.
- The brain consists of a pair of ganglia in the head region, from which two or three pairs of nerve cords.
- Trematodes generally lack any specialized sense organs.
- Most trematodes are hermaphrodites.
- Egg are generally operculated or lid at one pole except blood fluke eggs which are non-opercualted.


Oral sucker
Esophagus
Acetabulum
Uterus
Vitelline duct
Testes
(a)
Pharynx
Cecum
Genital opening
Seminal vesicle
Ovary
Seminal receptacle
Excretory bladder


Ventosa oral
Ventosa ventral
Intestino ramificado (visto por transparência)
Faringe musculosa (vista por transparência)
Poro genital

Life- Cycle of Trematodes (FLUKES)

- Life- cycle is always indirect involving snail as intermediate host.
- First Intermediate host always snail and 2nd Intermediate host may be snail or other species.

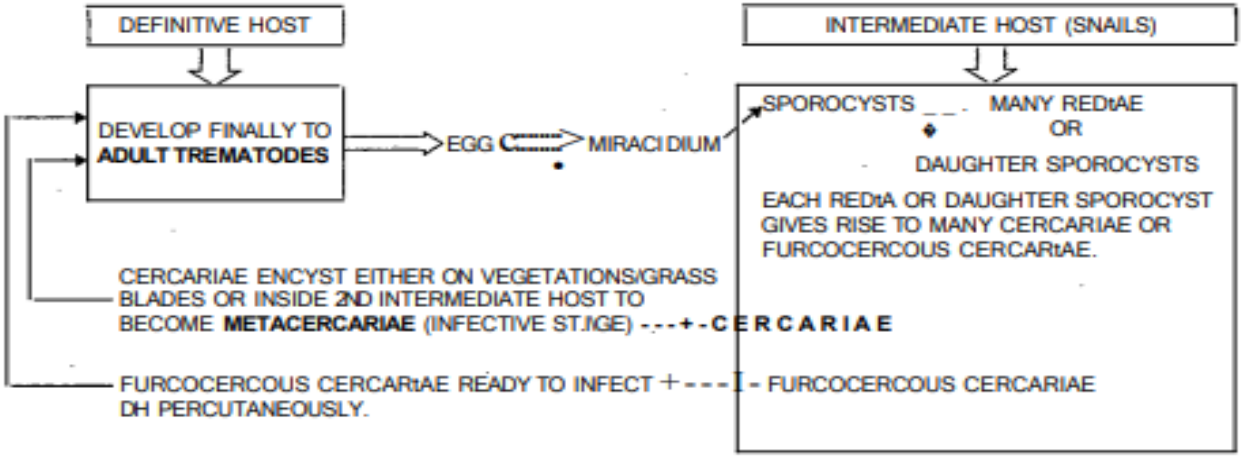


Fig. 2. Life-cycle of Digenelic Trematodes

Egg → **Miracidium**

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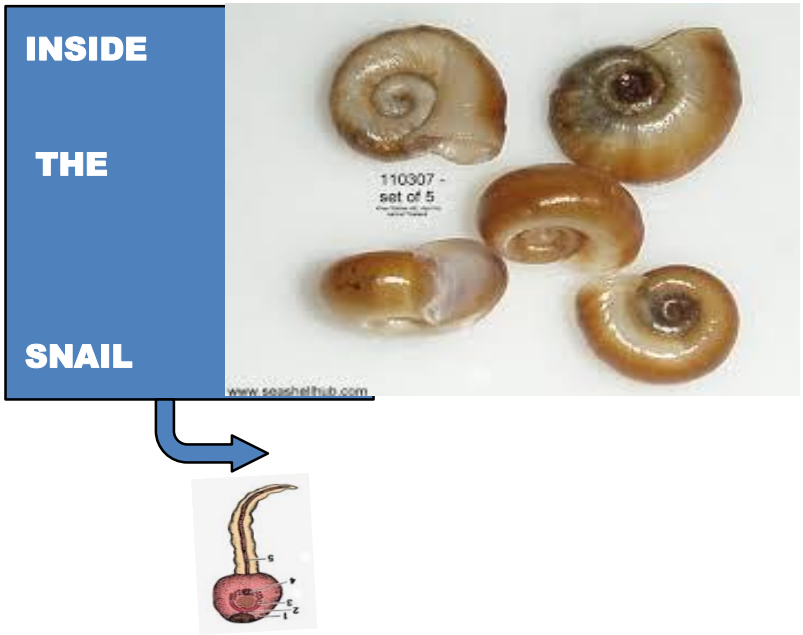
Sporocyst

↓

Redia

↓

Cercariae



cercaria emerge from the aquatic snail and encyst on aquatic vegetation or enter inside 2nd intermediate host & form Metacercaria.

Trematodes

- Phylum- Platyhelminthes
- Class- Trematoda
- Subclass- Digenea
- Families of importance
- Fasciolidae
- Dicrocoeliidae
- Opisthorchiidae
- Paramphistomatidae
- Schistosomatidae
- Prosthogonimidae
- Paragonimidae

Fasciolidae

- Important genera
  - Fasciola: F. hepatica & F. gigantica
  - Fasciolopsis
  - Fascioloides
  - Parafasciolopsis

Genus: Fasciola

- *Fasciola hepatica* is one of the largest flukes in the world.
- The Adult Worms are 30mm in length and 13 mm in width.
- The adult worm has a very characteristic leaf shaped body with the anterior end being broader than the posterior end and an anterior cone-shaped projection.
- The fluke possesses a powerful oral sucker at the end the anterior cone and a ventral sucker at the base of the cone which allow it to attach to the lining of the biliary ducts.
- Each worm possesses ovaries and testes which are highly branched and allow for individual flukes to produce eggs independently.
- The eggs of *Fasciola hepatica* are operculated and average 140 μm in length and 75 μm in width.
- *Fasciola jacksoni*: Liver fluke of Elephant

Difference between *F. gigantica* and *F. hepatica*

Fasciola gigantica	***Fasciola hepatica***
1. The parasite is larger in size.	1. This parasite is smaller in size.
2. The anterior cone is smaller.	2. The anterior cone is larger.
3. The shoulder is not broad.	3. The shoulder is broader than *F. gigantica*.
4. Duration of life cycle is long in definitive host.	4. The duration of life cycle is short in definitive host.
5. The intermediate hosts are *Lymnaea rufescens* and *L. auricularia*.	5. The intermediate hosts are *Lymnaea tomentosa* in Australia and *L. bulimoides* in North America and in Asia *Lymnaea truncatula*.
6. The duration of development in the snail is long.	6. The duration of development in the snail is short compared to the *F. gigantica*.
7. The flukes are abundant in tropical countries.	7. The flukes are abundant in temperate countries.
8. The amount of isoenzyme, Glutathione S–transferase present in these fluke is much.	8. The amount of Glutathione S - transferase present in these fluke is less.

Fasciola: Life cycle

- The Immature eggs are discharged in the biliary ducts and passed in the faeces.
- After hatching the miracidia released from the eggs, which invade a suitable snail, the intermediate host .
- In the snail the parasites undergo several developmental stages e.g sporocysts, rediae , and cercariae.
- The cercariae are released from the snail and encyst as metacercariae on aquatic vegetation or other surfaces.
- Mammals acquire the infection by eating vegetation containing metacercariae.
- After ingestion, the metacercariae excyst in the duodenum and migrate through the intestinal wall, the peritoneal cavity, and the liver parenchyma into the biliary ducts, where they develop into adults .
- The adult flukes reside in the large biliary ducts of the mammalian host.
- *F. hepatica* flukes can infect various animal species, mostly herbivores.

- Hosts - Cattle, sheep, goat and other ruminants. Elephant, horse, pig, dog and cat are also affected by the parasite.
- Site -Bile duct and liver
- Disease /pathological conditions caused - Fasciolosis, Liver fluke disease, liver rot
- Prevalence - The parasite is very commonly available. These are cosmopolitan in distribution.
- Definitive host - sheep, goat, cattle and other ruminants.
- Intermediate host - Lymnaea trunmcatula, L. auricularia, L. blllimoide., L. nifesceno., L. luteola etc.
- Pathological features /lesions: Peritonitis, hepatitis, hyperplastic cholangitis, pipe stem liver condition, hazel nut cyst formation

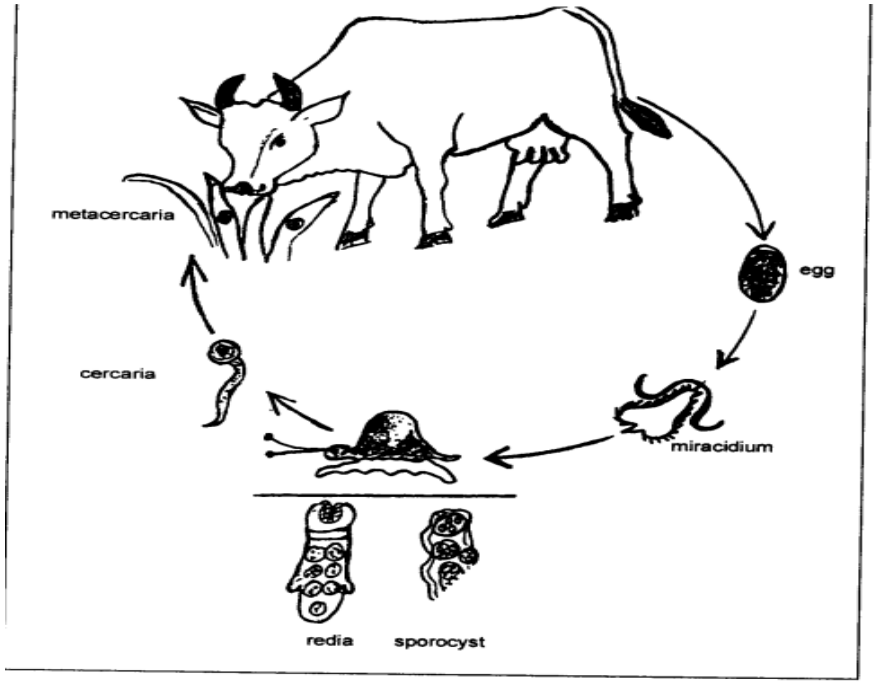


Fig. 2. Life cycle of Fasciola spp.

Bottle Jaw

- Due to massive hyperplaSia in the epithelium of the bile duct, there occurs alternation of selective permeability and the plasma protein is drained out from the bile duct wall.
- It ultimately leads to the hypoproteinimic condition due to alternation of colloidal osmotic pressure.
- Because of this, the fluid comes out from the tissues and results in formation of oedema.
- The fluid comes out where loose skin is available. The submandibular oedema is common.

Clinical Signs

- Acute Phase: sheep dies suddenly due to migrating fluke in the liver exhibiting the clinical signs like anthrax.
  - Blood mixed with froth comes out from nostril and rectum and other natural orifices.
- Chronic Phase: loss of vigor, anemia, pale mucous membranes, constipation and diarrhea

Diagnosis

- Faecal examination: oval, operculated and yellow



- Enzyme estimation - Enzyme estimation (Glutamate dehydrogenase and Glutamyl transpeptidase) is the indicative step for diagnosis of the disease.
- ELISA test is also diagnostic test of choice using Cathepsin L as antigen
- Sandwich ELISA is performed for early detection of infection.

- The pathological feature caused by Fasciola parasite becomes more aggravated due to concurrent infection of Clostridium oedematiens/ novyi causing Black disease
- The parasite sometimes accidentally enters into the lung of cattle and other hosts and it causes great problems due to formation of hazel nut-sized cysts.
- Diarrhoea of fasciolosis is not principally by Fasciola but because of complication with some gastrointestinal nematode like Oestertagia and other species.

Genus :Fasciolopsis

- Species: *Fasciolopsis buski*
- Location: Small intestine
- Host: Man and Pig
- Identification

  1. The ventral sucker is extremely large in comparison to the oral sucker.

  2. Intestinal caeca is not branched as is found in F. hepatica and F. gigantica

Intermediate host - Segmentina spp.

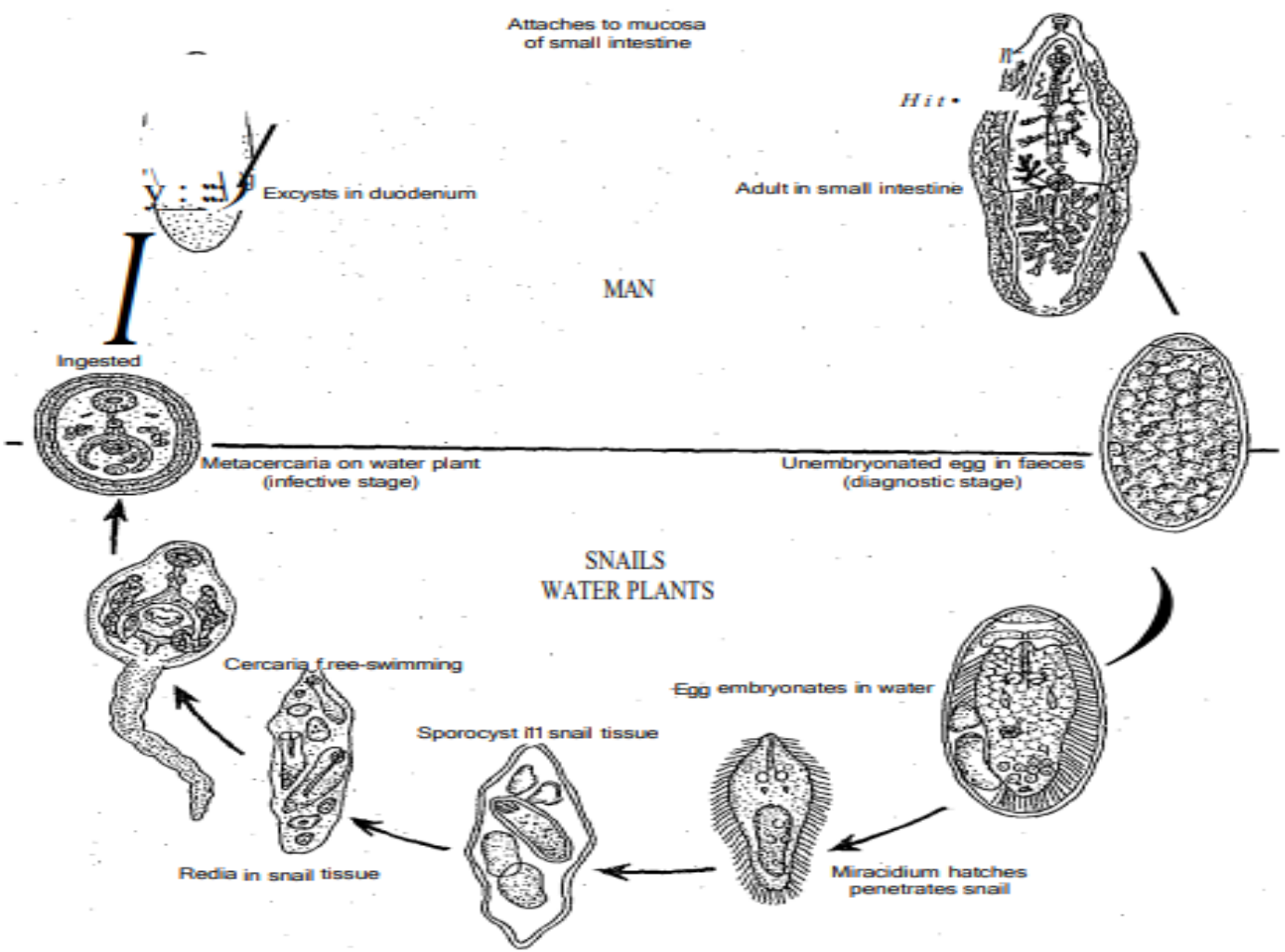


Fig. 13. Life-cycle of Fascio/opsis buski.

Fasciolopsis : Prevention & control

- Properly wash then cook all aquatic plants well before eating.
- Never eat raw aquatic plants like Water hyacinth
- In endemic areas, prevent fecal contamination (from pigs) of water where aquatic plants are grown.
- Do not feed raw aquatic plants to pigs.

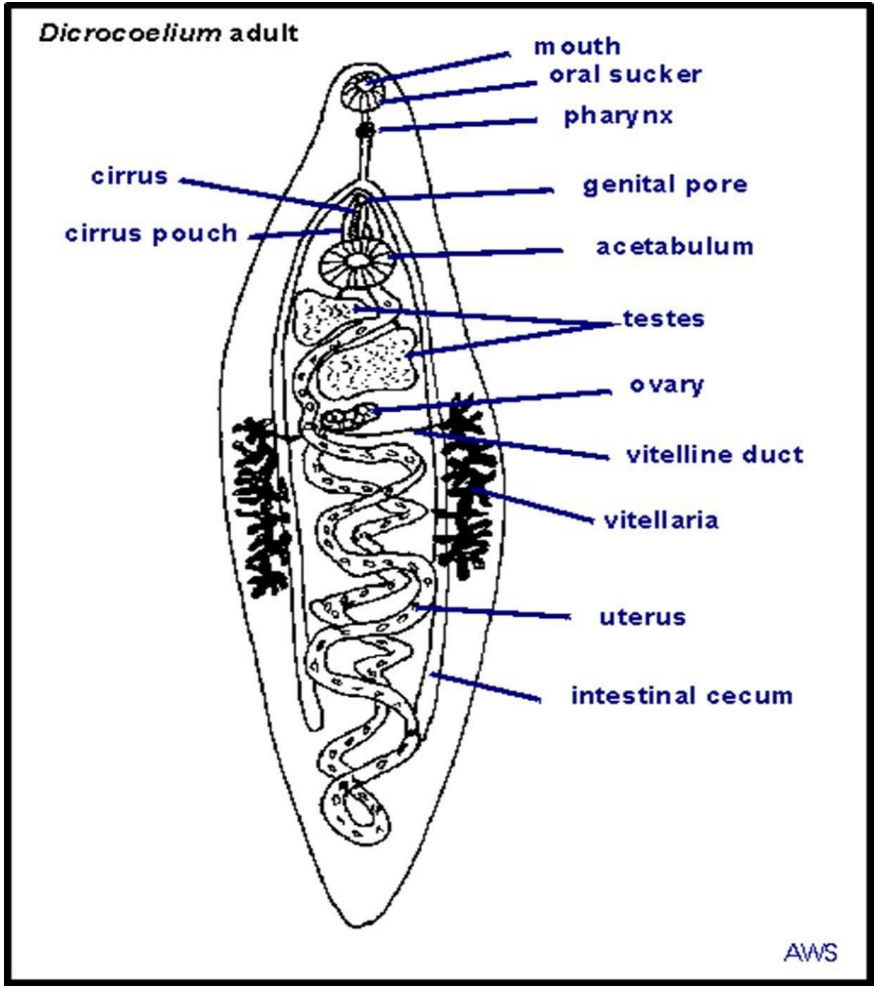
Genus - Fascioloides

- Species - *Fascioloides magna*
- Site / location - Liver
- Host - Cattle, sheep
- Intermediate host – Fossaria spp.

Genus - Dicrocoelium

- FAMILY - DICROCOELIIDAE
- Family - Dicrocoeliidae
- Genus - Dicrocoelium
- Species
  - *Dicrocoelium dendriticum*
  - *D. hospes*
- Common name - Lancet fluke
- Prevalence - Worldwide in distribution
- Seat of predilection - Bile duct, liver, gall bladder and pancreas. Of these, the most common site is bile duct and liver.

1. The parasite is small and lancet- shaped. That's why this is called the lancet-fluke. The length is more or less 1 cm.
2. The flukes are soft and partially transparent except the uterus and other genital parts which look dense. The transparent and the dense areas are clearly visible by naked eye's examination.
3. Two suckers are present, the oral being the smaller than the ventral.
4. Posterior to the ventral sucker, there is presence of a pair of testes. Testes are at tandem in their position.
5. Posterior to the testes ovary is present.
6. Vitelline glands are present in the lateral field of the parasite
7. The eggs are operculated and brown in colour.


Dicrocoelium adult
mouth
oral sucker
pharynx
cirrus
genital pore
cirrus pouch
acetabulum
testes
ovary
vitelline duct
vitellaria
uterus
intestinal cecum
AWS

Life cycle

- Definitive host - Sheep, goat and cattle
- Intermediate host
- 1st intermediate host is land snail i. e. Zebrina detrita and Cionella lubrica.
- In India the important snail - hosts are Macrochlamys cassida and Luastenia.
- 2nd intermediate host is ant (Formica fusca)
- Developmental stages
- Egg • Miracidium • Sporocyst (2 generations) • Cercaria followed by metacercaria and adult
- Note : Redia stage is absent.

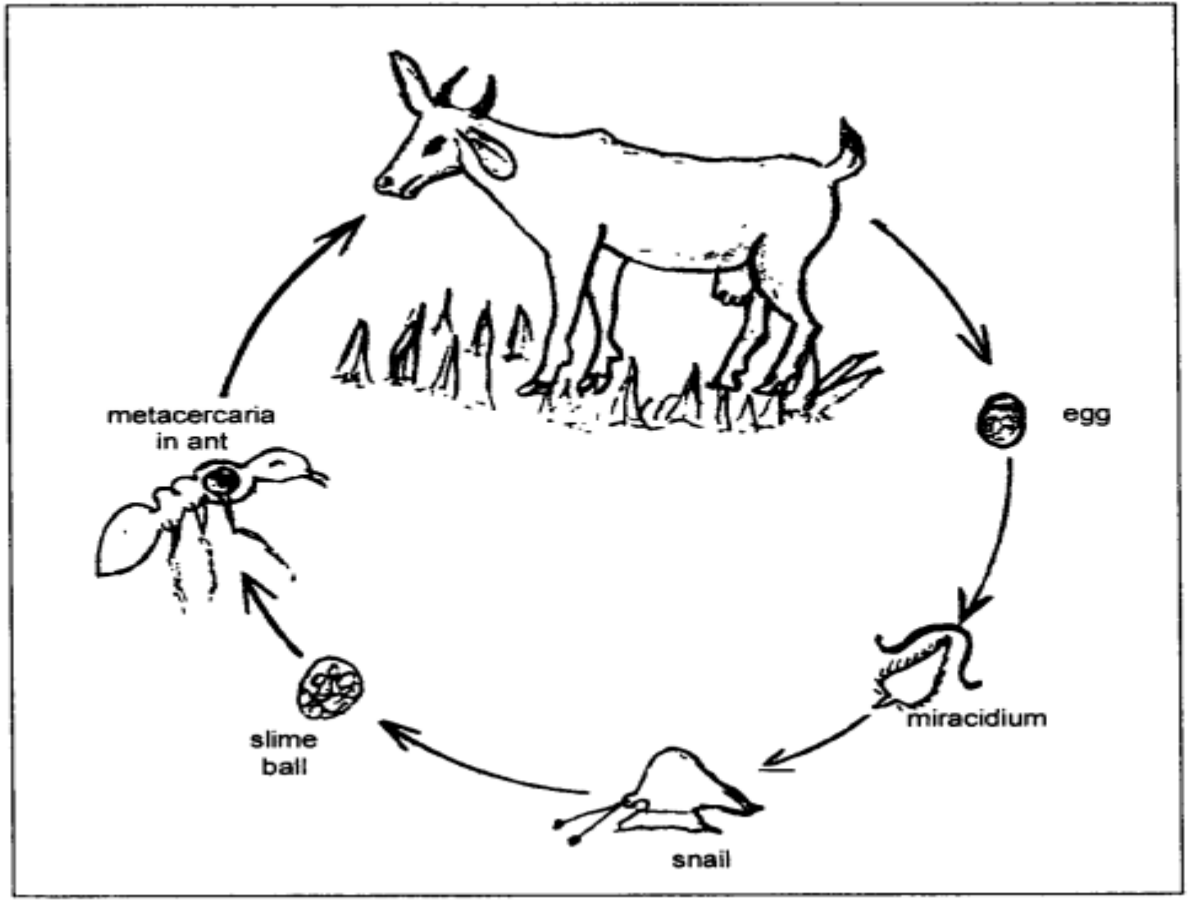


Fig. 4. Life cycle of Dicrocoelium spp.

Life Cycle

- 1. Eggs are voided out of the host.
- 2. Eggs hatch after being ingested by the land snail.
- 3. In the 1st intermediate host, miracidium transports into sporocyst in the hepatopancreas.
- 4. Sporocyst gives rise to second generation of sporocyst. The second generation of sporocyst produce cercaria directly without formation of redia. The cercaria is named as Cercaria vitrina having a stylet and tail.
- 5. Cercaria remains in the gelatin -like material which is called as slime-ball. In a slime-ball there remains 200 - 400 cercariae .
- 6. The slime balls are attractive to the ants and are ingested by the ants.
- 7. In the ants metacercariae are formed.
- 8. Final host gets the infection by ingestion of the infected ants along with feed (grass and other vegetation).

Pathological features / conditions Cholangitis, cholangiectasis, portal cirrhosis

- 1. The seat of predilection of the parasite is bile duct. Therefore, most of the pathological features occur in the bile duct.
- 2. In the chronic phase, deposition of fibrous tissue occurs which leads to the hyperplastic condition of the bile duct.
- 3. Biliary stasis which is pathognomoically called cholangiectasis occurs due to aggregation of large number of parasites in the lumen of tile bile duct
- 4. Portal cirrhosis is the common pathognomoic feature found in the chronic phase of the disease. The cirrhosis spreads very characteristically which starts from the portal triad and spreads interlobularly and perilobula rly later on. And eventually this affects the whole part of the liver
- Migration of the immature fluke does not occur in the liver as is found in Fasciola parasites.

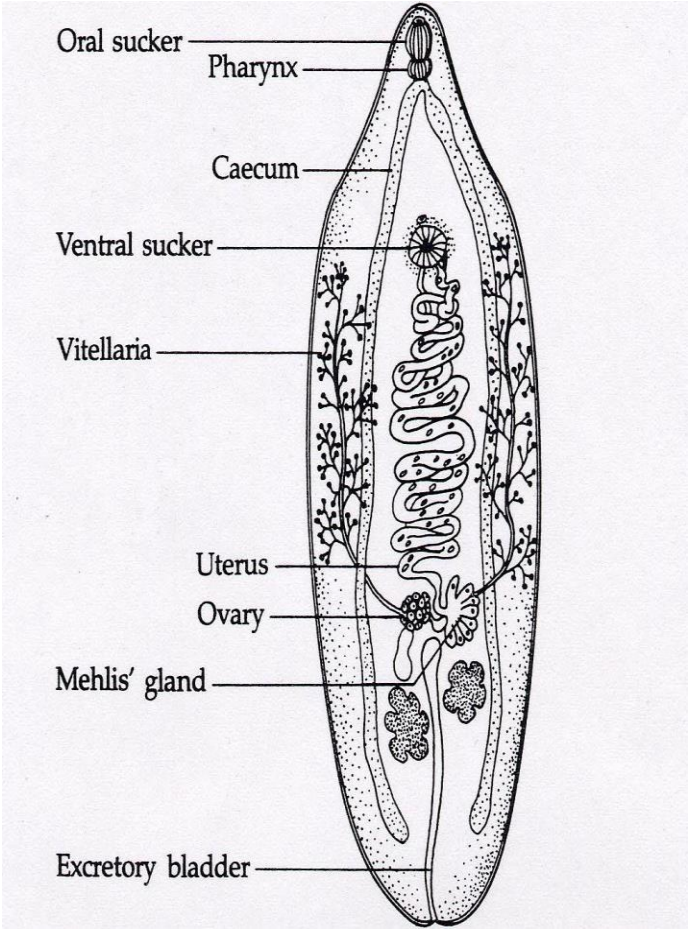
FAMiLY - OPISTHORCHIIDAE

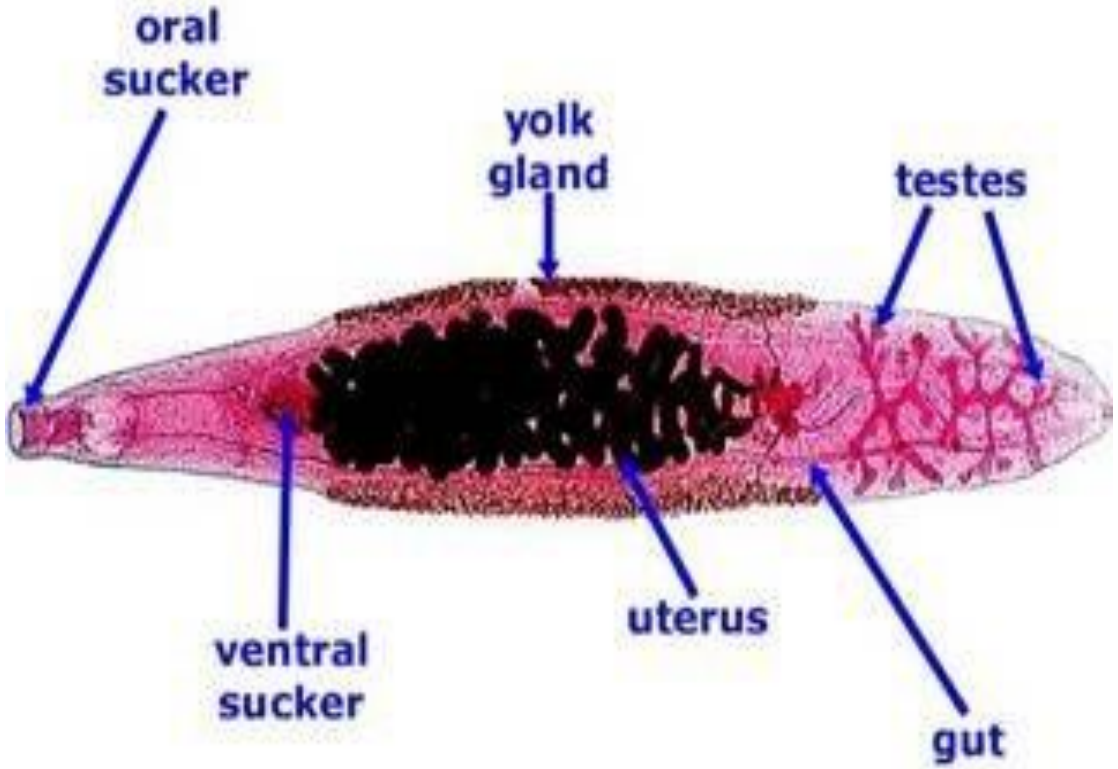
- small to medium-sized distomes occurring in the bile duct and gall bladder of the mammals and birds etc.
- Opisthorchis spp will rank third position if comparison is made among Fasicola, Dicrocoelium and Opisthorchis in terms of pathology.
- History / Discovery: In Calcutta *Chlonorchis sinensis* was first recorded in the bile duct of a Chinese carpenter by McConnellin in the year 1875.
- Chinese Liver Fluke

- Genus Opisthorchis & Chlonorchis
- Species of opisthorchis
  - *O. tenuicollis*
  - *O. viverrini*
  - *O. caninus*
  - *O·felineus*
  - *O. noverca*
- Species of Chlonorchis: *C. sinensis*
- Site-Bile duct and liver
- Note - *Chlonorchis sinensis* is called as Chinese liver fluke.

Opisthorchis : Morphology

- dorsoventrally flattened like a leaf and transparent.
- A typical individual is 7 mm long and 1.5 mm wide.
- Oral and ventral sucker present
- The two testes are lobed and connected to the Seminal vesicle, which is a coiled tube running up to the ejaculatory duct, which in turn opens through a small opening called Genital pore just in front of the ventral sucker.
- Two ovaries are situated in front of the testes, and they form several lobes. The uterus runs along the ejaculatory duct and opens at the genital pore.
- A sac-like S-shaped tube called Excretory bladder is, in between the two testes.
- The remaining body spaces are mostly occupied by a highly branched glandular organ called Vitellaria or Vitelline glands.
- Operculated eggs

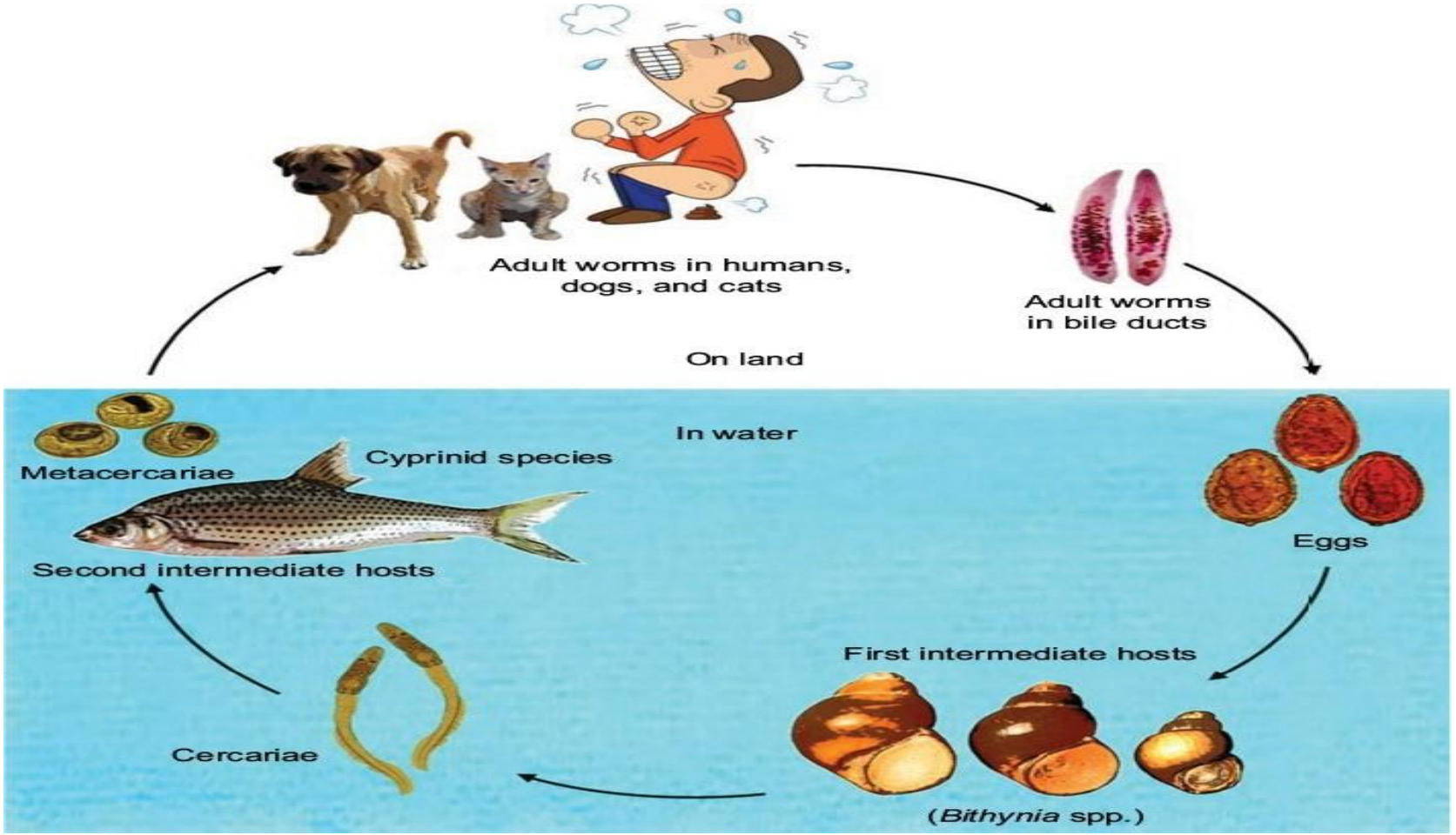




Opisthorchis : Parts of the body

Life Cycle

- 1. The eggs are expelled out of the host.
- 2. The eggs are hatched after being ingested by the snail (Bithynia sp.).
- 3. In the snail, the eggs hatch and the miracidium comes out. The miracidium further transforms into sporocyst. The sporocyst gives birth to one redial generation.
- 4. Cercaria is formed from the redia which are tailed and posseses pigmented eye-spots.
- 5. The cercaria penetrates the fish (Cyprinidae family). The cercaria has affinity to transform into the metacercaria on the base of the fin of the fish.
- 6. The final host gets the infection by ingestion of the infected raw, uncooked or undercooked fish.


Adult worms in humans, dogs, and cats
Adult worms in bile ducts
On land
In water
Metacercariae
Cyprinid species
Second intermediate hosts
Eggs
First intermediate hosts
(Bithynia spp.)
Cercariae

- Pathological features /lesions Cholangitis, cholangiocarcinoma, biliary stasis
- Control
- 1. Treatment of the affected animals.
- 2. Uncooked or undercooked fish should not be allowed to clogs.
- 3. Control of the intermediate hosts (snails) by using the molluscicidal agents.

FAMILY -PARAMPHISTOMATIDAE

- The fluke under this family, are mainly found in the rumen and reticulum so it is known as “ruminal fluke” or “Conical fluke” of ruminant
- One species found in the bile duct of buffalo and rarely in cattle. i.g. Gigantocotyle explanatum
- The disease amphistomosis, immature amphistomosis in particular, is one of the major disease of ruminants in India is next to fasciolosis
- There are eight genera of veterinary importance viz., Paramphistomum, Cotylophoron, Gastrothylax, Fischoederius, Carmyerius, Gastrodiscus, Gastrodiscoides and Pseudodiscus.

- These flukes are thick, having fleshy body and are mostly conical.
- The testes are usually lobed and anterior to the cavity.
- The intestine caeca are simple.
- The intermediate host is aquatic snail.
- The flukes are common in Indian subcontinent.
- These are thick and circular in transverse section.
- Body is conical or oval in shape.
- Pharynx is absent
- The life-cycle of these amphistomes is indirect involving snails as intermediate hosts.
- Eggs - operculated

Genus	Species	Host	Location	Intermediate host
Paramphistomum	***P.cervi***	Ruminant	Rumen and reticulum	*Indoplanorbis exustus*
	P. epiclitum	Camel	do	Do
Cotylophorum	***C. cotylophorum***	Ruminant	Do	do
	C.Indicum	do	do	do
Caliphoron	***C.calocophorum***	do`	do	*Pygmanisus spp.*
Gastrothylax	***G. crumenifer***	do	do	*gyraulus*
fischoederius	***F.Elongatus***	do	rumen	*Lymaea luteola*
Carmyerius	***C.gragarious***	Cattle, buffalo	Stomuch , rumen	
Gigentocotyle	***G.explanatum***	Ruminants	bile duct and gall bladder.	*Gyraulus.*

Gastrodiscus	***G.secundus***	Horse, elephant	colon	*I.exustus*
	G.aegyptiacus	Horse , pig	intestine	*I.exustus*
Gastrodiscoides	***G.Hominis***	man, pig	caecum(Man) Colon(Pig)	*helicorbis*
Psedodiscus	***P. collinsi***	Horse, elephant, cattle	Colon	*I.exustus*

Genus : Paramphistomum



- Species
  - Paramphistomum cervi
  - P epiclitum
  - P microbothrium
- Hosts: Cattle, sheep, goats and other related animals.
- Intermediate host - Indoplanorbis exustus and Planorbis
- Seat of predilection - Rumen, reticulum, small intestine.
- Body is elongated or conical – Conical Flukes

- *Paramphistomum explanatum (Gigantocotyle explanatum)* : The flukes are found in the bile ducts inside the liver, gall bladder mostly of buffaloes, and rarely of cattle, sheep and goats.
- The life-cycle involves the snails, *Gyraulus convexiusculus* as intermediate host.

- Genus Cotylophoron
- Important species *Cotylophoron cotylophorum*
- Hosts Cattle, Sheep and goat
- Site/location Rumen and reticulum
- Intermediate host - Indoplanorbis spp

- Genus : Gastrothylax
- *Gastrothylax crumenifer*
- Hosts: Sheep, cattle and buffalo,
- Site/location: Rumen and reticulum
- Intermediate host - *Gyraulus convexiuscvlus*

- Genus : Fischoederius
- Species:
  - *Fischoederius elongatus*
  - *F. cobboldi*
- Host: Cattle
- Site Rumen, Reticulum
- Intermediate host -*Lymnaea luteola*

- Genus: Gastrodiscus
- Important species: G. aegyptiacus
- Host: Equines
- Site / location: Intestine
- Intermediate host - Cleopetra spp

- Gastrodiscoides
- Important Species G. hominis
- caecum and colon of pig and man
- intermediate host:Helicorbis coenosus

Pathogenesis

- Pathological features / lesions: Enteritis, hypoproteinimia, hydrothorax, hydropericardium
- Adult flukes located in the rumen and reticulum are non pathogenic.
- The disease is commonly called ‘immature amphistomosis’ (locally called as ‘pittu gillar’ or ‘bissi rog’).
- Pathological changes are due to the mechanical damage caused by the immature flukes to the mucosa of affected parts of the gastrointestinal tract.
- Immature flukes are drawing a plug of mucosa into their acetabula. The pieces of the affected parts of the mucosa involved become necrosed and eventually slough off is known as “Plug feeder”
- protein is lost through the ruptured intestine because of the alteration of the selective permeability of the wall of the intestine. Due to hypoprotaenimia there occurs oedema.
- There is extensive erosion and petechiae on the mucosa causing intestinal discomfort to the host which eventually loses appetite.
- Anorexia coupled with the impaired food assimilation results in loss of weight.

- Gigantocotyle explanatum flukes parasites mainly the bile ducts, gall bladder and liver of buffaloes, and rarely in other ruminants including goats.
- The disease caused by both immature and mature flukes is called ‘biliary amphistomosis’
- juvenile flukes in the duodenum enter through the opening of the bile ducts and reach the gall bladder and connecting ducts inside the liver and mature there. The presence of a large number of flukes causes extensive thickening (fibrosis) of the bile ducts preceded by a series of superficial erosion of mucosa and haemorrhages

Clinical Signs

- Severe abdominal pain due to plug feeding is caused by the immature amphistomes.
- Profuse fluidy diarrhea occurs.
- affected animals show increased thirst which is due to loss of large amount of body fluid on account of severe diarrhea.
- Oedema, weight loss, emaciation

- Diagnosis
- Based on the clinical signs, history of area and the presence of immature amphistomes in fluid faeces
- At postmortem – Enteritis is evident with large number of brownish pink parasites are found on the mucosa.
- Eggs are oval in shape and fairly large in size, they are whitish to transparent in colour except those of Gigantocotyle explanatum which are yellowish transparent like those of Fasciola eggs.
- The shell has a distinct operculum and frequently a knob-like thickening is present at the broader end.
- Treatment, Prevention and control: Resorantel and Oxyclozanide

FAMILY: SCHISTOSOMATIDAE

- All the members of this family are found in the blood vessels of their definitive hosts and are commoqly called as 'blood flukes'.
- Elongate, unisexual (sexes are separate) dimorphic (Morphology and size of the female and male is different)
- The male is stout and short with tuberculated tegument while the female is longer, slender and with smooth tegument.
- The female is carried by male during the copulation in a ventral gutter like groove gynaecophoric canal in male formed by the edges of body.

- The oral and ventral suckers lie anteriorly.
- The digestive system starts with the oral sucker followed by oesophagus and two intestinal caeca which reunite prior to its termination as a blind tube at the hind end.
- The reproductive system is well developed.
- In the male, the number of testes varies from 2 to 10 and is placed dorsal and posterior to the ventral sucker.
- The ovary is elongated, compact and lying in front of posterior union of intestinal caeca.
- The uterus occupies the anterior half of the body
- The eggs are thin shelled, non-operculum, embryonated, transparent and bear or terminal spine.
- The cercariae are furcocercous. The tails of the cercariae are bifurcated.

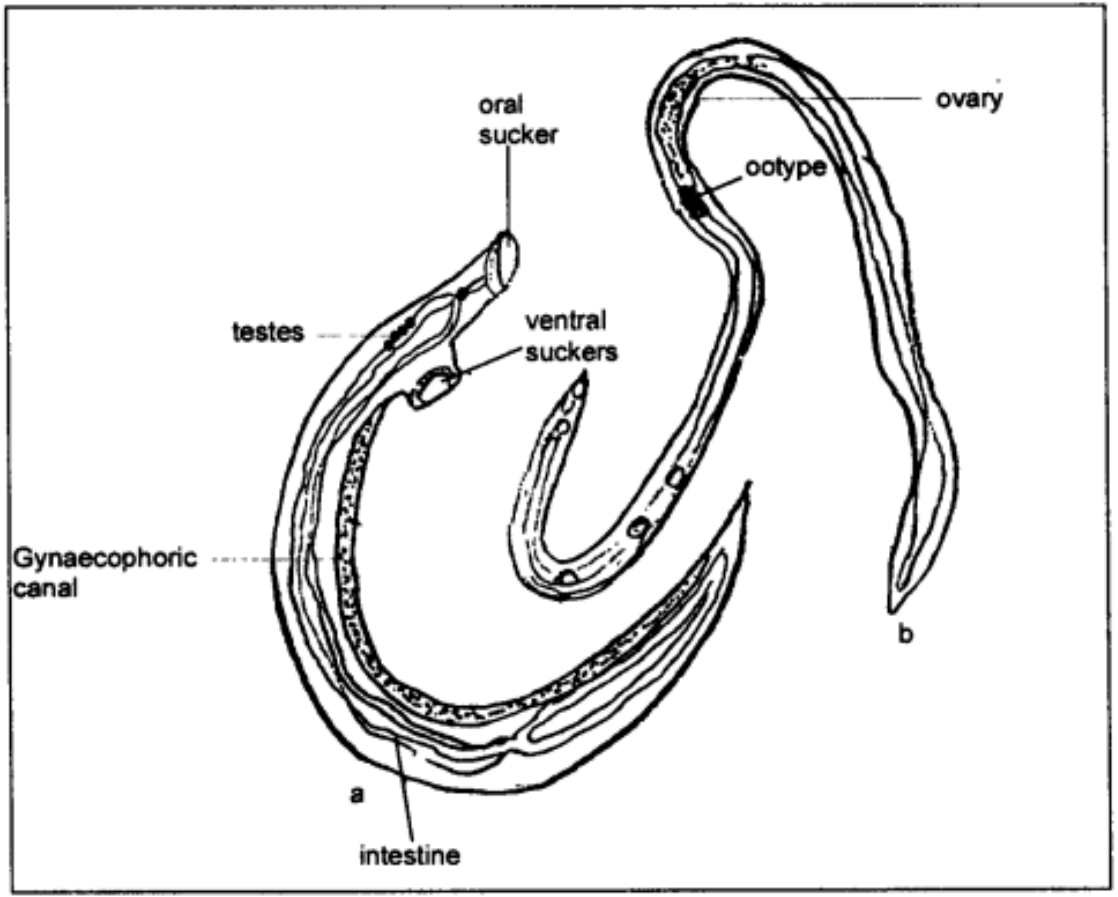


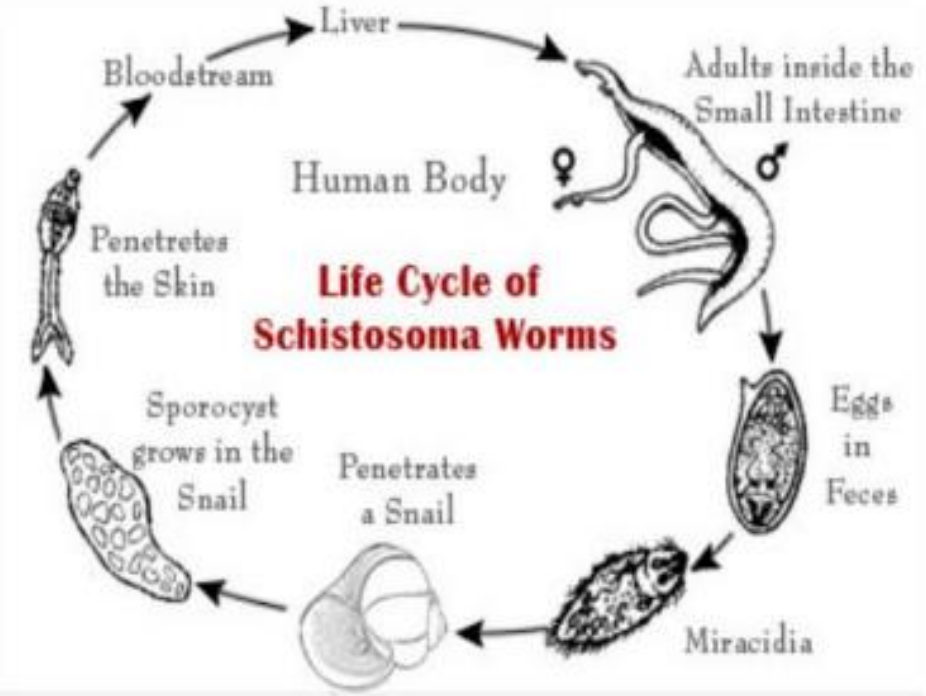
Fig. 15. Schistosoma spp. a - male; b - female

- Genus Schistosoma
- Common name -Blood fluke or Bilharzia worms
- Hosts: Cattle, sheep, goat, pig and dog etc
- Intermediate host: Indoplanorbis sp, Bulinus sp, Planorbis sp etc.
- Site /location: Mesenteric vein, portal veins, nasal vein (s. nasale)

Genus	Location	Descptition	Intermediate host
***Schistosoma spindale* (India)**	The mesenteric veins of cattle, buffalo, sheep, goat, equines and dog	The eggs are **spindle shaped / Napolean hat shaped** with a terminal spine shaped with a terminal spine******	*Indoplanorbis exustus* acts as its intermediate host 
***Schistosoma nasalis:* (India)**	veins of nasal mucosa of buffalo and cattle,	The eggs are typically **boomerang-shaped** with a terminal spine****	*Indoplanorbis exustus* 
Schistosoma incognitum(India)	The flukes occur in the mesenteric veins of pig and dog	The sub-oval and yellowish brown egg is flat at one side with a terminally placed stout spine.	*Lymnaea luteola* 

Schistosoma indicum	Mesentric vein & Portal vein	Ruminant, horse and camel	*Lymnaea luteola*
S.haematobium	Vein of urinary tract	man	*Lymnaea luteola*
Ornitobilharzia dattai	Portal and messentric vein	Ruminant	*Lymnaea luteola*
Bivitellobilharzia nairi	Portal vein	Elephant	*Lymnaea luteola*
S.japonicum	Human		*Lymnaea luteola*
S.mansoni	Human		*Lymnaea luteola*

Life Cycle


Liver
Bloodstream
Adults inside the Small Intestine
Human Body
♀
♂
Penetretes the Skin
Life Cycle of Schistosoma Worms
Sporocyst grows in the Snail
Penetrates a Snail
Eggs in Feces
Miracidia

- Developmental stages
- Egg
- Miracidium
- Sporocyst (two generations)
- Cercaria
- Adult
- Note : Metacercaria stage is absent.
- Schistosomula stage is produced.
- Redia stage is also absent.

Life cycle

- The female flukes lay eggs in veins, from where the eggs cross the tissue wall and come to the lumen of intestine or urinary or nasal passage and are passed out with faeces or urine or nasal discharge respectively depending upon the species.
- The embryonated eggs hatch immediately after contact with the water.
- The released miracidia swim in the water and search their suitable host for further development.
- A ciliated pyriform miracidium released from the egg search of a suitable aquatic snail – an intermediate host(Eg:Indoplanorbis spp.)
- The miracidium has a short life span of 12-20 hrs and does not feed outside.
- The miracidium penetrates the appropriate species of snail, remove its cilia and changes into a sac-like structure inside the snail called sporocyst' possessing a number of germ cells.
- Each germ cell which in turn develops to the forked-tailed cercaria called 'furcocercous cercaria'.

- Redia stage is absent
- The cercariae are the final larval stage of the blood flukes.
- The cercariae are liberated from the snail in the morning hours. The furcocercous cercariae does not convert in to metacercariae. They swim actively in the water in search of a suitable definitive host.
- The cercariae penetrate the host'species skin
- During penetration of the host's skin the cercaria loses its tail and convert in to a globular body known as schistosomulum (Young fluke)
- large number of schistosomula passes to the lungs via the systemic circulation and then to the liver where further development and pairing takes place in portal veins and becomes sexually mature.
- Finally, these flukes pass to the mesenteric veins where they become adults and start egg laying.
- PP. 6-7 weeks

Pathogenesis

- The eggs produced by the females are mainly responsible for the pathogenesis creating harm to the host both mechanically and immunologically.
- Most of the species of S. indicum, S. spindale, S. incognitum and others which reside in the portal and mesenteric veins of animals and man cause ‘hepato-intestinal schistomosis’.
- S. nasalis of domestic ruminants is responsible for causing ‘nasal schistomosis’

Hepato-intestinal schistosomosis (Visceral schistosomosis)

- It has mainly two types of clinical syndromes-an acute ‘intestinal syndrome’, and a chronic ‘hepatic syndrome.
- The intestinal syndrome is seen in acute schistosomosis with the beginning of laying of eggs by the females.
- The passage of eggs through the intestinal wall causes severe inflammatory changes and haemorrhagic lesions particularly in the posterior small intestine wall.
- The intestinal mucosa becomes blood stained mucus covering the intestinal surface.
- The eggs may be found free, in small granuloma or in small abscesses in the mucosa of small intestine.
- Long standing infections are characterized by granulomatous lesions in all layers of the intestinal wall including its thickening.
- Adult parasites cause phlebitis in the mesenteric veins

- Hepatic schistosomosis
- The hepatic syndrome which is found due to migration of parasites toward liver through portal circulation, is caused by cell mediated immune response to eggs in liver.
- These granulomatous lesion are also accompanied with portal fibrosis provoked by the eggs

- Nasal schistosomosis
- S. nasalis infection produces severe clinical disease in cattle whereas buffaloes usually carry the infection without significant symptoms and lesions.
- The eggs of the fluke enter the mucous glands of the nasal cavity evoking a cellular reaction fibrosis and cauliflower-like growths in nasal passage of cattle.
- The affected animals show rhinitis, mucopurulent discharge, manifested clinically by coryza, sneezing, dyspnoea and snoring (snoring disease)
- The snoring disease in cattle adversely affects production, gain in body weight and draught capacity in bullock

Diagnosis

- Clinial Signs
- Feacal examination
- Nasal discharge examination: typical boomerang-shaped eggs of S. nasalis
- Serological Tests: Cercarien mullen test (CHR), IHAT, CFT, DID, Ring precipitation test, ELISA and Dot-ELISA etc.

Clinical Signs

- **Nasal schistosomosis**: The infected animal shows the symptoms like sneezing, snoring sound and difficulty in breathing due to the presence of granulomatous growth, mucopurulent discharge and coryza
- **Hepato-intestinal Schistosomosis**: These acute condition menifestation by diarrhoea and dysentry ting with blood and mucus. Slight fever, anaemia, emation, anorexia, thirst and ascites are seen in chronic infection along with eosinophilic and hypoalbuminaemia
- **Urinary or vesical schistosomosis**: S. haematobium adult worms are widely distributed throughout the pelvic and mesenteric plexus. The presence of eggs and their secretion evoke development of delayed type of hypersensitivity reaction in the host leading to the formation of extensive granuloma. The obstructive lesion is well marked in the urinary bladder, ureter

Treatment

- Praziquantel
- Sodium antimony tartrate daily
- Potassium antimony tartrate
- Lithium antimony thiomate
- Tartar emetic, antimosan, stibophen, lucanthone, hycanthone, niridazole and trichlorophon.

Cercarial dermatitis

- occupasional hazard which occurs in the human being who come into contact with water harbouring the non-human schistosome cercariae. Simple redness of skin (erythema) is the feature during 1st contact of water.
- Repeated exposure can produce papule or pustule which may remain upto several weeks

Synonyms

a. Schistosome dermatitis
b. Gale des nageurs
c. Plumber's itch
d. Lake side disease
e. Fisherman's itch
f. Collector's itch
g. Swamp itch
h. Swimmer's itch
i. Clam digger's itch
j. Dhobi itch
k. Hunter's itch
l. Rice paddy itch

- Genus: Ornithobilharzia
- The testes are numerous and the uterus is short containing only one egg at a time.
- Orientobilharzia bomfordi: The flukes occur in the mesenteric veins of buffaloes in India.
- Bivitellobilharzia nairi - elephants in India.
- Heterobilharzia americanum- dogs and other mammals
- Australobilharzia variglandis-blood vessels of water fowl
- Gigantobilharzia- water fowl
- Trichobilharzia- birds

FAMILY - PROSTHOGONIMIDAE

- small distomes inhabiting the bursa of fabricious, oviduct of fowl and duck etc.

- This parasite has been considered to be one of the most pathogenic treamtode parasite of poultry in Europe and America.

- Genus Prosthogonimus
- Host - birds like fowl, pea fowl, guinea fowl etc. are affected.
- 1st intermediate host of the parasite is aquatic snail. *Bithynia tentaculata* acts as the 1st intermediate host.
- 2nd intermediate host is dragon fly. In India the dragon fly which acts as the 2nd intermediate host is *Sympatrum decoloratum*
- Site / location - oviduct, bursa of fabricious
- Important species: *Prosthogonimus pellucidus*, *P. ovatus P. mucrorchis*
- Common name -Oviduct fluke
- eggs are typically dark brown and operculated

- Developmental stages • Egg • Miracidium • Sporocyst • Cercaria • Metacercaria (infective stage) • Adult
- Redia absent
- Cercaria enter into the naiad stage of the dragon fly. The breathing movement of the fly enhances the entrance of the cercaria through the anus.

- Pathological features / lesion: Peritonitis
- parasites constantly irritate the oviduct which leads to passage of eggs without formation of the egg shell.
- Due to increased movement of the oviduct the eggs pass fast and are expelled out without the formation of the shell
- lime secreting glands secrete lime - white discharge - common symptom of this parasitic infection

FAMILY -PARAGONIMIDAE

- distomes inhabiting the lung of man and dog. The worms are significant in respect of having zoonotic importance.
- Genus Paragonimus
- Species: P. westermanii, P. kellicotti
- Common name - Lung fluke, oriental lung fluke
- Site/location - Lung
- Host - Dog, cat, fox and pig

- Required two intermediate host, first one is snails (Melania) and the second one is crab or crayfish.
- The different larval stages are miracidium, sporocyst, redia, daughter redia, cercaria and metacercaria.
- The immature fluke reach to the lung via peritoneal cavity.
- Eosinophilic granulomatous lesions in the lungs
- bithionol is drug of choice

FAMILY: ECHINOSTOMATIDAE

- flukes are elongate with a head-collar around oral sucker usually provided with a single of double rows of hooks (spines).
- Cuticle is usually with spines or scales.
- Ventral sucker is well developed and lies in anterior third of the body.
- Excretory vesicle is Y-shaped with many side branches.
- Eggs are large.
- Flukes are parasitic in the intestine, sometimes in the bile-ducts of birds and mammals

- **Genus: Echinostoma**
- Echinostoma revolutum: The flukes occur in the rectum and caeca of the domestic duck, goose, partridge, fowl and other aquatic birds,
- L. auricularia serves as the intermediate host in India.
- The cercaria is well known as Cercaria echinata.
- **Genus: Hypoderaeum**
- Hypoderaeum conoideum: Posterior part of Intestine.
- First intermediate host- snail
- 2^{nd} intermediate host- kidneys of tadpoles of frog Rana temporaria

FAMILY: NOTOCOTYLIDAE

- No ventral sucker (Monostomes)
- Testes and vitellaria lie lateral to intestinal caeca while ovary lies between them
- Mainly found in intestine of birds
- Eggs have polar filaments at both ends
- *Notocotylus attentatus*
- *Ogmocotyle indica*

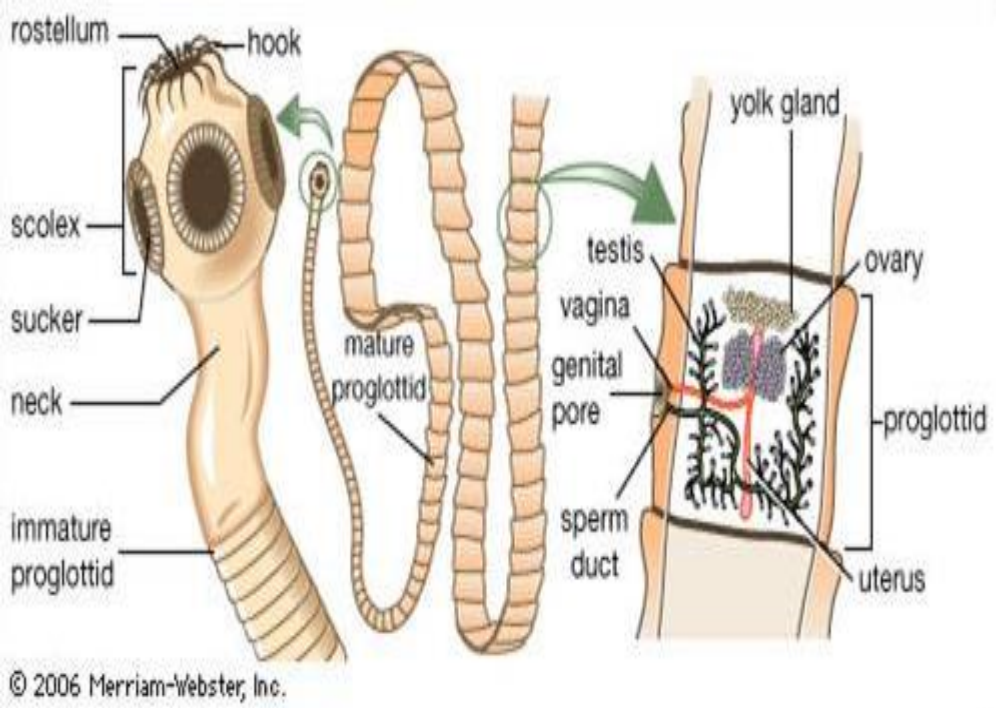
FAMILY: HETEROPHYIDAE

- Small or very small trematodes in intestine of birds and mammals
- Heterophyes heterophyes : small intestine of dog, cat, and man

Cestodes

Cestodes

- group of worms which have an elongated tape like or ribbon like body and lacks an alimentary canal.
- Body highly segmented and dorsoventrally flattened. Hermaphrodite and In each segment complete male and female reproductive systems are present.
- Most of the tape worms show indirect types of life cycle. The exceptional type of life cycle is found in Hymenolepis spp where direct and indirect types of life cycles are found.
- Cysts or bladder-worms are the intermediate or larval stage of the parasite.
- classified into two classes : Eucestoda (true cestodes) and Cotyloda (primarily cestodes of fish).


rostellum
hook
scolex
sucker
neck
immature proglottid
mature proglottid
yolk gland
testis
ovary
vagina
genital pore
proglottid
sperm duct
uterus
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Morphology

- Head or Scolex, neck, body or Strobila
- The body is made up of head or scolex which has attachment organs such as suckers and hooks, a short unsegmented region called neck is succeeded by a chain of segments called proglottids which constitute the body or Strobila.
- Single segment is called proglottids and entire chain of segment is called strobila.
- Outermost layer is called tegument. Drugs used should be effective against scolex because it can rejuvenate the entire tapeworm.
- Praziquantel, drug of choice for cestodes mainly act upon tegument.

- head or scolex bears four suckers as the organs of attachment which may be armed with hooks.
- A protrusible cone, called rostellum, often armed with hooks may be present in the scolex.
- The scolex may have two long muscular grooves called bothria instead of suckers (Cotyloda)
- Suckers are the organ of attachment to stay in intestine during peristalsis

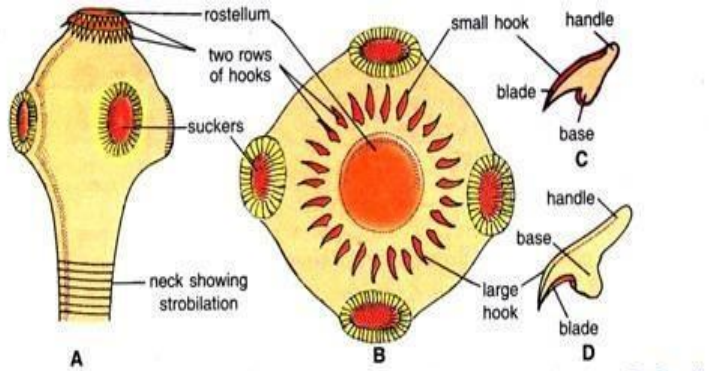
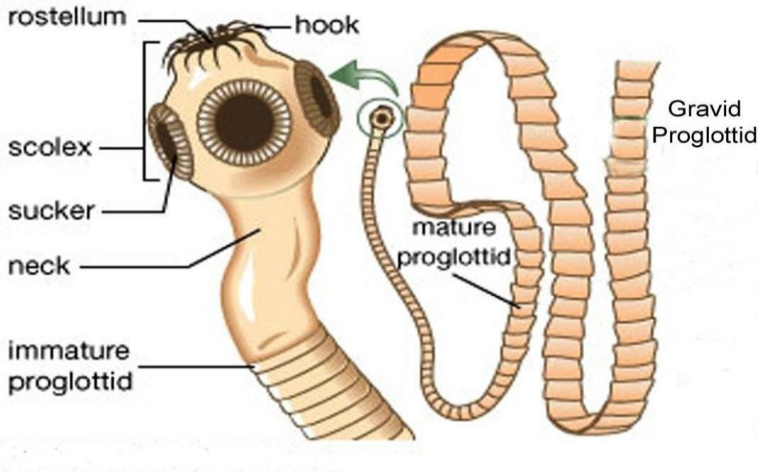


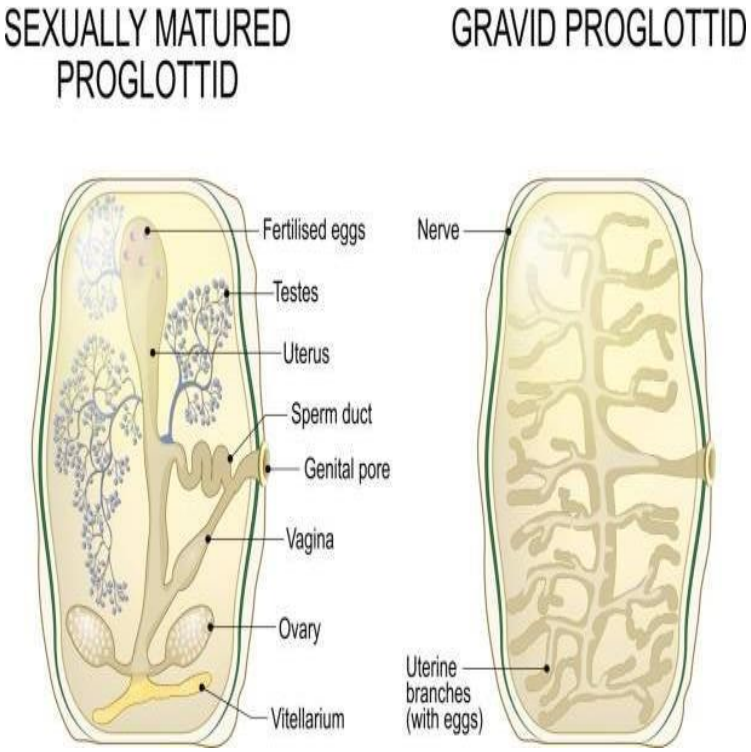
Fig. 42.2. *Taenia solium*. Scolex. A—Scolex magnified; B—Frontal view of scolex; C—Small hook; D—Large hook.



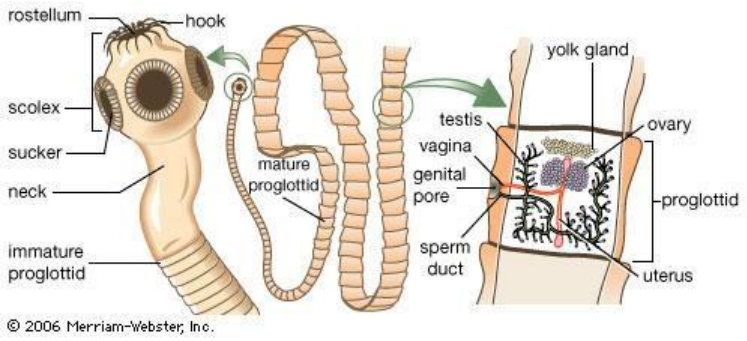
- Proglottids are of 3 main types:
- **Immature:** Reproductive organs are nor fully developed or functional
- **Mature:** Reproductive organs are well developed and functional. These are situated in the middle of the strobila.
- **Gravid:** When the eggs are fertilized either by self or cross fertilization, the reproductive organs degenerate leaving only the uterus full of fertilized eggs.
- The segment which reach this stage lies in the posterior part of the body and known as gravid segment.

GENERAL CHARACTERS

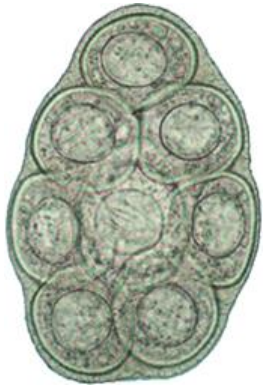
- The gravid or ripe proglottids are shed by some species either singly or in chain of 3-4 segments.
- After shedding eggs are liberated by disintegration of segment, this phenomenon is termed as **apolysis** and such tapeworm as **apolytic** and those which retain them are called **Anapolytic.**
- Sometimes eggs are liberated through an opening created in the uterus due to presence of eggs and muscular activity of uterus, such opening is termed as **thysanus**
- As the segment matures, its internal structure dissapears and the gravid segment is left which contains only uterus with eggs.
- The outer covering of the body is called the tegument which is a highly specialized structure and a major absorptive surface.

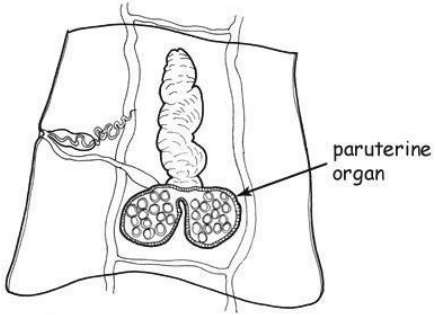


REPRODUCTIVE SYSTEM



- The eggs are liberated from the gravid segments which are usually shed intact from the strobila and pass out with the faeces.
- The uterus may persist as a protective envelope for the eggs or **Egg capsules** may be formed by the uterus or **Paruterine organs** formed by denser parenchyma near the uterus or arise as dilatations of uterus in which eggs remain after the uterus disappears.





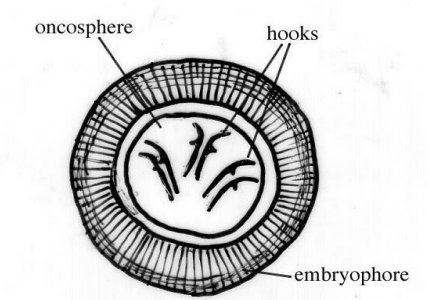
FEMALE REPRODUCTIVE SYSTEM

- Female genital pore lead into a tubular vagina which ends into ootype (site of fertilisation and egg formation). Oviduct, uterus and vitelline duct also connects to ootype.
- Ootype is surrounded by Mehli's gland which helps in formation of shell and egg yolk.
- Ovary is usually bilobed. Vagina bears a receptaculum seminis which function to release sperm and store spermetazoa.
- Mehli's gland and vitelline gland contribute in shell and yolk.
- Ootype is an assembly plant in which finished eggs are prepared.
- Uterus may be of various shale like tubular, sac like or may have extensive branching
- Sometime uterus may degenerate or eggs either singly or in groups passed into protective structure within the segment.
- They form two types of protective structure, *viz*. egg capsule (egg sac; hyaline in nature) and paruterine organ (fibromuscular in nature).

MALE REPRODUCTIVE SYSTEM

- It consists of numerous globular and round testes which discharge into vasa efferentia that joins to form vas deferens.
- Vas deferens ends into cirrus which is surrounded by bag like structure called as cirrus sac.
- Male and female genital pore (atrium) lies close together in the genital sinus on the lateral or ventral side of the segment.
- Self or cross fertilization between proglottid may occur.
- Cross fertilization between proglottid of same tapeworm is known as selfing.

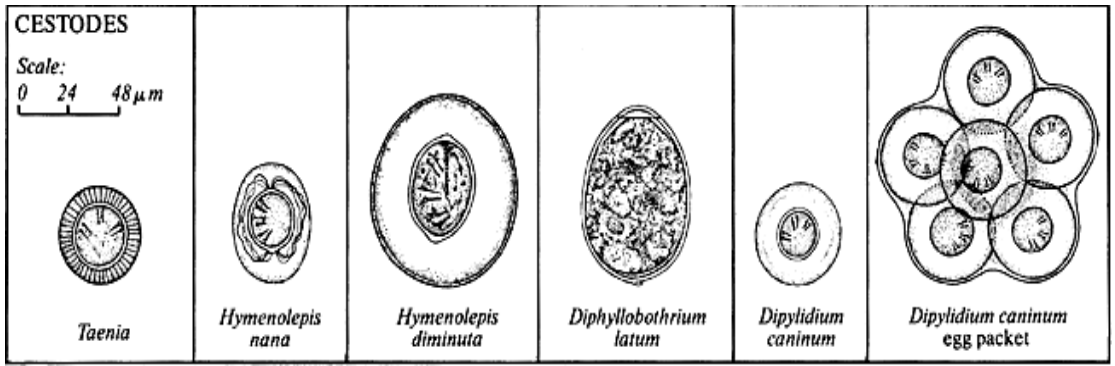
Egg



- It consists of a 6 hooked or hexacanth embryo.
- Oncosphere – A hexacanth enclosed by one or two embryonic envelopes.
- Coracidium – A hexacanth enclosed only by a ciliated inner envelope that provides a mechanism for free swimming.
- Embryophore – Name applied both to the full ciliated inner envelope of a coracidium, and to a specialised intracellular proteinaceous lamina produced within the inner envelope of a cestode with a non-swimming oncosphere.
- Embyophore is striated in *Taenia* sp., Ciliated in *Diphylobothrium latum* and pear shaped in *Moniezia* sp.
- Note: Some authorities prefer to distinguish the motile inner envelope of a coracidium by referring to it as a “ciliated embryophore”.

DIFFERENT TYPES OF EGGS

- Anoplocephalidae - The embryophore has a pair of spines forming the pyriform apparatus.
- Taeniidae - The capsule is a thin membrane which is not seen in faecal eggs and embryophore is a thick structure made up of keratin blocks called shell which gives a radially striated appearance.
- Hymenolepidae - Egg shell is retained and embryophore is thin.
- Several ova are enveloped in a single embryonic membrane - *Dipylidium*.

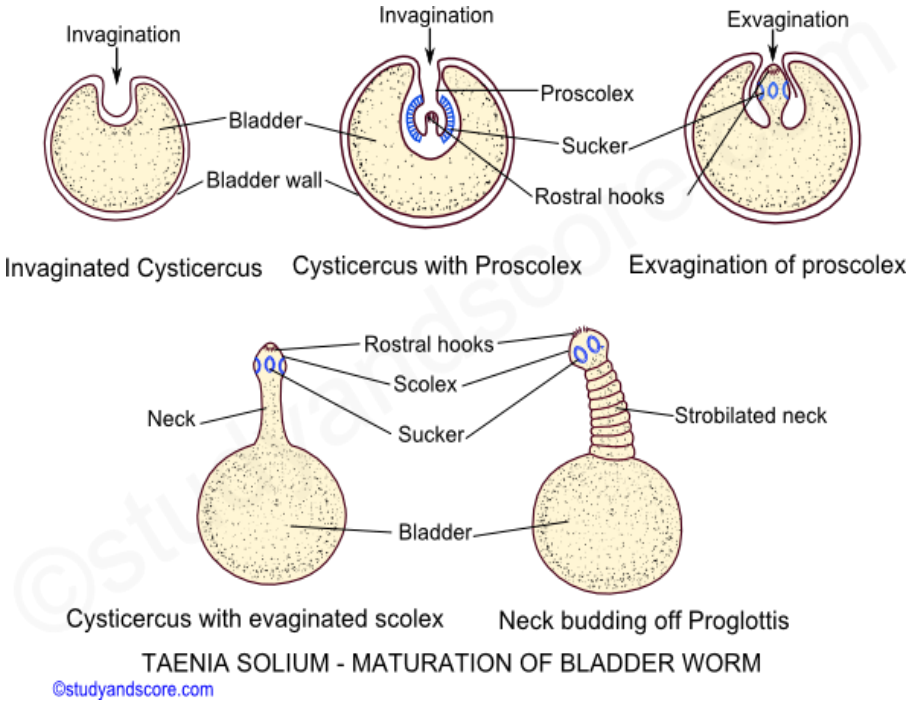


GENERAL LIFE CYCLE

- Eggs from gravid segments are passed through faeces.
- In the IH, if vertebrate, it is hatched and activated by action of gastric and intestinal secretions through the mucosa and the oncosphere burrows and through the blood/lymph stream they reach to the site/organ of predilection and become a cyst.
- In case of invertebrate intermediate hosts they go to the body cavity.
- In the site of predilection the oncosphere loses its hooks and develops into **Bladder worm** or cyst or **Metacestode.**

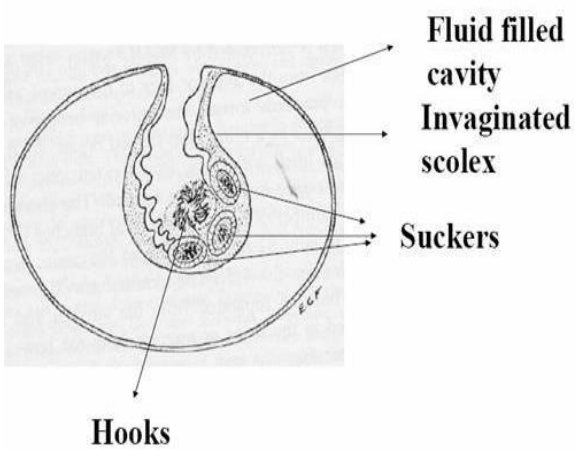
GENERAL LIFE CYCLE

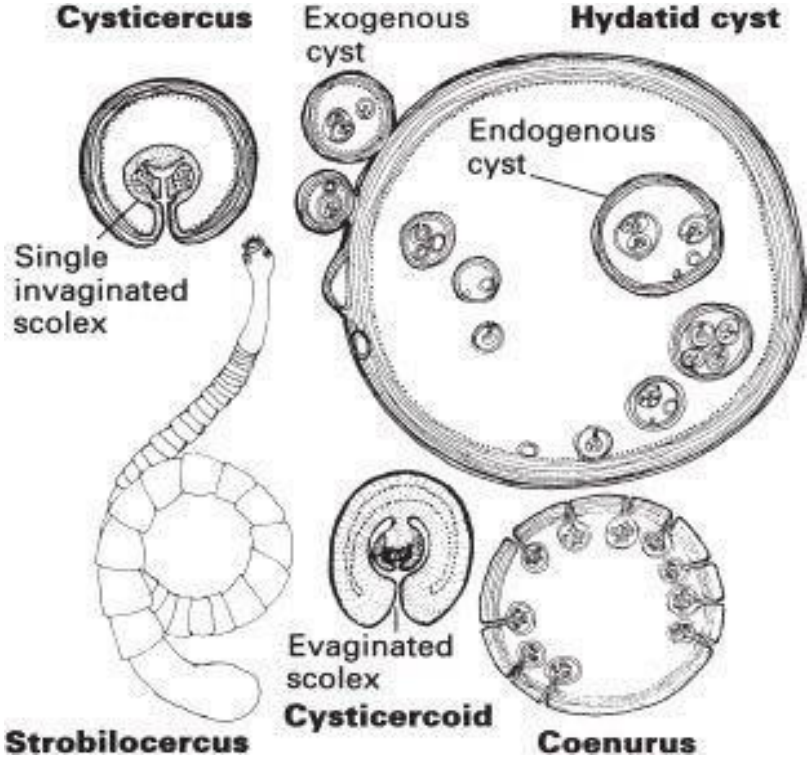
- The cyst has an outer cuticle, an inner germinal layer and contains fluid.
- Inside it develops 1 or more heads on its wall or free floating.
- The wall invaginates at the bottom of which is a rostellum with hooks and suckers.
- The final host gets infected by ingesting cyst infected meat/organs and in the intestine the scolex evaginates to attach on the intestinal wall and develop into a tapeworm.



CESTODE LARVA/CYSTS/BLADDERWORMS/METACESTODES

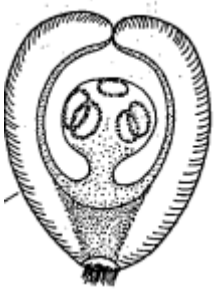
- **Cysticercus** - A bladder enclosing a single scolex retracted and invaginated within itself.Scolex is sometimes also called a protoscolex. It is usually found in vertebrates.

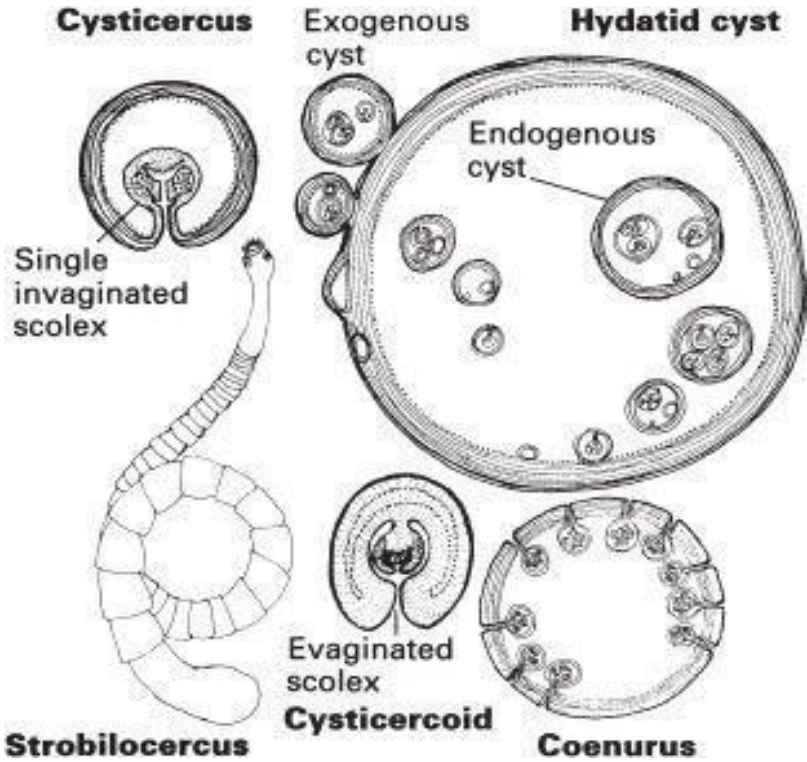




CESTODE LARVA/CYSTS/BLADDERWORMS/METACESTODES

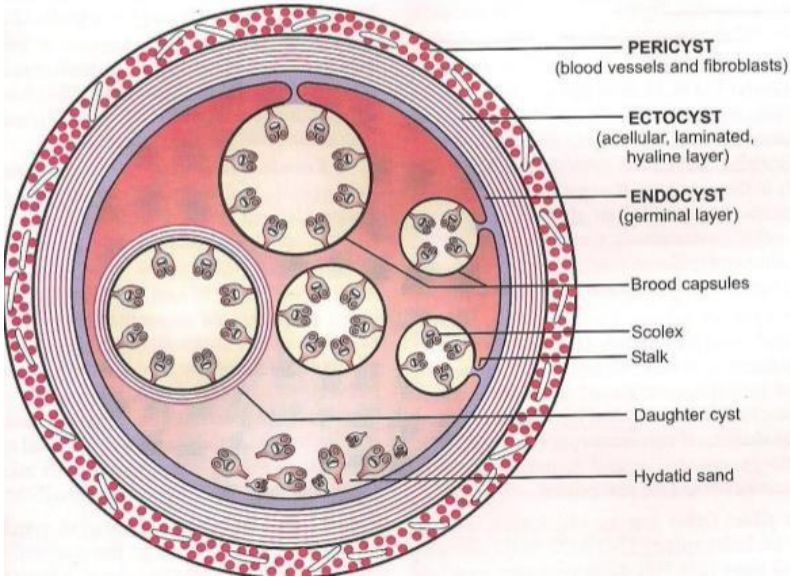
- **Cysticercoid** - pin-point sized vesicle with one scolex not invaginated without a cavity, and develop in invertebrates
- **Cryptocystis** is a type of cysticercoid in which tail is found during early phases of development (*D. caninum* in flea).
- Cysticercoids are found only in arthropod intermediate hosts.





CESTODE LARVA/CYSTS/BLADDERWORMS/METACESTODES

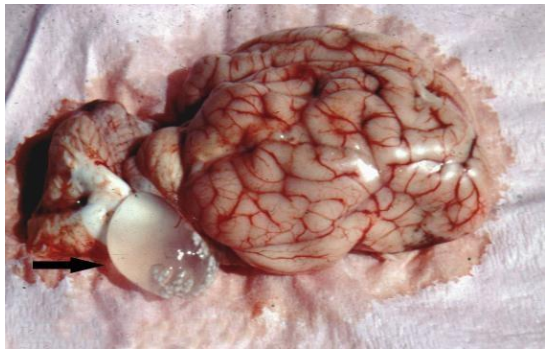
- **Strobilocercous** - The scolex is evaginated and is connected to the cyst by a chain of asexual proglottids. The proglottids are digested after ingestion by final host. Eg.*T. taeniaeformis.*
- **Hydatid cyst** - Large fluid filled cyst lined with germinal epithelium from which numbers of invaginated scolices are produced.
- They lie free or in bunches surrounded by germinal epithelium called brood capsules.
- The scolices and brood capsules are called **'Hydatid sand'.**

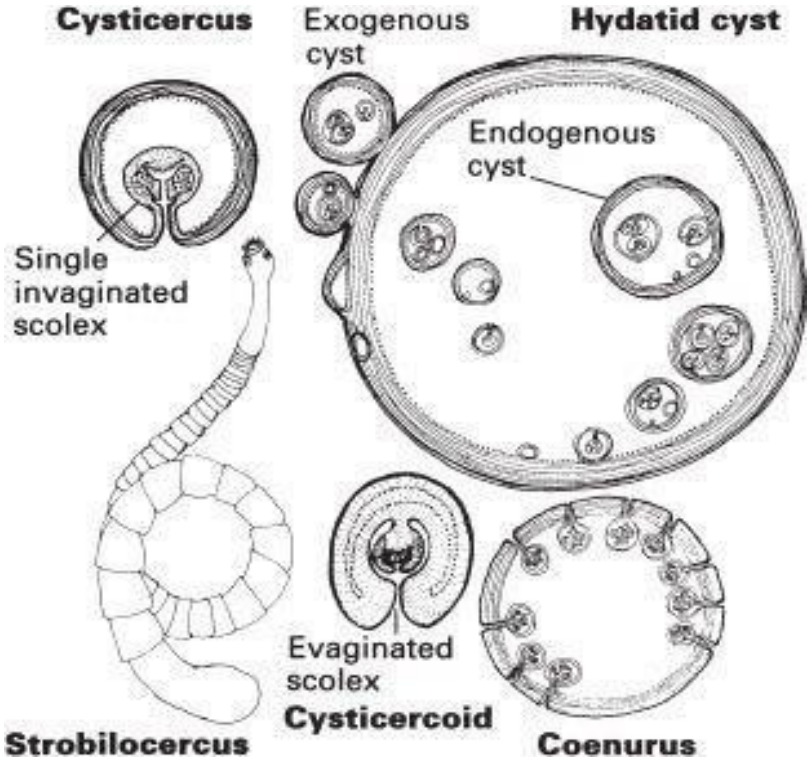


CESTODE LARVA/CYSTS/BLADDERWORMS/METACESTODES

- **Coenurus** - A large cyst containing fluid and numerous invagnated scolices in groups budded from the wall of bladder and connected to the wall. Eg.*Multiceps multiceps*(=*Taenia multiceps*). Daughter cysts are also formed in Coenurus.

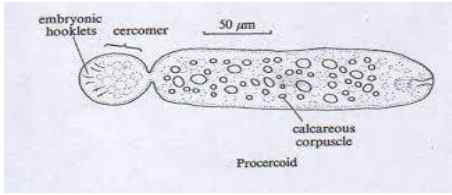






CESTODE

LARVA/CYSTS/BLADDERWORMS/METACESTODES





Tetrathyridium

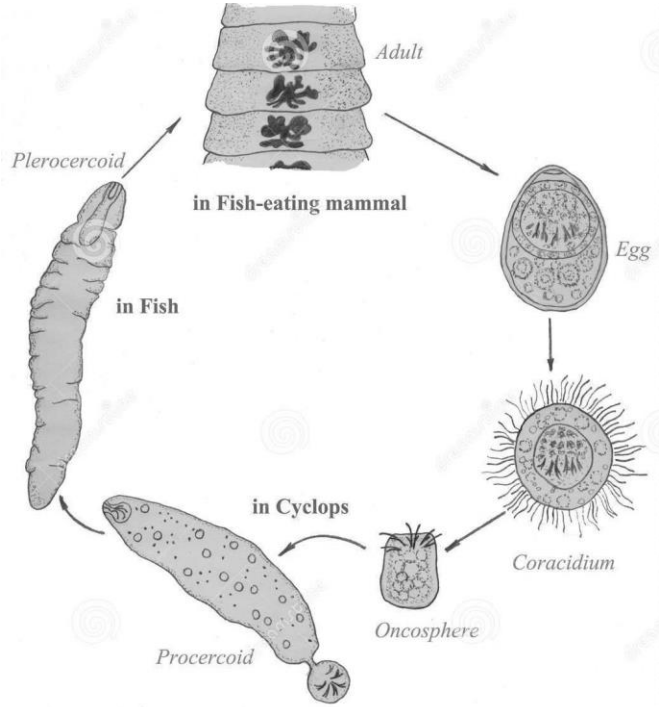
- Worm like elongate larva with invaginated scolex.

Procercoid

- Solid body and bear hooks

Pleurocercoid

- Elongated solid body which bear an adult scolex
- Found in *Diphyllobothrium latum*



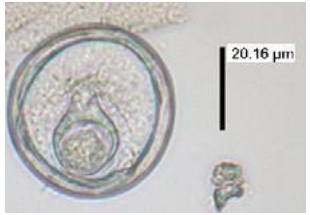
TAPEWORM OF EQUINES- FAMILY ANOPLOCEPHALIDAE

Genera

- *Anaplocephala* : *A. magna* and *A. perfoliata*
- *Paranaplocephala* : *P. mamillana*
- *Moniezia*: Tapeworm of Ruminants







Morphological Characters

- Scolex is without rostellum and hooks
- Single set of reproductive organ in each mature segment except *Moniezia* sp.
- Proglottids are usually wider than long
- Genital pore unilateral in position but it alternate irregularly in *Paranaplocephala*
- Eggs have pyriform apparatus, i.e. hexacanth embryo surrounded by pear shaped oncospheral membrane

CLASS: EUCESTODA

ORDER: ANOPLOCEPHALIDEA

- Uterus persists as transverse tube or network of tubes.
- Microscopic mites of family: Oribatidae acts as i/m host, in which cysticercoids develops
- Large cestode, parasitising intestines of equines
- Single set of reproductive organs with numerous testis in median
- Ovary is lobed, vitellaria lie posterior to the ovary
- Mostly parasites of herbivores
- Devoid of rostellum & hooks on scolices
- **Proglottids wider than long**
- One or two sets of genital organs
- Genital pores marginally placed
- Uterus may persist or may be replaced by egg capsules or paruterine organs
- Eggs has 3 coverings: outer- Vitelline membrane; Middle- albuminous layer and inner- chitinous layer

GENUS: *ANOPLOCEPHALA*

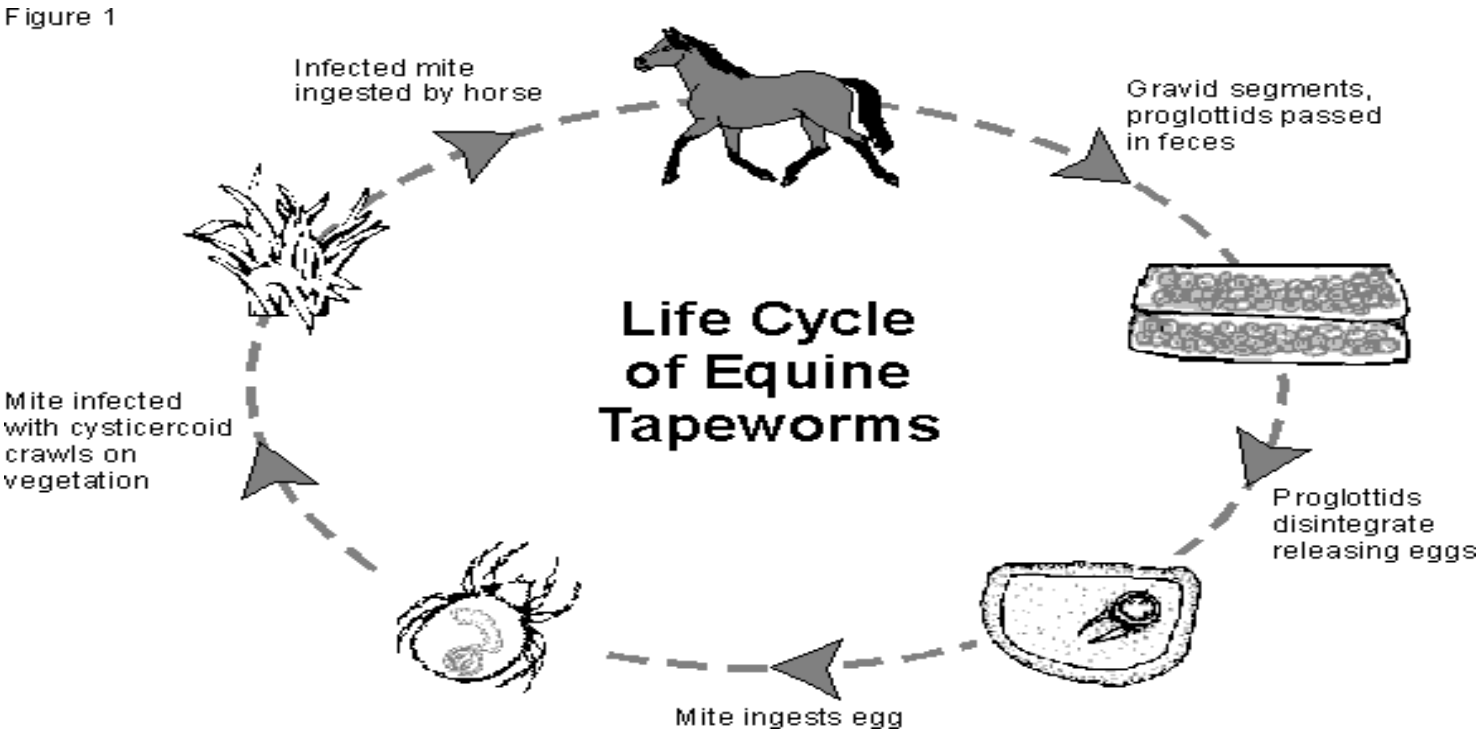
Genus	Size	Habitat	Host	Remarks
Anoplocephala magna	80x2.5 cm	SI (jejunum) rarely stomach	Equines	Lappets absent Largest cestode of equines
Anoplocephala perfoliata	8x1.5 cm	SI and LI of horse and donkey	Equines	Lappets present (outgrowth under each sucker which helps in perforation)
Paranoplocephala mamillana	6-50x 4-6 mm	SI	Equines	Dwarf tapeworm of equines Lappets absent

LIFE CYCLE (*ANOPLOCEPHALA* AND *PARANAPLOCEPHALA)*

- Three stages are encountered in life cycle, viz. Egg, Cysticercoid and Adult
- Adult worm occurs in SI of DH
- Eggs are released from shed off gravid segments.
- Oribatid mites (*Scheloribates* and *Galumna*) act as IH
- Cysticercoids develop in these mites after 2-4 months
- Infected mites are commonly found on grass in grazing fields and ingested with contaminated herbage by horse.
- Oribatid mites are dissolved and cysticercoid are released in intestine.
- Adult tapeworm develop in the intestine in 4-6 weeks

Life cycle of equine tapeworm

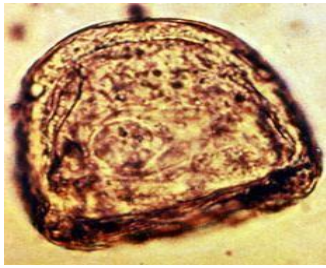
Figure 1



PATHOGENESIS

- Light infection in horses produce no clinical signs.
- Heavy infection may cause ill health, unthriftiness and even death.
- Due to attachment by scolex of *A.perfoliata* near the ileocaecal orfice, depressed ulcerative lesions are produced
- Partial occlusion of ileo-caecal orifices due to excessive growth of granulation tissue which may be one of the causes of intussusceptions
- In heavy infection with *A.magna*, there may be catarrhal or hemorrhagic enteritis in the small intestine
- In both the infection perforation of the intestine has been recorded.
- *P. mamillana* is rarely pathogenic, i.e. does not produce clinical sign/disease

DIAGNOSIS



- Stool samples examination
- Each egg has three coverings, outermost **vitelline membrane**, a middle **albuminous coat**, innermost **chitinous membrane**, which is frequently pear shaped, bearing on one side a pair of hooked projections (altogether called **pyriform apparatus**)
- Pyriform apparatus is hexacanth embryo surrounded by pear shaped oncospheral membrane
- PM Lesions: Small, dark, depressed, ulcerative lesions at iliocaecal junctions.

TREATMENT

- Micronized mebendazole@ 15-20mg/kg bwt
- Bithionol @ 7mg/kg bwt
- Niclosamide @ 88 mg/kg bwt
- Benzimidazole are als effective against some tapeworms but with some higher doses.

Narrow spectrum anthelmintics are more effective in tapeworm. Tapeworms are usually non pathogenic unlike their large size. They share the part of host nutrition only. In heavy infection, they may cause intestinal obstruction.

TAPEWORM OF RUMINANTS

- *Moniezia* (Anoplocephalidae)
- *Avitellina* (Thysanosomidae)
- *Stilesia* (Thysanosomidae)
- *Thysaniezia* (Thysanosomidae)
- *All the tape worms except Thysanosoma actinioides and Stilesia hepatica are found in the small intestine invariably.*

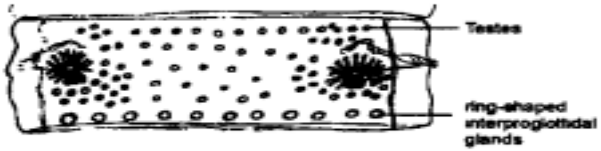
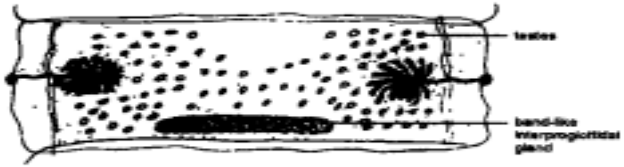
TAPEWORM INFECTION IN RUMINANTS

- ***Moniezia*:** M. expansa and M. benedeni
- Common name - Double-pored tape worm
- Hosts - Sheep, goat and cattle
- Site/location - Small intestine

- Main identifying character is presence of inter proglottid gland. These interproglottidal glands are band- like in M. benedeni. These are ring- like in M. expansa.
- Eggs have pyriform apparatus
- Adults have prominent suckers but rostellum and hooks are absent
- Genital pore are bilateral in position, thus called as double pored tapeworm of ruminants

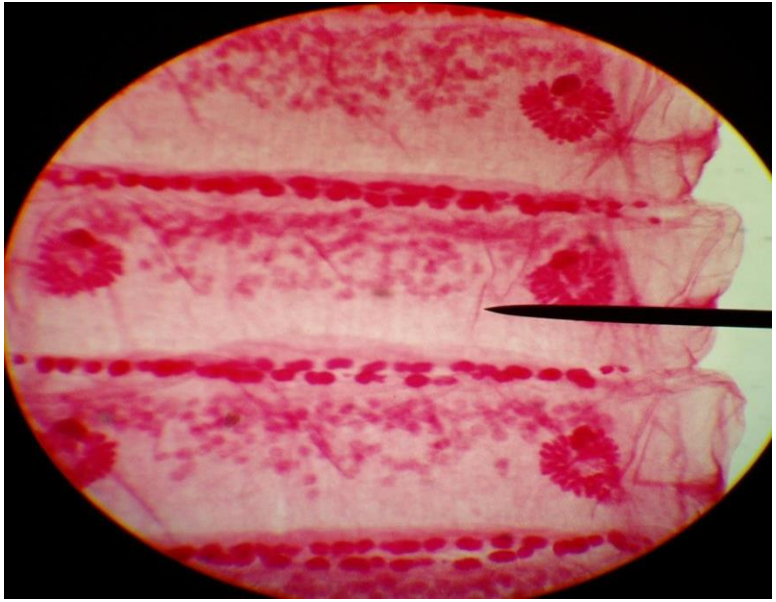
SPECIES: *M.EXPANSA* (FREQUENTLY AFFECT SHEEP)
M.BENEDINI (FREQUENTLY AFFECT CATTLE)

- It is the largest tapeworm of family anoplocephalidae.
- They are found in the SI of sheep, goat, cattle, buffalo and they are widely prevalent in India.
- Size may reach upto 6m and segments are broader than long and mature proglottid has 2 sets of genital organs
- Body is creamish white in colour and scolex is unarmed with distinct neck
- The horse shoe shaped ovary & vitelline gland come together to form a ring like structure on either side of tapeworm
- Testis are lobed and scattered in the through out the medial field
- Along the post margin of each proglottid, interproglottid glands are present

Moniezia expansa	*Moniezia benedeni*
1. This tape worm is found in sheep, goat and cattle.	1. This tape worm is found in sheep, goat and cattle.
2. Interproglottidal glands are band- like which are present in the posterior part of the segment.	2. The interproglottidal glands are ring-like, present in the posterior part of the segment.
	
Fig. 35. Mature segment of M. expansa	*Fig. 36. Mature segment of M. benedeni*
3. The eggs are square-shaped.	3. The eggs are triangular.

Moniezia expansa

- Interproglottidal gland is saccular or rossette like and expand throughout the width of the segment



Moniezia benidini

- Interproglottidal glands are linear and restricted to the centre of the segment



LIFE CYCLE

- Developmental stages • Egg • Oncosphere • Cysticercoid in the inetermediate host (developmental stage in oribatid mites) • Adult
- Adult worm is present in intestine of DH
- Cooked rice grain like segments are voided in feces
- Segments disintegrate & eggs containing pyriform apparatus are released
- Eggs swallowed by oribatid mites in which cysticercoid develops (4 months)
- Some eggs may be eaten by birds which spread the infection
- Cattle, Buffalo, Sheep and Goat develop infection after swallowing oribatid mites containing cysticercoid along with herbage

PATHOGENESIS

- Infection of *Moniezia* is not common in old age, i.e. more in young one.
- Generally, lambs, kids and calf under 6 months of age are infected.
- As the parasite is very long, it has a great surface for absorption. It results in reduction of availability of nutrition to host.
- It causes emaciation, depressed wool and meat production.
- In heavy infection, intestine may be virtually a solid mass of tapeworm and obstruction of intestine may occur.
- They can cause constipation, diarrhoea, unthriftiness and even death.
- A high incidence of enterotoxemia is associated with *Moniezia* in lambs.

DIAGNOSIS

- By observing characteristic eggs in faeces.
- Presence of cooked rice grain like gravid segment or white specks in faeces
- PM Lesions: Because of the very large size of cestode, their presence is clear at post mortem.

TREATMENT

- Praziquantel @ 15mg/kg b.wt.
- Albendazole @ 10 mg/kg b.wt.
- Fenbendazole @ 5 mg/kg b.wt.
- Cambendazole @ 20 mg/kg b.wt.
- Resorantel @ 65 mg/kg b.wt.
- Niclosamide @ 75-150 mg/kg b.wt.
- Bithional @ 200 mg/kg b.wt.

FAMILY - THYSANOSOMIDAE

- Gravid uterus dissapears and is replaced by paruterine organs or capsules.
- It includes 3 genera of veterinary importance, viz. *Avitellina*, *Stilesia* and *Thysaniezia*
- *Avitellina centripunctata*- Found in SI of sheep and other ruminant. It is the most common species found in India.
- *A. chalmersi* and *A. gonghi* are found in SI of sheep in Asia
- *A. tatia* is found in SI of goat in India

GENUS: *AVITELLINA*

SPECIES: *A.CENTRIPUNCTATA*

- Present in SI of cattle, sheep and goat
- Rostellum is absent
- Scolex unarmed with distinct neck
- In mature proglottid segmentation is indistinct
- There is one set of genital organs alternating in irregular fashion
- As the name indicates, vitelline glands are absent
- Ovary is spherical located to the side where genital pore situated
- Testis are in groups and lies on either side of excretory canal
- Uterus is like transverse sac like and lies transversely in middle of mature segment.
- Pyriform apparatus is absent in the eggs.

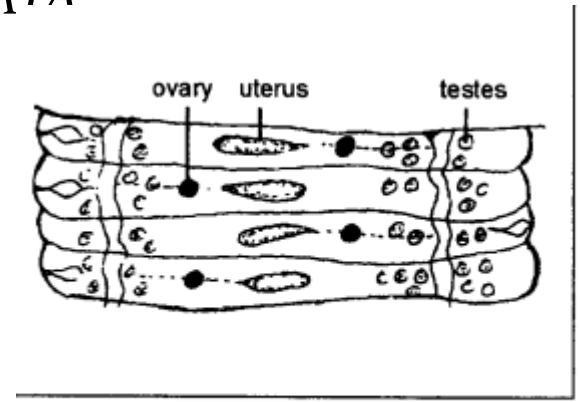


Fig. 40. Avitellina centripunctata (mature segment)

LIFE CYCLE

- Gravid proglottid passed in the faeces which disseminates the egg.
- Life cycle indirect.
- IH is not clearly known but different species of Psocids (Bark lice, book lice, dust lice) are suspected to act as i/m host
- Upon ingestion of egg, cysticercoid develop because IH is invertebrate
- DH get infection by ingestion of IH
- In the DH, arthropod are digested and larval stage, i.e. cysticercoid is liberated which subsequent develop into adult tapeworm

DIAGNOSIS

- On observing gravid proglottids with one paruterine organ in centre
- By finding eggs in faeces
- On PM Examinantion: By finding unsegmented worm in the intestine having a dark opaque line in the centre of the segment

GENUS: *STILESIA*
SPECIES: *S.HEPATICA*
S.GLOBIPUNCTATA

- *S.hepatica*: occurs in the bile duct of sheep, goat, cattle and other wild ruminants.
- *S.globipunctata:* present in the small intestine of sheep, goat, cattle and other ruminants
- Strobila is very thin and membranous, therefore margins appear wrinked
- Morphologically resembles *Avitellina*
- Vitelline glands absent
- The testes are chateristically present median to the excretory canals.
- Two bulging part of the uterus are connected by a transverse duct , therefore, uterus is **dumb bell shaped**
- Two lobe of uterus later on form two paruterine organs in gravid proglottids.
- Mites – IH
- Causes bile duct thickness

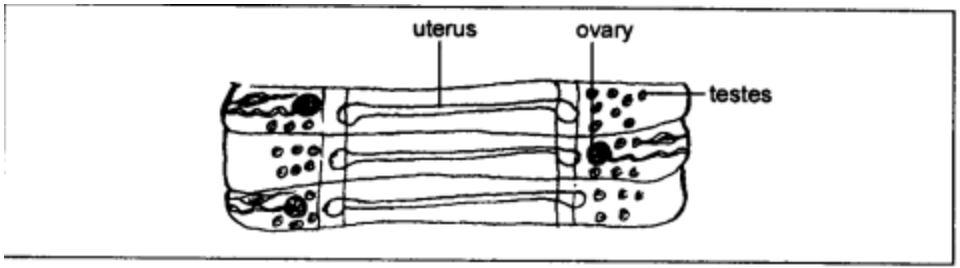


Fig. 41. Stilesia hepatica (Mature segment)

HELICOMETRA GIARDI (=*THYSANIEZIA GIARDI*)

- Adult worm may reach around 2 meters in length
- Found in SI of sheep, goat and cattle
- Scolex unarmed with distinct neck
- Segments are short, each having single set of genital organ
- Genital pore alternate irregularly
- Testis are lateral to excretory canal
- Uterus is transversely placed and ‘M’ shaped
- Side of the segment which contains cirrus sac bulges out giving the margins of the worm an irregular appearance
- Gravid segment contain many small size parutrine organs containing single cell each

THYSANOSOMA ACTINOIDES

- Genus - Thysanosoma
- Species - T. actinioides
- Host - Sheep, goat and cattle
- Site/location - bile duct, pancreatic duct and small intestine.
- Common name - Fringed tape worm and double-pored tape worm.
- The worms are called fringed tape worms as the segments are fringed posteriorly.

- **Pathogenecity** - Digestive disorders and unthriftiness.
- **Life cycle-** Intermediate hosts - Psocids - book lice or barklice (free living lice resembling mallophaga).

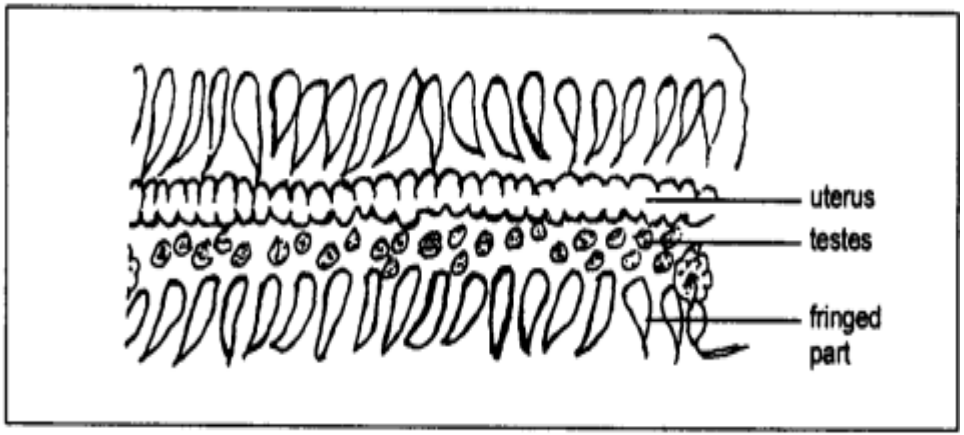


Fig. 38. Mature segment of Thysanosoma actinioides

Tapeworm of poultry

Family Davaineidae

Family Dilepididae

Family Dipylididae

Tapeworm of poultry

- Family Davaineidae: *Davainea*, *Raillietina*, *Cotugnia*
- Family Dilepididae: *Aboebotaenia*
- Family Dipylididae: *Choanotaenia*
- Family Hymenolepididae: *Hymenolepis*

- Order - Davaineidea
- Family - Davaineidae
- Genus - Raillietina
  - Davainea
  - Cotugnia

- Order - Dilepididea
- Family – Dipylidiidae (The scolex has an armed rostellum)
- Genus - Dipylidium and Choanotaenia
- Family -Dilepididae
- Genus - Amoebotaenia

Family: *Davaineidae*

Davainea proglottina : dwarf tapeworm of poultry

small intestine of fowl, pigeon and other gallinaceous birds.

Morphology

Adults are microscopic with 4-9 segments

Size measures around 4mm in length. It is the smallest tapeworm of poultry and causes huge mortality in poultry

It has a scolex provided with rostellum and suckers which are armed with thorn shaped hooks

- **Family is characterized rostellum by hammer shaped hooks.**
- Neck is almost absent.
- Single set of reproductive organ with genital pore alternate irregularly.
- In gravid proglottid uterus is replaced by egg capsule
- Gravid proglottid has egg capsule but each egg capsules contain only one egg
- Segments are narrow anteriorly and wider posteriorly giving triangular appearance

Life cycle

- Gravid proglottids are voided in the droppings of infected birds
- The egg capsule & eggs are released
- Eggs swallowed by diff. types of gastropod mollusc (Snails or slugs like *Limax*, *Arion*, *Cepoea*, *Agriolimax* sp.) which act as the I/M host
- In the body cavity of this slugs, eggs hatch and cysticercoid develops after 3 weeks
- Birds acquire the infection by swallowing slugs containing cysticercoid
- In S.I. adult worm develops 2 weeks after infection, i.e. PP is 14 days

- Pathogenesis: Haemorrhagic enteritis, reduced growth rate, emaciation and weakness.
- Diagnosis:
  - Examination of the faecal sample reveals presence of one egg in one capsule.
  - mucosal scrapping is taken and sieved through the mesh of minute pores so that the small tape worms do not escape. The sieved material is examined under the dissecting or stereoscopic microscope.

Raillietina

- There are about 200 species described in the literature occurring in different types of host but the one occurring in poultry are divided into 2 sub genera

***Raillietina tetragona* : Largest tapeworm of poultry**

R.echinobothrida

Raillietina cesticillus

Location: Small intestine of poultry

Ants and fly *(Musca domestica)* act as intermediate hosts of R. tetragona and R. echinobothrida. The beetle acts as the intermediate host of R. cesticillus.

Raillietina tetragona

- Large tapeworm of poultry.
- Size around 25 cm long
- Suckers are oval in shape & armed with 3-4 layers of spines
- Rostellum armed with 100 spines
- Mature proglottids has one set of genital organs and genital pore which is unilaterally placed and alternate irregularly
- Ovary is median in position in mature segment
- Gravid proglottids has egg capsules with each egg capsule containing 6-12 eggs

R. tetragona	*R. echinobothrida*	*R. cesticillus*
Suckers are oval in shape	Suckers are circular in shape	Suckers are inconspicuous, i.e. not clear
Rostellum is armed with single row of hooks (100 spines)	Rostellum is armed with 2 rows of hooks (200 spines)	Rostellum is armed with 400- 500 small hooks
Uterus has 6-12 eggs per egg capsule	Uterus has 8-10 eggs per egg capsule	Uterus has single egg per egg capsule
	Gravid proglottids frequently separate in middle forming windows in the strobila	

Life cycle

- In *R.tetragona* and *R.echinobothrida*, different species of ants (*Pheidole* and *Tetramorium*) acts as I/M host in which cyticercoid develops. Birds acquire infection by swallowing ants. Prepatent period is 13-21 days.
- In *R. cesticillus*, IH are beetle of different types. Prepatent period is around 20 days.
- Developmental stages
- Egg • Oncosphere • Cysticercoid in the intermediate host (infective stage) • Adult

pathogenesis

- *Raillietina echinobothrida* is the most pathogenic of these three species.
- It forms nodules at the site of attachment and causes hyperplastic enteritis. This is also known as **nodular tapeworm of poultry**.
- These nodule protrude out from serosal surface into the peritoneal cavity and the condition is known as **nodular taeniasis.**
- These nodule may appear as Tuberculosis nodules containing necrotic mass in the centre surrounded by zone of inflammation and fibrosis comparatively *R.echinobothridia* is less pathogenic but during heavy infection there may be mild enteritis resulting in loose dropping.
- *R. tertagona* is less pathogenic but more common and may result in loss of weight, decreased production etc.
- *R. cesticillus* is not harmful until present in large numbers.

Cotugnia	Location	Species
C. digonophora	SI	Fowl
C. fastigata	SI	Duck
C. cuneata	SI	Pigeon

Cotugnia dignophora

- Adult tapeworm are around 10 cms long
- Present in small intestine of birds
- Rostellum armed with 2 rows of spine
- Scolex is provided with unarmed suckers
- Mature proglottids has two sets of genital organs, thus known as **double pored tapeworm of poultry.**
- Numerous testes lies posterior to genital pore, extending from one side of proglottid to other and crossing beyond excretory canal
- Gravid proglottids contains egg capsules containing single egg

Order Dilepididea: It has two families

A)Dilepididae (Poultry tapeworm): *Amoebotaenia*

B)Dipylidiidae (Dog, poultry): *Choanotaenia*, *Dipylidium*, *Diplopylidium*, *Joyeuxiella*, *Metroliasthenes*

Amoebotaenia cuneata (*A. sphenoides*)

- Present in the small intestine of domestic fowl
- Rostellum armed with 14 elongated bottle shaped hooks. Suckers oval in shape and unarmed
- Strobila of is triangular in shape containing about 20 segments.
- Mature proglottids has one set of genital organ with genital pore alternating irregularly and open at extreme anterior end of margin
- Testis are located at the posterior margin of each mature proglottid
- Gravid proglottid has transverse uterine sac filled with eggs
- Bilobed ovary appears like wings spreaded by bird

Life cycle

- **Earthworm** of Genera *Eisenia* and *Phertina* acts as I/M host in which the cysticercoid develops in 2 weeks after the infection
- Cysticercoid develop in 14 days
- Fowl acquire infection after rains because earthworms come to the surface.
- Earthworms are digested inside the birds and cysticercoid are liberated.
- Pre-patent period is 4 weeks
- Cysticercoid has a lot of protective secretory covering (anti-enzymatic substances) over it which protect it from digestion by enzymes.

Choanoetaenia infundibulum

- Occurs in the upper half of small intestine of fowl and turkey.
- Scolex is provided with armed suckers
- Rostellum armed with 16-20 elongated spines
- Mature proglottids has one set of genital organ with genital pore alternating irregularly and opens near the posterior margin of the segment
- Ovary is lobed and testis lies below ovary.
- Vitellaria has two branches.
- Proglottids are markedly wider posteriorly and narrow anteriorly giving funnel shaped appearance, thus named as C. infundibulum.
- Beetles (of genera *Aphodius*, *Calathus*, *Tribolium*) and house flies act as the I/M host in which cysticercoid stage develops

Family Hymenolepidae

Species: *Hymenolepsis carioca*

Species	Host	Intermediate Host
Hymenolepis nana	Rodents and man	Man-Nil Rodents- Flour beetle and flea
H. diminuta	Rodents and man	Flea and flour beetle
H. microstoma	Rodents (Gall bladder, bile duct, duodenum)	Unknown
H. carioca	Fowl	Dung beetle and flour beetle
H. lanceolata	Duck and Geese	Aquatic crustacean
H. cantaniana	Chicken/ birds	Aquatic crustacean
H. nyrocae (Diorchis nyrocae)	Ducks	Copepod crustacean

Hymenolepis carioca

- Present in small intestine of poultry
- Rostellum armed with elonagted spines
- Mature proglottid contains genital pore unilaterally placed
- There are three testis in each mature proglottid
- Different beetles and *Stomoxys* spp. acts as I/M host

- *Moneizia expansa*: eggs triangular and inter proglottid glands ring like or rossette shaped
- *M. bendeni*: eggs square shaped, glands are linear or band shaped

Tapeworm of CANINES

- Family Taeniidae
- Family Dilepididae
- Family Dipylididae
- Family Diphyllobothridae

Family Taeniidae

- They are usually large worms measuring in metres (length).
- Adult tapeworms are found in carnivores and man.
- Gravid proglotids are longer than wide.
- Rostellum, if present, has 2 rows of small and large hooks.
- Single set of genital organ and large number of testis are present.
- Ovary is present in posterior part of segment. Uterus is median
- The eggs of Taenia spp are very much characteristic. The capsule of the eggs are easily lost and the embryophore is striated in appearance.
- Genera of importance: Taenia and Echinococcus

Genus -Taenia

- Species
- *T solium*
- *T saginata*
- *T hydatigena*
- *T pisiformis*
- *T taeniaeformis*
- *T multiceps*
- Common name - *Taenia solium* is called as pork tape worm and *T saginata* is called as beef tape worm.

Intermediate stages and the hosts affected

	T. solium	***T. saginata***	***T. hydatigena***	***T. pisiformis***	***T. taeniaeformis***	***T. multiceps***
Intermediate stage	*Cysticercus cellulosae*	*Cysticercus bovis*	*Cysticercus tenuicollis*	*Cysticercus pisiformis*	*Cysticercus fasciolaris*	*Coenurus Cerebralis, C gaigeri*
Intermediate host	Pig	Cattle	Sheep and other ruminants	Rabbits	Rodents	Sheep and goat

T. solium

- Prevalence The tape worms are cosmopolitan in distribution.
- DH - man
- IH - Pig
- Site/location - Small intestine
- Morphology

- This tape worm is 3-5 metres long.
- Rostellum is present which bears two rows of hooks.
- gravid segments do not leave the host spontaneously as that of T. saginata.
- The ovary is trilobed.

Life cycle

- The eggs are expelled out. The eggs hatch after being ingested by the intermediate host. Pig is the intermediate host. In the intestine of the pigs, the eggs hatch and the oncospheres come out.
- oncospheres migrate in different organs and tissues. By hepatoportal circulation the oncospheres reach the liver.
- oncosphere may be disseminated by general circulation in different organs and muscles like lung, diaphragm, heart etc where the oncosphere develops to bladder worm or **metacestode (Cysticercus cellulosae) .**
- Human beings get the infection by ingestion of the ham or pork containing the cysticercoid.

- The human beings get infection by the following ways :
- By ingestion of the pork containing the cysticercus.
- By ingestion of the eggs through the food like coriander and salads and cysticercus develops in man.
- By autoinfection due to retrosperistaltic movement.
- Pathological features / lesions: enteritis, neurocysticercosis, measly pork condition, conjunctivitis, rhinitis (aberrant migration of oncosphere)

In man:

1. The tapeworms utilize the nutrition of the host thus causing great loss of nutrient in the hosts.
2. Presence of large number of Taenia soiium and T. saginata cause enteritis.
3. The serious effect which is exhibited by the human being is due to neurocysticercosis. Migration of the oncospheres in the brain and formation of cysticercus causes severe damage in the brain. Apart from this, there may be occular cysticercosis due to formation of cysticercus in the eye. This results in conjunctivitis, rhinitis etc.

- In pig: In pig, the pathogenesis is caused by the migration of oncosphere and formation of the cysticercus in the vital organs.
- The cysticerci present in different organs are called 'measly pork'. If the oncosphere migrates to the brain, the condition becomes very severe. Different neurological problems occur.

Pathogenesis & symptoms

- **IN HUMAN:**
- When cysticercosis develop in subcutaneous tissue practically harmless
- When in C.N.S tissue, condition is called neurocysticercosis
- When cyst is alive in CNS tissue there is generally no symptom
- In man the cysticerci may become racemose (when cysticercus of *T. solium* form lateral protrusions producing grape-like aspects) and are referred to as ***Cysticercus racemosus***.
- cysticerci reaches CNS, it causes **Neurocysticercosis**
- eyes are involved, the condition is termed as **Opthalmo-cysticercosis**.

Control

- Preventing humans from consuming measly pork
- Preventing pigs from consuming eggs of *T.solium*
- Proper sanitation, confined pig rearing, cysts can survive for 6 weeks after death of pigs, washing raw vegetable
- proper cooking of pork 50-60^{0}C
- Vaccine: CYSVAX, which is the world's first vaccine to fight tapeworms in pigs.

Control

Cold treatment:

- Carcass must be exposed to freezing temperature
- -15^{0}C for 5 days
- -10^{0}C for 10 days
- -5^{0}C for 15 days

Taenia saginata

- Beef Tape worm producing measly beef
- Site / location -Small intestine
- Definitive hosts -Man
- Intermediate host - Cattle
- Develomental stages - Same as T. solium except the intermediate host is cattle.
- Meatcestode: Cysticerus bovis
- Cooking at 65.5°C or refrigeration of meat at -20°C or below for 2 or more days will prevent transmission of infection to man.

Taenia saginata	*Taenia solium*
1. Hosts – man	1. Hosts – man
2. Protruded part of the scolex (rostellum) is absent.	2. Rostellum is present and armed with characteristic hooks.
3. Number of segments is more (1000-2000)	3. Number of segments is less (800 – 1000).
4. Ovary is bilobed.	4. Ovary is trilobed.
5. Eggs are oval.	5. Eggs are spherical.
6. Uterus has 14 -32 branches.	6. Uterus has 16 branches.
7. These are called as beef tape worm.	7. These are called as pork tape worm.

Taenia asiatica

- A new species has been found in Taiwan, Indonesia and Phillipines (Asian) and has characters between *T. solium* and *T. saginata* and is called **Taiwan Taenia** (*Taenia saginata asiatica*) as it was first described in taiwanese aboriginals.
- *Cysticercus viscerotropica* is the metacestode stage of *Taenia saginata asiatica* found mainly in liver.

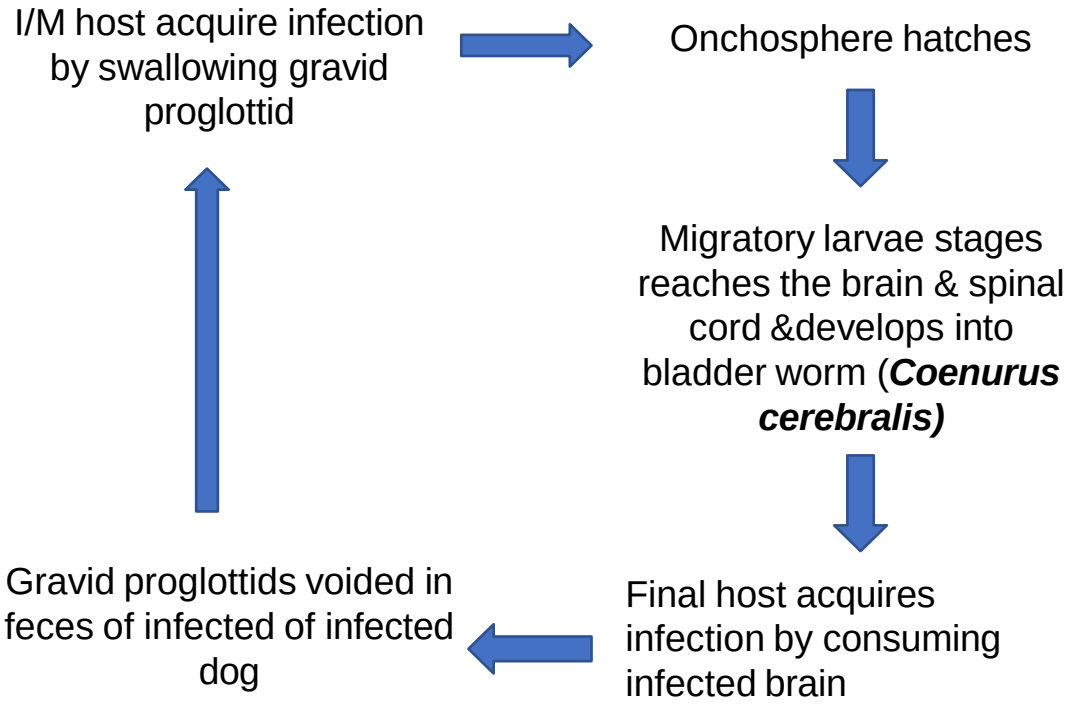
Taenia multiceps

- Prominent armed rostellum is present.
- intermediate stage is the Coenurus cerebralis which is apparently a transparent cyst containing about 200 - 400 scolices.
- The cysts are formed in the brain and other parts of the nervous system like spinal cord, medulla etc.
- Final Host: Dog
- Intermediate Host: Sheep, Goat

Life cycle

- Developmental stages
- Egg
- Oncosphere
- Coenurus (infective stages are formed in the brain of sheep and goat)
- Adult

Life cycle of *T.multiceps*



Pathogenesis and clinical signs

- Neurological clinical signs are referred as **Staggers or Gid**
- **Clinical signs depends on the location of the cyst**
- Cyst is mainly located on the parietal region on the surface of cerebral hemiphere
- Animal holds its head to one side and turns in circle towards the affected side
- It may also be blind in eye of opp side
- If the parasite is located at the ant. part of brain, then the head is held against chest and the animal walks in straight line untill hits an object and becomes motionless for some time.

Location of cyst	Sign and symptoms
Parietal region	Sheep holds its head on one side and move in a circle towards affected side and blind in the eye of opposite side.
Anterior part of brain	Trotter i.e. sheep holds its head against the chest , steps high or walk in straight line and on observing obstacles stop for a while, changes its direction and then again walk straight.
Ventricles of brain	Sheep holds its head backward and doesn't move in straight line
Cerebellum	Hyperaesthesia i.e get frightened easily and has jerky or staggering gait
Lumbar region of Spinal cord	Paralysis of hind legs

T. gaigeri

- Adult tapeworm occurs in small intestine of dogs.
- It is 182cm long and carries 28-32 hooks in 2 rows.
- Gravid uterus contains 12-15 lateral branches.
- ***Coenurus gaigeri*** is the metacestode stage found in intramuscular connective tissue of goats especially muscles of jaw.

***T. serialis* (*Multiceps serialis*)**

- Adults tapeworm are found in dogs and foxes.
- ***Coenurus serialis*** is the metacestode stage found in rodents especially rabbits, so called because protoscoleces in the larva form in rows or series hence the name.
- Metacestode stage is found in CNS (sheep), CT (rabbit), abdominal cavity depending upon host so need to be differentiated from *Coenurus cerebralis*.

Similarly, ***Coenurus brauni*** is found in case of ***Taenia brauni***.

- *Taenia ovis* (Dog-sheep tapeworm)
- *Cysticercus ovis* is the metacestode which occurs in the muscles of sheep, cardiac muscles and other organs.
- IH: Sheep
- DH: dogs and other wild carnivorous

Taenia hydatigena (Dog sheep tapeworm)

- Definative Host: Dogs, fox, cat, other canid and felid host
- Location: Small intestine
- I/m host: sheep, goat, cattle & buffalo
- bladder worms called ***Cysticercus tenuicollis***
- onchospheres are carried through the blood to liver in which they migrate for 4 weeks, and then they emerge on the surface and attach to the peritoneum.
- **Pathological Condition: Hepatitis cysticercosa**

Taenia pisiformis (Dog-rabbit tapeworm)

- Definative host: Dog, fox, several wild carnivores & rarely cats
- Location: Small Intestine
- I/M host: Logomorphs, rabbits, hares and rodents
- Adult tapeworm occurs in small intestine of dog and wild carnivores rarely cats but not so far in house dogs.
- Metacestode stage is *Cysticercus pisiformis* which develop in peritoneum of rabbit and hare.

Taenia taeniaformis (Cat rat tapeworm)

- Definitive host & location: Cats and other wild carnivores. , Small intestine
- I/M host: Rodents
- Intermediate stage is *Cysticercus fasciolaris* which is a strobilocercous with small vesicle having evaginated scolex connected to a segmented strobila resembling a small tapeworm.

- ***Taenia krabbei***: It is found in dogs and its metacestode stage *Cysticercus tarandi* is found in muscles of reindeer or caribou. It is also known as wolf **caribou tapeworm.**
- ***Taenia cervi***: It occurs in dog and the metacestode stage *Cysticercus cervi* occurs in deer and other ungulates.
- ***Taenia crassiceps***: It occurs in wild carnivores and *Cysticerci* found in rodents

Genus: *Echinococcus*

- *Echinococcus granulosus*
- *Echinococcus multilocularis*
- *Echinococcus oligarthus*
- *Echinococcus vogeli*
- *Echinococcus shiqucus*

Echinococcus granulosus

- Definitive host - dog and other related animals may be affected.
- Intermediate host - Sheep, goat, cattle and other related animals.
- Site / location - Small intestine
- Smallest tapeworm of dog
- Rostellum armed with two rows of spines
- The ovary is kidney-shaped.
- Meatcestode: Hyadtid cyst

Life cycle

- Developmental stages • Egg • Oncosphere • Hydatid cyst in the intermediate host (cattle, sheep and goat) • Adult
- eggs are expelled out of the host. The intermediate host gets the infection by ingestion of the eggs.
- oncosphere hatches out and penetrate the wall of the intestine.
- oncosphere develops to become the cyst (Hydatid cyst) in different organs like lung, liver etc.
- final host gets the infection by ingestion of the meat containing the cyst.

- Pathological features / lesions: Enteritis in dog and pressure atrophy in the vital organs due to presence of large-sized cysts and functional disturbances.
- intermediate host immature worms (cysts), if located in the vital organs like lung, liver or the diaphragm, these cause great damage to the host.

Diagnosis

- Faecal examination
- Different serological test like Double diffusion test, IHA, ELISA
- Human hydatidosis: X-ray technique, sonography, CT scan, MRI and Serological test
- ELISA, RIA, CFT, IHAT and CIE are better sensitive and specific tests.

Casoni's Test

- Scientist Casoni (1971) performed the test which is popularly called as Casoni's test. Hydatid cyst fluid is inoculated in the suspected individual and there would be hypersensitive reaction within 15 minutes or less in positive cases.

Treatment

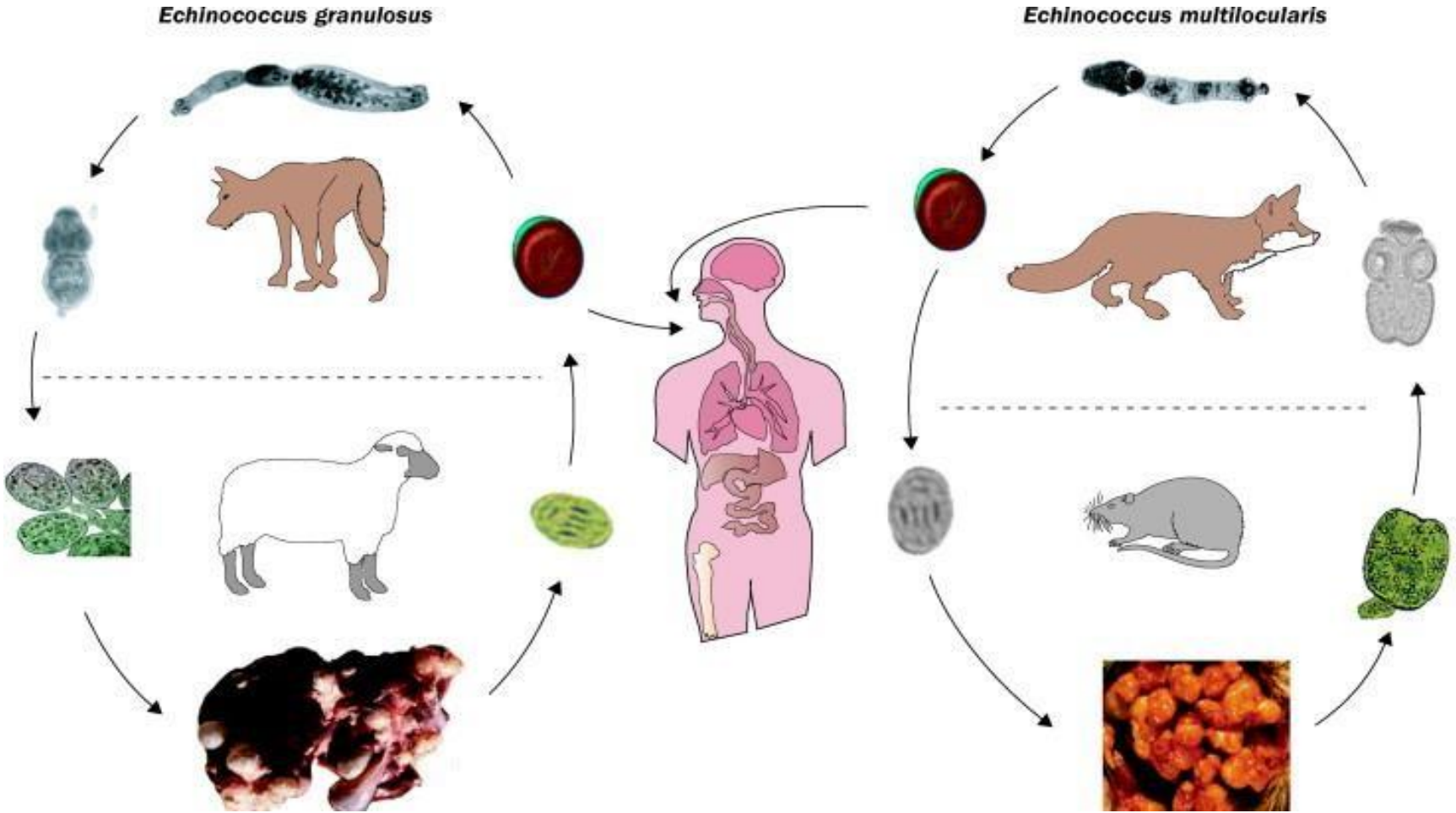
- In final host: Dogs can be treated with Praziquantel @5mg/kg b.wt. but it is not ovicidal.
- In I/M host: Albendazole @ 50mg/bwt
- Praziquantel @ 50mg/bwt
- In man, surgical removal of hydatid cyst or drugs like mebendazole, albendazole and praziquantel can be used.
- After the exposure of cyst, fluid is aspirated and 2.5% -10% formalin is injected to kill the germinal membrane
- Alternative technique, substitution of formalin with fresh serum with high complement activity

PAIR technique

- performed using either ultrasound or CT guidance.
- **P**uncture the cyst from thicker portion using 22G needle.
- **A**spiration of hydatid cyst content using a suitable cannula
- **I**njection of a scolicidal agent (sponge soaked in hypertonic salt solution of chlorhexidine gluconate or 10% formalin)
- **R**easpiration of cystic contents

Echinococcus multilocularis

- Present in S.I. of wild canids like fox, jackal
- Intermediate hosts are microtine rodents, squirrels, monkeys, pigs and man.
- Similar to *E.granulosus* but the hydatid cyst of *E.multilocularis* is multilocular (No. of cavities)
- Cyst doesn't contain fluid but its filled with gelatinous material

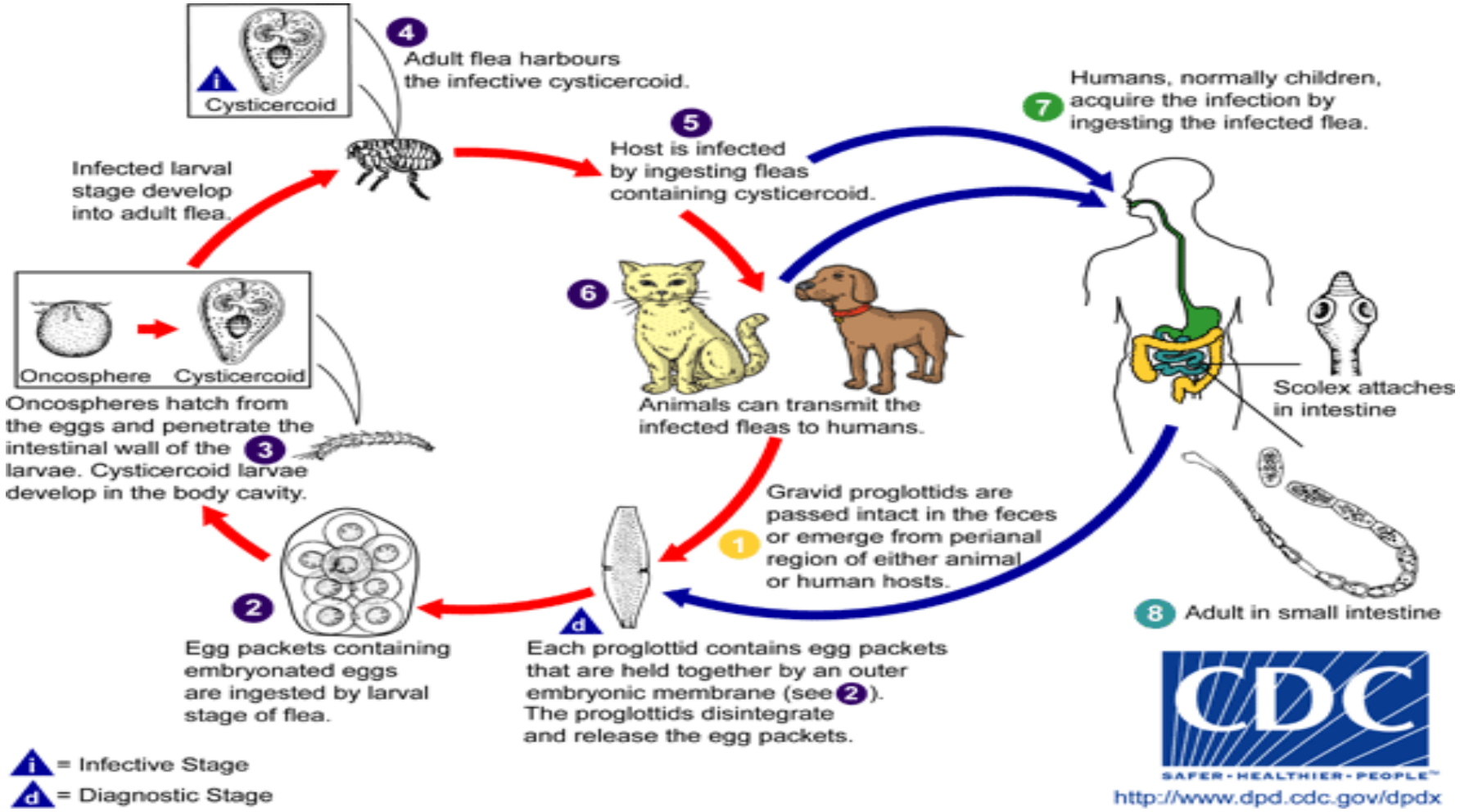

Echinococcus granulosus
Echinococcus multilocularis

Family - Dilepididae

- Tapeworms of dog, cat and fowl.
- Scolex usually has rostellum armed with several rows of hooks.
- Intermediate stage is a cysticercoid.

Dipylidium caninum

- Found in small intestine of dog, cat, fox and rarely man.
- It is the double pore tapeworm of canines.
- It is 50cm in length.
- Rostellum with 3-4 rows of small **rose thorn** shaped hooks.
- Mature segment with 2 sets of genital organs and numerous testes – double pored tape worm of dog
- Ovary and vitellaria form a mass on either side resembling a **bunch of grapes**.
- Mature segments are elongated and oval resembling cucumber seeds/large rice grain.
- Gravid segments are expelled in faeces and show some crawling activity.


Cysticercoid
4
Adult flea harbours the infective cysticercoid.
5
Host is infected by ingesting fleas containing cysticercoid.
7
Humans, normally children, acquire the infection by ingesting the infected flea.
Infected larval stage develop into adult flea.
Oncosphere
Cysticercoid
Oncospheres hatch from the eggs and penetrate the intestinal wall of the larvae. Cysticercoid larvae develop in the body cavity.
3
6
Animals can transmit the infected fleas to humans.
Scolex attaches in intestine
Gravid proglottids are passed intact in the feces or emerge from perianal region of either animal or human hosts.
1
2
Egg packets containing embryonated eggs are ingested by larval stage of flea.
d
Each proglottid contains egg packets that are held together by an outer embryonic membrane (see 2). The proglottids disintegrate and release the egg packets.
8
Adult in small intestine
i = Infective Stage
d = Diagnostic Stage
CDC
SAFER · HEALTHIER · PEOPLE™
http://www.dpd.cdc.gov/dpdx

Life cycle

- Segments passed out are active and shows crawling activity.
- They are either voided in the faeces or leave the host spontaneously.
- The eggs have to be ingested by dog lice *Trichodectis canis* or fleas *Ctenocephalides canis, C. felis* or *Pulex irritans* and in the abdominal cavity of these arthropods it develops into cysticercoids in 30 days in lice or many months in fleas.
- Final host gets infected by ingesting the infected intermediate hosts.
- Pre-patent period is 3 weeks.
- Humans infection are due to accidental ingestion of infected fleas when children play with dogs or cats.

Pathogenesis

- Adults are not very harmful.
- However, gravid segments are found crawling around and cause irritation.
- Dog drags its anus on ground to get rid of irritation (scooting behavior).
- Very heavy infections can cause gastroenteritis.
- By close contact with infected dogs, children get infected and usually even presence of one worm can cause gastroenteritis.

Diagnosis

- Based on anal irritation and dragging of anus.
- characteristic cucumber shaped proglottids.
- They are quiet active and crawl in faeces.
- Egg capsule contains upto 30 eggs which can be seen after triturating the gravid segment.

FAMILY -MESOCESTOIDIDAE

- *Mesocestodes lineatus*
- medium- sized cestodes of canids which inhabit the small intestines. For biological development, the tape worms require two intermediate hosts, mite and bird or the reptiles.
- Definitive host- Dog, cat, fox and other related animals.
- Intermediate host - 1st intermediate host -mites
- 2nd intermediate host -birds
- Developmental stages • Egg • Oncosphere • Cysticercoid in mite • Tetrathyridium in birds • Adult

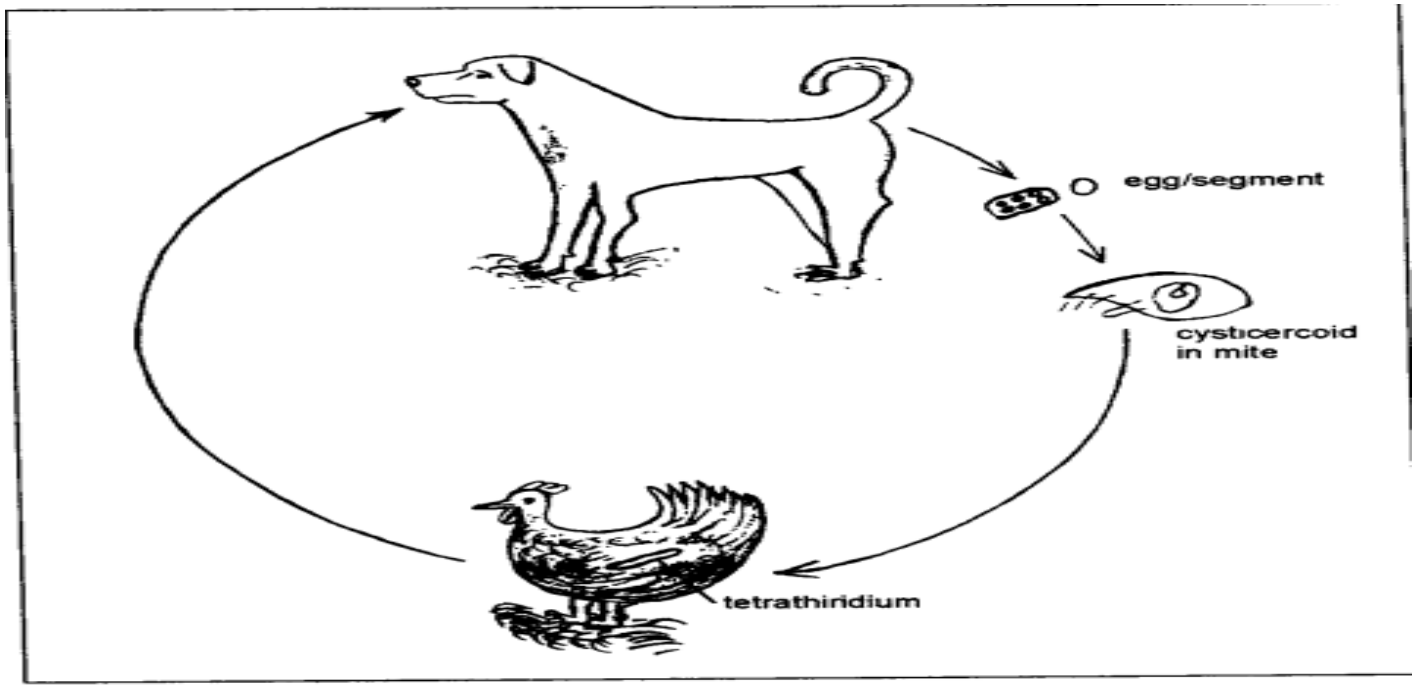


Fig. 47. Life cycle of Mesocetoides spp.

FAMILY - HYMENOLEPIDIDAE

- tape worms found in the small intestine of man, rat, rodents and birds.
- direct and indirect types of life cycle.
- Hymenolepis nana is called as dwarf tape worm of man

Species	Host	Intermediate Host
Hymenolepis nana	Rodents and man	Man-Nil Rodents- Flour beetle and flea
H. diminuta	Rodents and man	Flea and flour beetle
H. microstoma	Rodents (Gall bladder, bile duct, duodenum)	Unknown
H. carioca	Fowl	Dung beetle and flour beetle
H. lanceolata	Duck and Geese	Aquatic crustacean
H. cantaniana	Chicken/ birds	Aquatic crustacean
H. nyrocae (Diorchis nyrocae)	Ducks	Copepod crustacean

- Life cycle Developmental stages • Egg • Oncosphere • Cysticercoid in the intermediate host (beetles and fly) • Adult

- In man, life cycle is direct type. In the intestinal villi, the cysticercoids develop which get detached and develop to become sexually matured tape worm in the lumen of small intestine.
- In case of the Hymenolepis carioca, beetles and flies act as intermediate hosts. In the intermediate host cysticercoid develops which is the infective stage of the parasite. The final host gets the infection by ingestion of the intermediate host harbouring the cysticercoids.

FAMILY DIPHYLLOBOTHRIIDAE

- Class - Cotyloda
- Order - Diphyllidea
- Family – Diphyllobothriidae
- Genus – Diphyllobothrium and Spirometra

GENUS -DIPHYLLOBOTHRIUM

- ***Diphyllobothrium latum*** **(Fish Tapeworm/ Broad Tapeworm)**
- characteristic shape of the head is having taxonomic importance which is spatula-shaped with a deep groove in the middle. This is called as bothria.
- No elevated or protruded part (rostellum) of the scolex is present.
- eggs are oval and operculated and have fair resemblance to the eggs of trematode.
- The ovary is bilobed and uterus is rosette -shaped
- Definitive host - Dog, cat, fox are the usual hosts but these parasites may be found in other animals like pigs and other related animals.
- Intermediate hosts 1st intermediate host - cyclops 2nd intermediate host - Fish

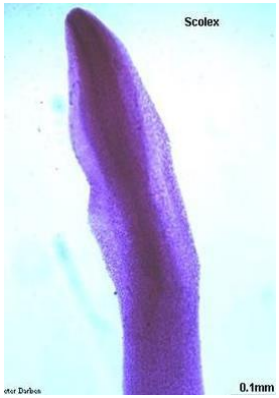
Life cycle of Diphyllobothrium latum

Eggs voided in the feces of infected host

Eggs develop for several weeks to produce **Coracidium**

Coracidium hatches out from the egg to become free in water

Coracidium stages are swallowed by 1st I/M host **cyclopid** or **diaptomid copepod**







In the haemocele of 1st I/M host coracidium is converted to **procerciod** (2-3 weeks)

Different types of fresh water fishes act as 2nd I/M host which swallows cyclopid/ diatomid copepod containing

Procercoid are released in the gut of fish penetrate the gut wall and develop to infective stage called **pleurocercoid**

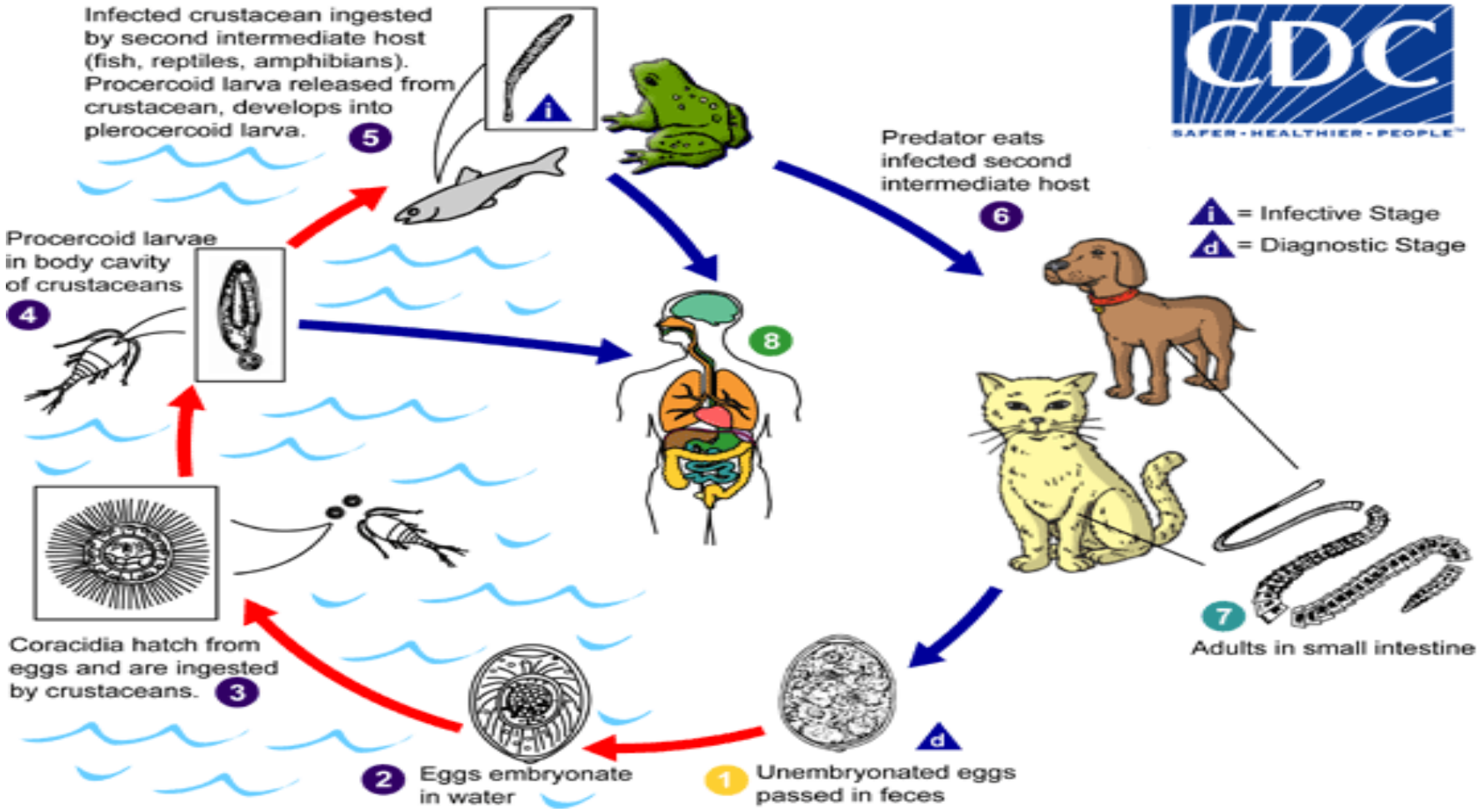
Definitive host acquire infection by consumption of raw and inadequately cooked fishes containing pleurocercoid

Adults in the SI of DH

- Developmental stage • Egg • Ciliated coracidium • Procercoid (Found in cyclops) • Plerocercoid (Found in fish) • Adult

- deficiency of Vit B-12 is common feature in man which ultimately results in pernicious anaemia.
- When the gravid segments crawl or lodge in the anal region, these gravid segments cause constant irritation in that region.
- nervous damage due to absorption of the metabolites released by the tape worm which is toxic to the host.
- Freezing of fish for atleast 10 days can kill the scolices.

- Genus Spirometra
- Important species: *S. mansoni S. mansonoides S. erinacei*
- Hosts - More three species occur in small intestine of cat.
- **Sparganosis:** It is a disease caused by plerocercoid of Spirometra in human beings.
- Man gets the infection by accidental ingestion of the cyclops harbouring procercoid. This procercoid transforms into plerocercoid in subcutaneus tissues of man.


Infected crustacean ingested by second intermediate host (fish, reptiles, amphibians). Procercoid larva released from crustacean, develops into plerocercoid larva.
5
i
Predator eats infected second intermediate host
6
i = Infective Stage
d = Diagnostic Stage
Procercoid larvae in body cavity of crustaceans
4
8
7
Adults in small intestine
Coracidia hatch from eggs and are ingested by crustaceans.
3
d
2
Eggs embryonate in water
1
Unembryonated eggs passed in feces

Pathogenesis

- Adult *Spirometra* are rarely pathogenic
- Plerocercoids are of public health importance as they causes sparganosis in man
- Human may get infected in 3 ways:

1. By accidental ingestion of crustacea infected witth procercoids. The procercoids migrate to the subcutaneous tissues and musculature and develop as plerocercoids.

2. By the ingestion of plerocercoids in second intermediate hosts.

3. When infected frog or flesh used as a dressing for wounds or eyes, the plerocercoids may migrate in the human eye or flesh.

GENERAL TREATMENT OF CESTODES

Dogs	Sheep, goat and cattle
1. Arecolie hydrobromide Dose -2 mg / Kg	1. Praziquantel Dose – 15 mg / kg
2. Arecoline acetarsol Dose-5 mg / kg	2. Albendazole Dose – 10 mg / kg
3. Dichlorophen Dose - 0. 3 mg / Kg	3. Oxfenbendazole Dose -5 mg / kg
4. Hexachlorophene Dose – 15 mg / Kg	4. Fenbendazole Dose – 5mg / Kg
5. Bunamide hydrochloride Dose -25 – 50 mg / Kg	5. Bithionol Dose – 200 mg / kg
6. Bithionol Dose- 200 mg / Kg	6. Niclosamide Dose – 75 – 150 mg / Kg
7. Nitroscanate Dose -50 mg / Kg	
8. Niclosamide Dose – 100-150 mg / Kg	
9. Praziquintel Dose -5 mg / Kg	

- Cucumber seed shaped gravid proglottids are passed out in faeces of dogs infected with
- (1) Echinococcus granulosus
- (2) Diphylidium caninum
- (3) Taenia hydatigena
- (4) Diphyllobothrium latum

- Hydatid cyst is the infective stage found in
- (a) Dipylidium caninum
- (b) Echinococcus granulosus
- (c) Taenia multiceps
- (d) Toxocara canis

- The dogs may drag their anus over the ground due to following reasons.
  - Dipylidium caninum infection.
  - Migration of gravid proglottid in perianal region causes irritation.
  - Pruritus ani and impacted anal glands may also be responsible.
- Which statement among the above is true?
- Options:
    - a is true but b and c are false
    - a and b are true but c is false
    - a and c are true but b is false
    - All are true

- Coenuriasis in sheep causes:
- (A) Sheep Gid
- (B) Nervous ataxia
- (C) Hydatid disease
- (D) Alveolar hydatid disease

- Neurocysticercosis in human-beings is caused by:
- (A) Cysticercus ovis
- (B) Cysticercus bovis
- (C) Cysticercus tenuicollis
- (D) Cysticercus cellulosae

- Taenia mutliceps is tapeworm of dog and its larval stage present in sheep/cattle is known as:
- (A) Cysticercosis
- (B) Hydatid
- (C) Coenurus cerebralis
- (D) Taeniasis

- Which of the following is an example of cestodes?
- (A) Trichuris vulpis
- (B) Isospora felis
- (C) Ancylostoma caninum
- (D) Dipylidium caninum

- "Hepatitis cysticercosa" in sheep is a condition associated with:
- (A) Cysticercus bovis
- (B) Cysticercus cellulosae
- (C) Cysticercus tenuicollis
- (D) Cysticercus fasciolaris

- . Neurocysticerocis is due to:
- (A) Eating salads
- (B) Eating uncooked pork
- (C) Both (A) and (B)
- (D) Eating uncooked beef

- The intermediate host of Dipylidium caninum is:
- (a) Flea
- (b) Fly
- (c) Mite
- (d) Tick

A.Taenia hydatigena	1.	Cysticercus ovis	
B.Taenia ovis	2.	Coenurus cerebralis	
C.Taenia taeniaformis	3.	Cysticercus tenuicollis	
D. Taenia multiceps	4.	Cysticercus fasciolaris	

Code:

	A	B	C	D
i.	2	1	3	4
ii.	4	1	2	3
iii.	3	1	4	2
iv.	3	2	1	4

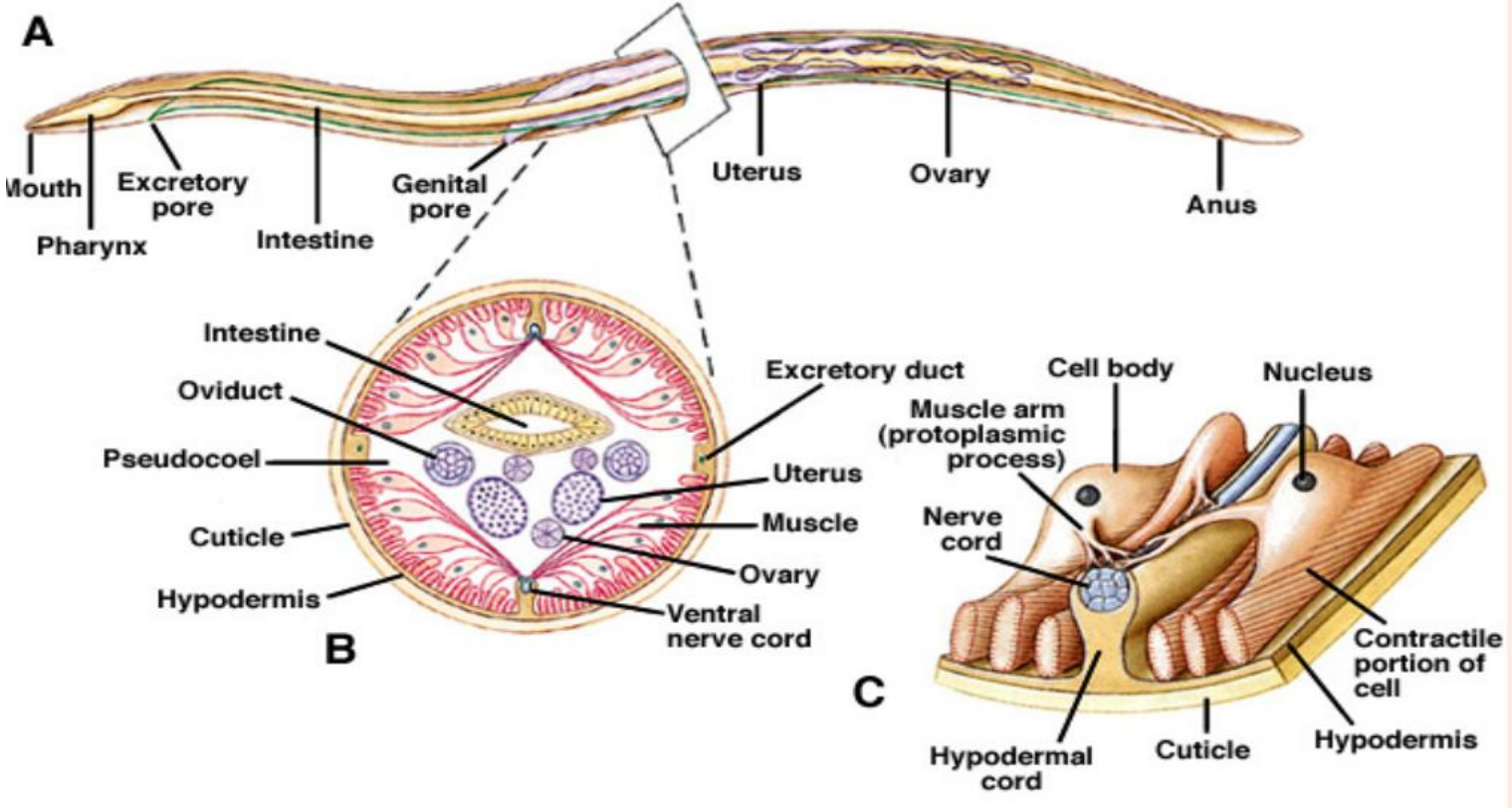
- Drug of choice for Echinococcus granulosus in dogs is
- Albendazole
- Praziquantel
- Oxfendazole
- Piperazine

Nematodes

Phylum – Nemathelminthes

- Class – Nematoda
- commonly called roundworms because of their appearance in their cross sections.
- free living or parasitic, unsegmented worms
- sexes are separate and females longer than male
- Suckers absent
- Outer covering is the cuticle. The cuticle is formed by : a. Hypodermis (Subcuticular layer) b. Muscle layer
- hypodermis projects into the body cavity forming two lateral cords which carry the excretory canals and dorsal and ventral cords which carry the nerves

Structures of a nematode



DIGESTIVE SYSTEM

- Moderately developed digestive system is found in the nematodes. The digestive system starts from the mouth. The mouth may be surrounded by lips.
- Structure and arrangement of lips are varied:
- The most primitive form having three lips, one dorsal and two subventral. . . . Ascarids
- Mouth surrounded by two lips, each lip being trilobed ... Spirurids
- Lips are absent ... Strongyle
- In the nematodes without lips, secondary structures develop in their place. For example, in Strongylidae, there are leaf crowns
- pharynx, oesophagus, intestine, anus etc.
- Oesophagus is very important in respect of taxonomic identification.

Oesophagus

- **Bulbus-** presence of a posterior bulb. Ex-Heterakis gallinantm.
- Oesophagus of some round worms is double bulbed (Oxyuroids).
- **Rhabditiform -** anterior pyriform and posterior bulbous appearance. Ex -Strongyloides spp.
- **Ventriculus -**Anterior part of the oesophagus is muscular and the posterior part of the same is glandular. Ex- All spirurid worms.
- **Filariform-** oesophagus is tubular. Ex - found in filarial worms.
- **Trichuroid-** Oesophagus is composed of cells arranged in a row. Example - Trichinella spp.

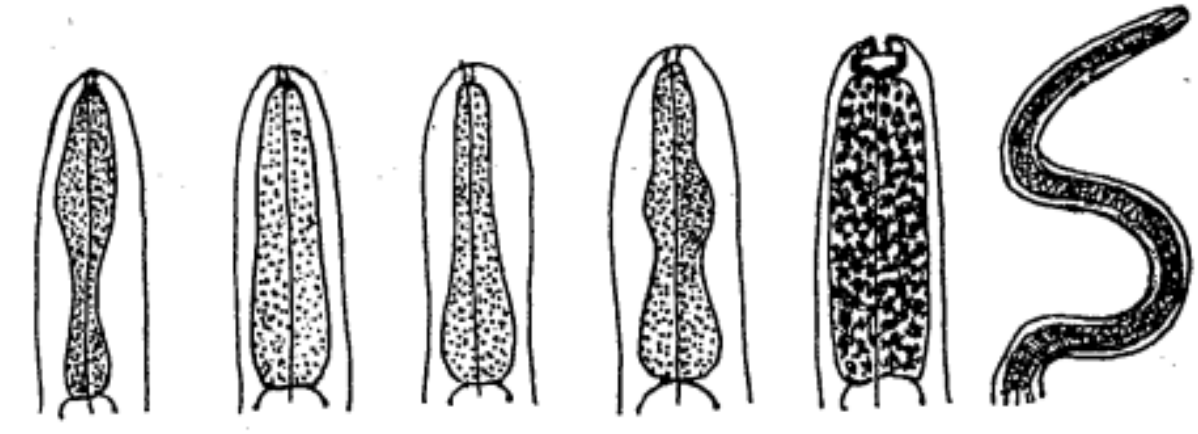


Fig. 2. Types of oesophageal structures in nematodes.

- **EXCRETORY SYSTEM**: It is an osmoregulatory system and opens by a ventral pore situated at a short distance behind the anterior extremity.
- Flame cells absent
- **Nervous system**:

a. Oesophageal nerve ring

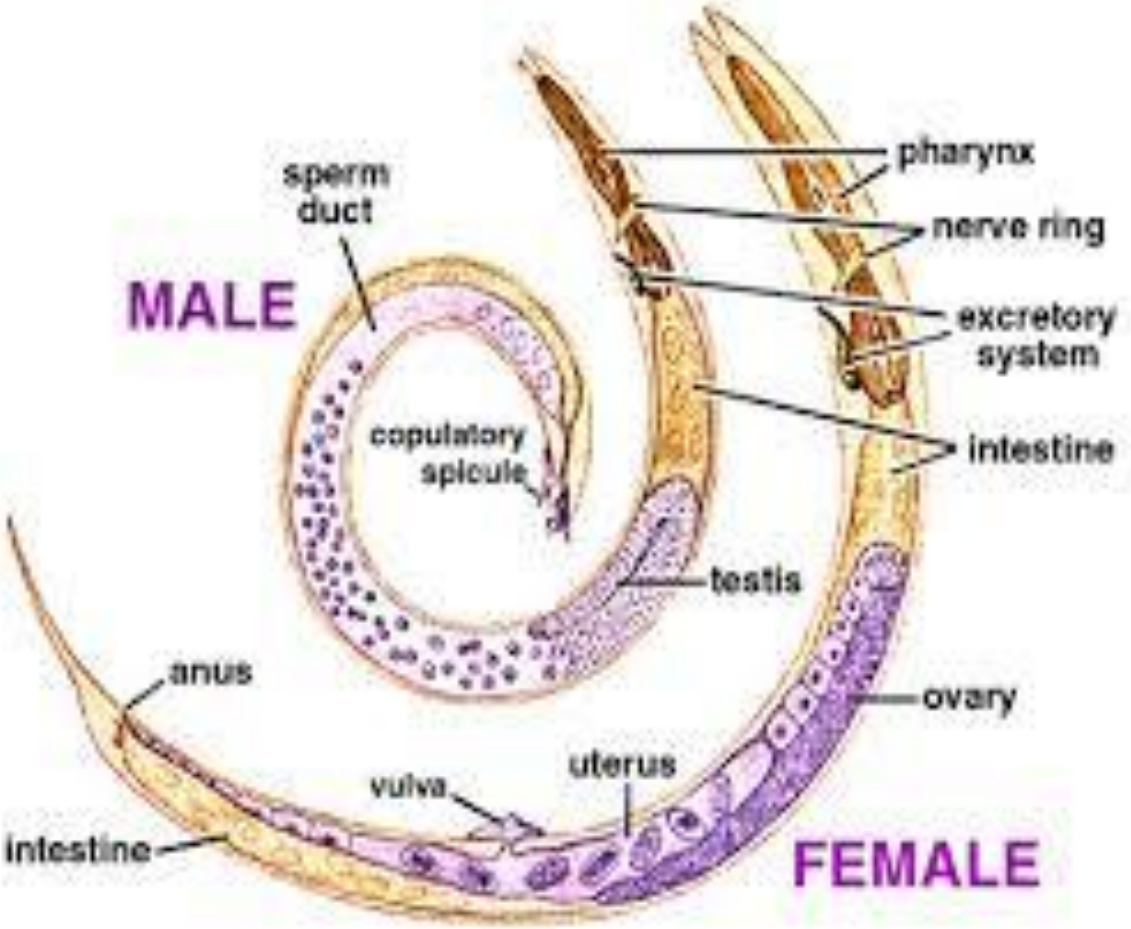
b. Nerve ganglia

c. Nerve fibres connecting nerve ganglia

d. Sense organs (phasmids, amphids, cervical papillae and genital papillae).

THE REPRODUCTIVE SYSTEM

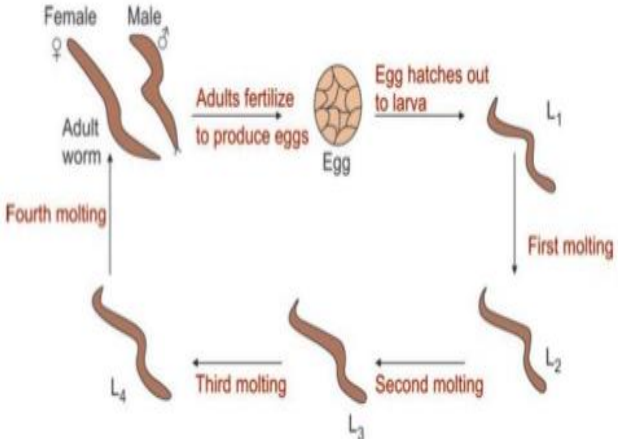
- unisexual and the sexes are separate.
- male organs are composed of a single testis, a vas deferens, sometimes a seminal vesicle and a muscular ejaculatory duct opening into the cloaca.
- In most nematodes, there are one or two spicules lying in sheaths. These are cuticular, often pigmented, and vary in shape and size. These help in the copulation for attachment and expanding the vagina for direct flow of the sperms.
- The spicules have, in some cases, other cuticular thickenings for guiding them e.g. a thickening on the dorsal wall is called gubernaculum and one on the ventral wall is called the telamon.
- Besides, there is a copulatory bursa, supported by cuticular bursal rays, which embraces the female during copulation .
- The parasitic nematodes are very prolific and a single female may lay several thousands eggs per day.


sperm duct
MALE
pharynx
nerve ring
excretory system
intestine
copulatory spicule
testis
anus
ovary
uterus
vulva
intestine
FEMALE

- In female nematodes, there is a vulva with two uteri and two ovaries. If the genital opening is in the posterior region, the uteri and ovaries run forwards (prodelph).
- In case the genital opening lies in the anterior region, the uteri and ovaries run backwards (opisthodelph).
- In case the genital opening is situated in the middle or closer to anterior extremity, the uteri may run in opposite directions (amphidelph).
- Some female nematodes are oviparous, others are ovo-viviparous or viviparous

Life cycle

- Life-cycle includes eggs and five larval stages and mature adult worm.
- Larval stages are designated as 1st, 2nd 3rd, 4th and 5th stage larva i.e. L1, L2, L3 ,L4 and L5 (Immature adult) .
- Molting or ecdysis i.e. shedding of cuticular sheath takes places between two larval stages .
- Four molting occur in the life-cycle of nematodes.



- Generally, the first three larval stages are pre-parasitic which may occur either as free-living larvae or develop inside the intermediate host of nematodes having direct or indirect life-cycles, respectively.
- L3 stage is generally sheathed within old cuticle and called the infective stage.
- However, in case of ascarid worms, the second stage larva, developing within the egg shell, makes the egg infective.
- In case of Trichuris, embryonated egg acts as infective stage

Life cycle

- In general, the nematodes are monoxenous (having direct life -cycle) or heteroxenous (having indirect life-cycle involving one or more intermediate hosts).
- There is only one example in which a host, at first stage acts as definitive host and the same host becomes an intermediate host at later stage of the infection. Such a nematode is called an **autoheteroxenous parasite (e.g. Trichinella spiralis).**
- In heteroxenous nematodes, the various intermediate hosts include beetle, earthworm, snail, slug, gastropod, mollusc, housefly, stable fly, cockroach, grasshopper, isopod, cyclops and other crustacea, mosquitoes, tabanid flies and other blood sucking flies, oligochaete, annelid etc.

A. Nematodes with direct life-cycle

Name of infective stage	Mode of infection	Example
Egg with L2 inside	Ingestion	Ascarids
Pre-parasitic infective larva (L3)	Ingestion	Strongylids
Pre-parasitic infective larva (L3)	Active penetration of the skin of the host	Hookworms, Strongyloides spp.

Name of infective stage	Mode of infection	Example
Dormant larvae (L2) in organs/ tissues	Prenatal or transplacental	*Toxocara canis, T. vitulorum,* sometimes *Ancylostoma caninum*
Migratory (L2) stage in body of female mammal	Transmammary or transcolostral	*Toxocara* spp.

B. **Nematodes with indirect life-cycle**

Name of infective stage	**Mode of** infection	**Example**
Infective larva (L3) inside intermediate host	Ingestion of intermediate host	Various metastrongylid and all spiruroid worms
Infective larvae (L3) inside proboscis of blood sucking (biological vectors)	Injection of L3 during blood feeding on the host	All filarial worms

Trichinella spiralis, being autoheteroxenous, is transmitted by ingestion of raw or partially cooked flesh containing encysted infective larvae of an infected definitive host.

FAMILY -ASCARIDIDAE

- Genus: *Ascaris*, *Toxocara*, *Parascaris*, *Toxascaris*
- Three lips are present. One dorsal and two subventral.
- Each lip bears two papillae. Between the bases of these lips, there may be smaller lips called interlabia.
- Teeth or cutting plates are absent.
- Pharynx absent
- Oesophagus is usually club-shaped, muscular, and without a posterior bulb.
- Usually two spicules are present. Bursa is absent.
- Eggs are typically round or subglobular and outer wall is pitted.

Species of Ascarid worms

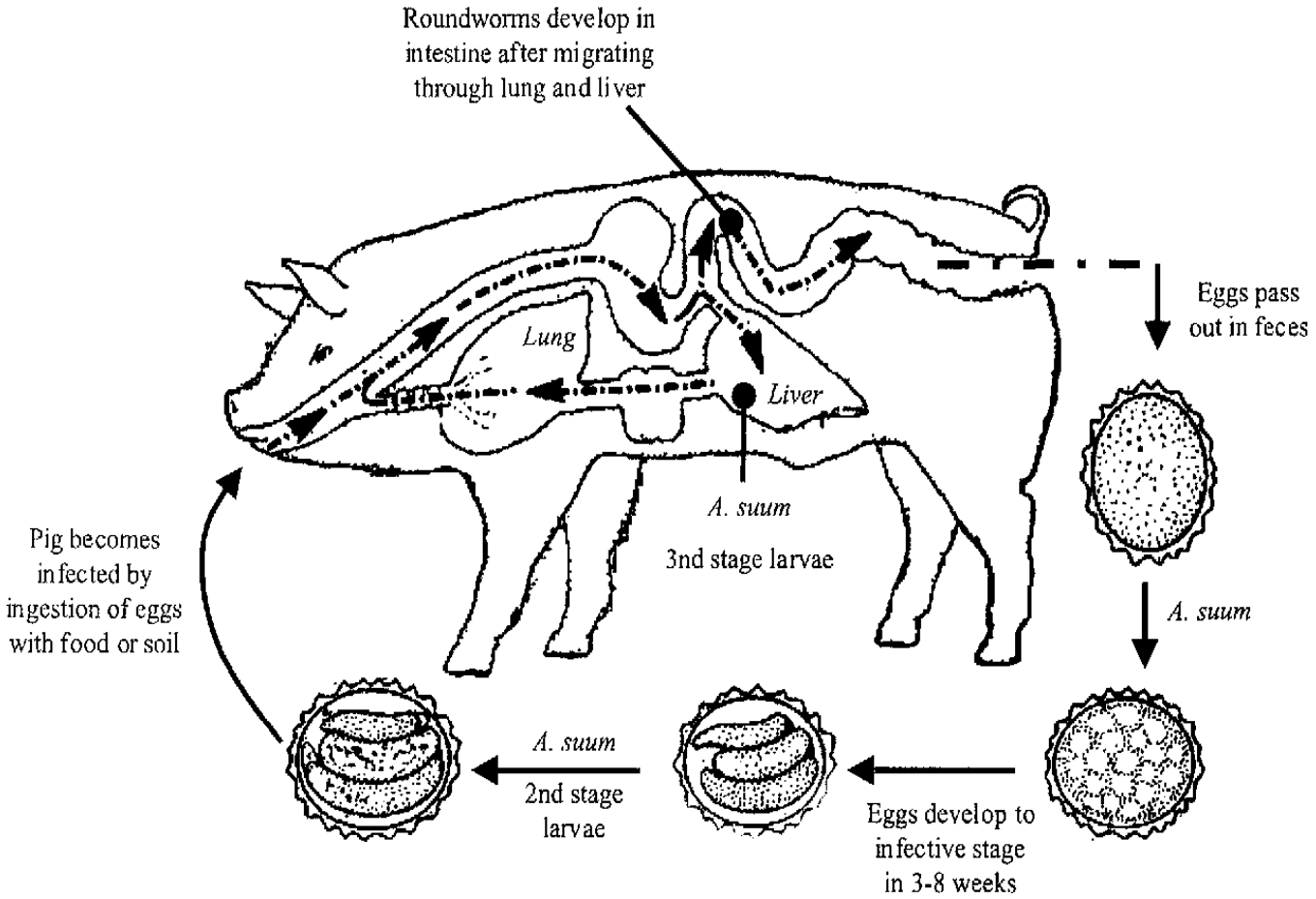
Sl. No.	Species of Ascarid	Common name
1	*Ascaris suum*	Ascarid worm of pig
2	*Toxocara vitulorum*	Ascarid worm of cattle, buffalo, sheep and goat
3	*Toxocara cati*	Ascarid worm of cat
4	*Toxocara canis*	Ascarid worm of dog
5	*Toxascaris leonina*	Ascarid worm of dog and cat
6	*Parascaris equorum*	Ascarid worm of horse
7	*Ascaris lumbricoides*	Ascarid worm of man

Genus - Ascaris

- *Ascaris Suum*: found commonly in the small intestine of domestic pig
- commonly called large intestinal roundworm of swine
- A. suum is sometimes considered synonymous with human roundworm A. lumbricoides because of the identical morphology
- Developmental stages • Egg • Larva 1 in the egg shell • Larva 2 in the egg shell (infective stage) • Larva 3 • Larva 4 • Adult

Life cycle

- Eggs are expelled out.
- Larvae develop within the egg-shell.
- 2nd larvae within egg shell are infective stage.
- The host gets the infection by ingestion of the infective eggs.
- Hatching occurs in the intestine and the larvae reach the liver either by active penetration via peritoneal cavity or hepatoportal circulation.
- The larvae are transported to heart and then to lung where these are found as 3rd stage larvae
- **Tracheal route of migration**: These larvae break out of the alveolar capillary into the alveoli and pass through the alveolar ducts to the small bronchioles and then gradually ascend the bronchial tree. The larvae then migrate from the trachea to the pharynx from where they are swallowed and reach the intestine and become L4


Roundworms develop in intestine after migrating through lung and liver
Lung
Liver
A. suum
3nd stage larvae
Eggs pass out in feces
A. suum
Eggs develop to infective stage in 3-8 weeks
A. suum
2nd stage larvae
Pig becomes infected by ingestion of eggs with food or soil

Pathological features / lesions

1 . The migrating larvae cause haemorrhagic lesion in liver. The **liver shows milk spot appearance.**

2. The migrating larvae causes haemorrhagic lesions in the bronchiole and alveoli which result in pneumonia.

- ✓ pneumonia (Ascaris pneumonitis)
- ✓ Coughing
- ✓ Decreased growth rate
- ✓ Diarrhoea.

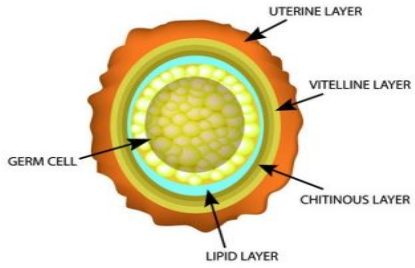


Diagnosis:

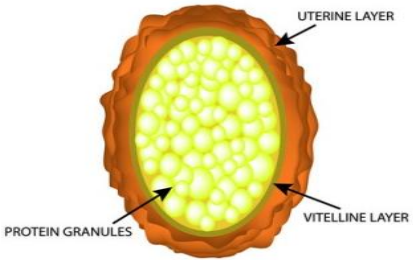
- On the basis of Clinical signs.
- Microscopic faecal examination: Egg is brownish yellow ovoid with thick shells, the outer layer of which is irregularly mamillated.

Treatment:

Piperazine: Drug of Choice



EGG OF ASCARID FERTILIZED



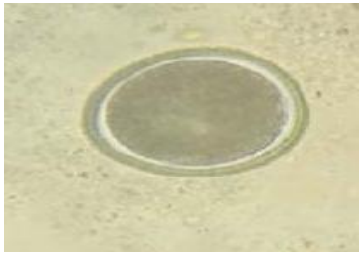
EGG OF ASCARIS UNFERTILIZED

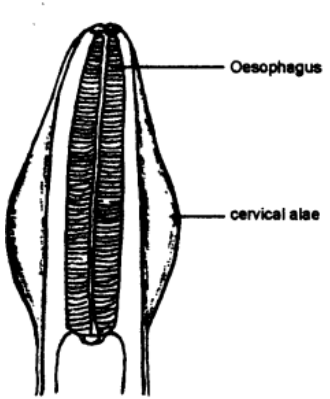
GENUS-TOXOCARA

- *Toxocara canis*
- *T. cati*
- *T. vitulomm*

Toxocara Canis

- Host- Dog
- Site/location - Small intestine
- Common name -Arrow-headed worm or Arrow worm
- Disease caused - Toxocariosis, visceral larva migrans
- head is arrow-like which is formed by the cervical alae. Hence, the worms are called as the arrow-headed worm.
- Egg
  - subglobular in shape, dark brown in colour
  - unsegmented embryos at the centre
  - thick finely pitted shells





Life cycle

- Direct life-cycle
- Infective stage: egg containing 2nd stage larvae

- There are four routes of infection of T. canis.

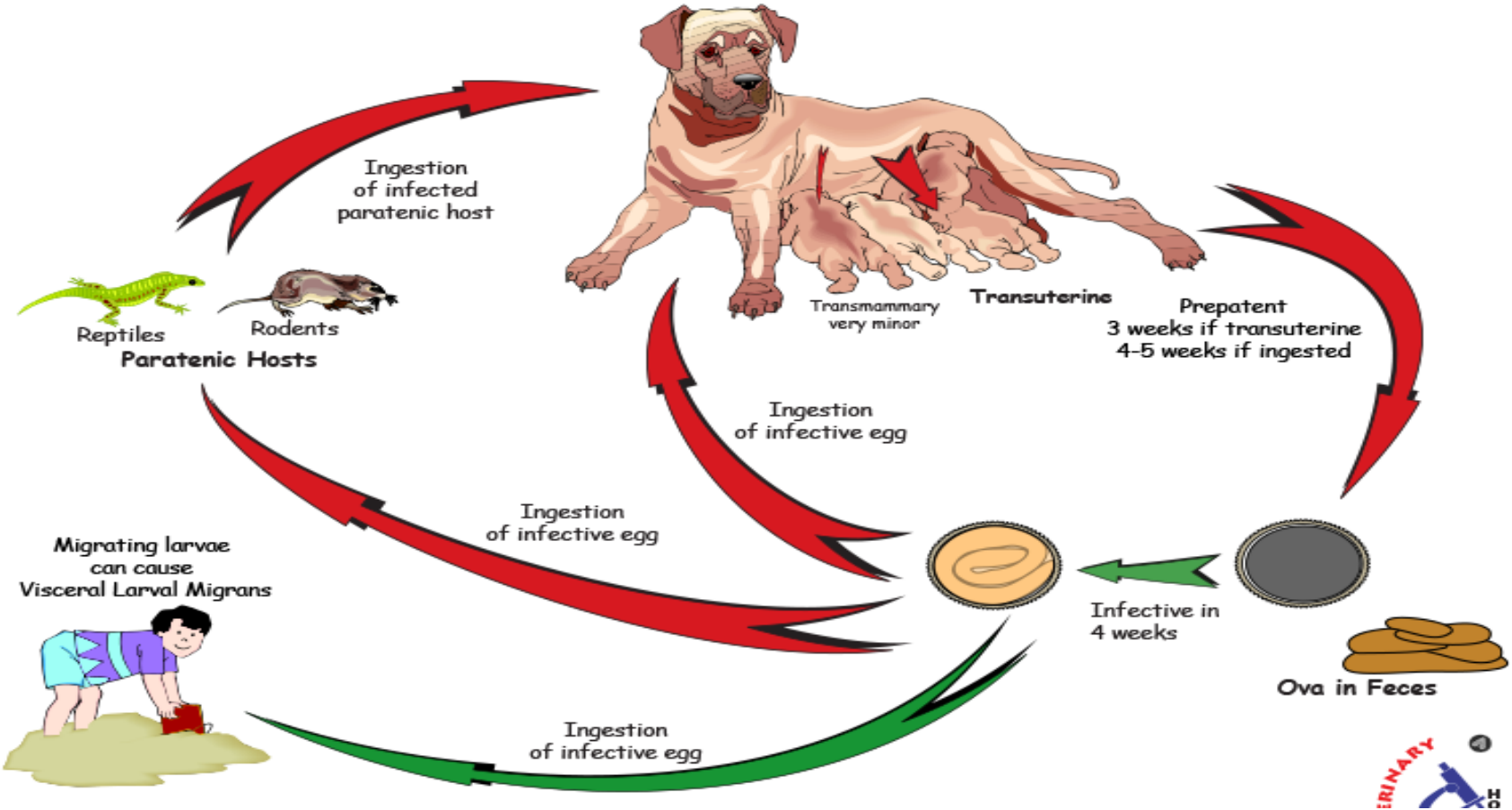
a. Oral infection or ingestion of infective stage of eggs of T. canis.

b. Transuterine infection (Congenital infection).

c. Transmammary infection (Lactogenic infection).

d. Parataenic host transmission.

Toxocara canis



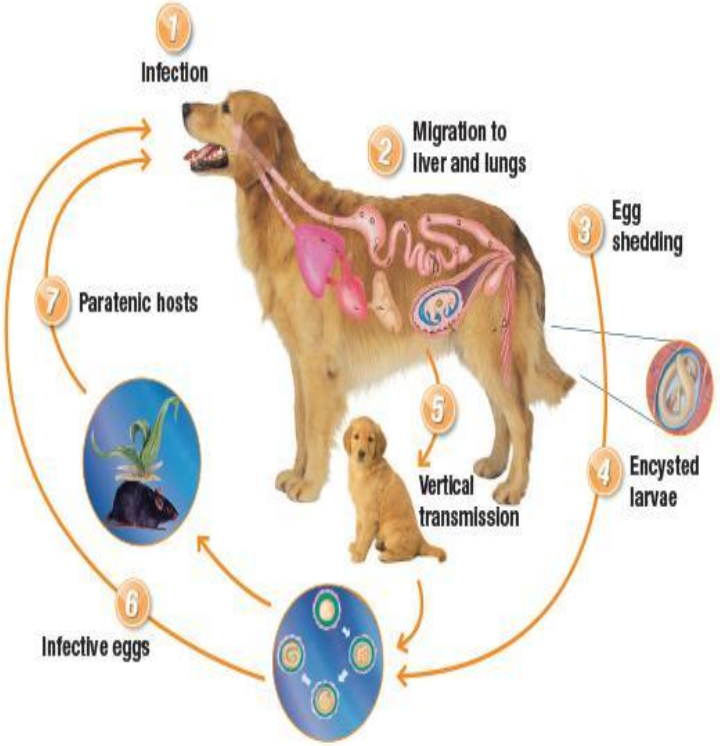
- **Oral infection or ingestion of infective egg containing L2: Both tracheal and Somatic route of migration**

i. **Tracheal route of migration:** When the pups are below 3 months of age, tracheal route of migration occurs.

ii. **Somatic route of migration:** This type of migration occurs when the dog is pregnant. The larvae migrate to different organs Where they remain in the dormant stage. After about 1. 5 months of the infection the larvae mobilize from the dormant stage and reach the general circulation. Through the blood the larvae enter the different organs of the foetus. In the liver of the foetus the larvae perform one moulting again.

Transuterine infection or Transplacental or Prenatal or Congenital infections :

- In dogs over three months of age, the hepatic-tracheal migration occurs less frequently and at six months it has almost ceased.
- Instead, only somatic migration of L_2 larvae and these remain in L_2 stage in organs/tissues.
- In the pregnant bitch, prenatal infection occurs, larvae becoming mobilized at about three weeks prior to parturition and migrating to the liver of the foetus where they moult to L_3 just before birth.
- A bitch, once infected, will usually harbours sufficient larvae to infect all her subsequent litters
- Mobilization and migration of larvae induce probably due to alteration of hormonal status during pregnancy stage.



3.Transmammary Transmission

- L_3 larvae are passed to suckling pups via the colostrums and develop directly to adult worms in the intestine of the puppy.
- There is no migration in the pup following infection by this route.

4. Paratenic host transmission

- Dogs, being predators, may eat on rodents having dormant larvae.
- L_2 stage develops to adult stage in the intestine of pups/dogs without migration.

Pathogenesis and clinical signs

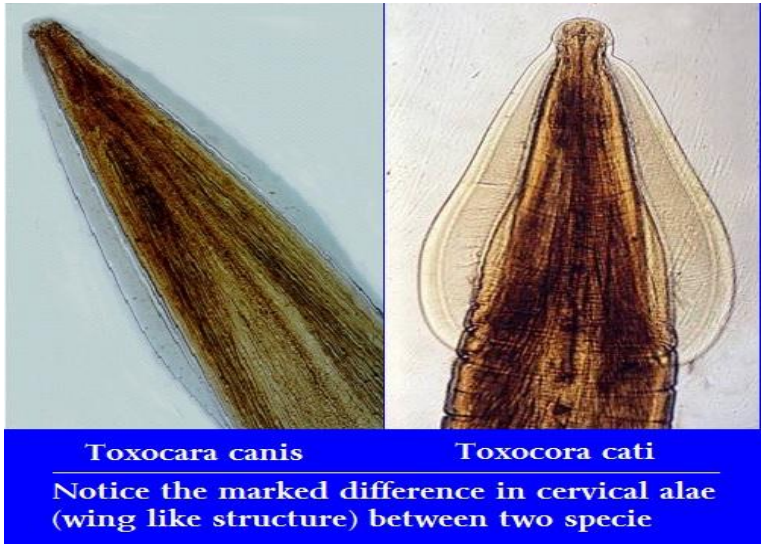
- Hepatic damage, alveolar destruction, pneumonia, chorioretinitis due to aberrant migration.
- Most fatalities from *Toxocara canis* infection occur during the pulmonary phase
- larvae cause destruction of the lung alveoli leading to pneumonia which is commonly called as the Ascarid pneumonia.
- Larvae are caused pneumonia, pulmonary oedema, haemorrhages, etc whereas adult worms lead to enteritis and occlusion of intestine.
- Pot-belly or tucked-up abdomen, coat is dull and harsh, nervous convulsions and diarrhoea or constipation, vomiting, coughing, poor body condition, loss of appetite etc.

TOXOCARA CATI

- small intestine of the cat and wild felids
- presence of very broad and striated cervical alae
- Egg are similar to the

eggs of *T. canis*

But colourless



Life-cycle:

- Direct life-cycle
- Infective stage: egg containing 2nd stage larvae.

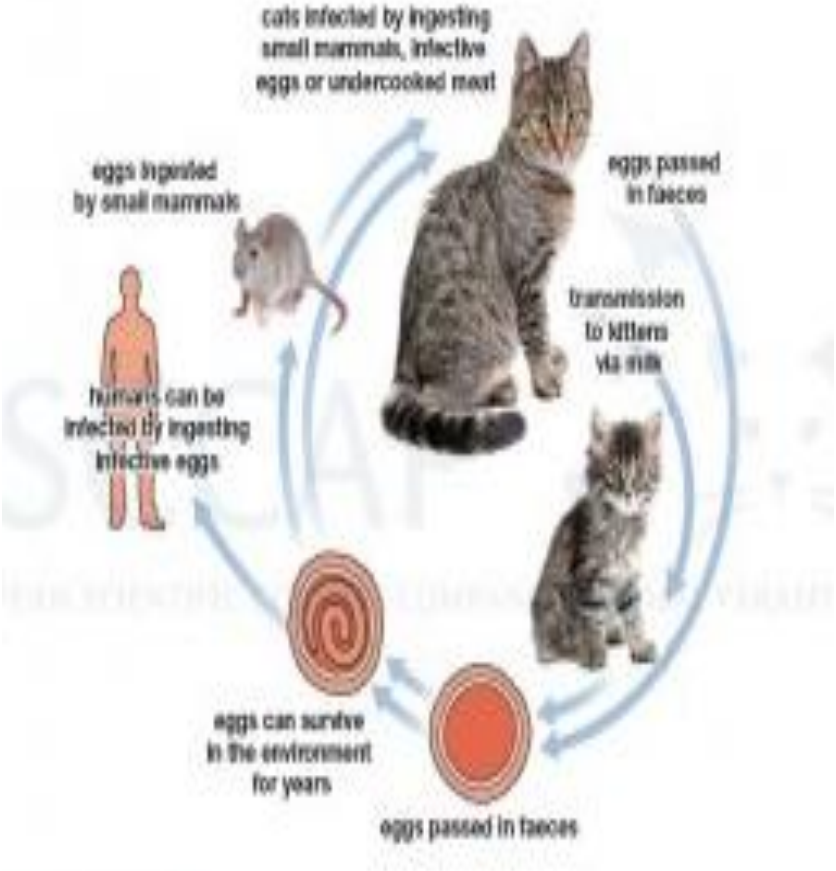
Transmission:

1. Oral or ingestion of infective egg containing L2

2.**Transmammary transmission**

3. Paratenic host transmission

Prenatal transmission absent



VISCERAL LARVA MIGRANS (VLM)

- infective eggs of T. canis, and probably of T. cati, are eaten by an abnormal host including humans, the hatched out larvae (L2 stage) behave similarly as in dog and cat and migrate into liver, lungs and other organs and tissues.
- However, the larvae do not complete the normal migration but undergo developmental arrest and continue to wander throughout the body. The resulting disease entity is known as visceral larva migrans (VLM).
- Mainly the liver is affected but also other organs may be affected. Eosinophilia occurs in the organs. Sometimes the eye is affected by the larvae causing retinoblastoma which may be named specifically as ocular larva migrans (OLM).
- **Larvae of *Toxocara canis* (mainly), *Toxascaris leonina, Toxocara cati, Capillaria hepatica, Gnathostoma spinigerum* and *Lagochilascaris minor* migrate in to visceral organs/tissue.**

TOXOCARA VITULORUM

- Final Host/ Host: Cattle & buffalo
- Predilection site: Small Intestine
- Largest nematode of Cattle & Buffalo.
- Body of worm is soft and cuticle is translucent. So, the internal organs can be seen
- Extremities are not so narrow.
- Eggs are subglobular shaped, colourless with thick finely pitted shell

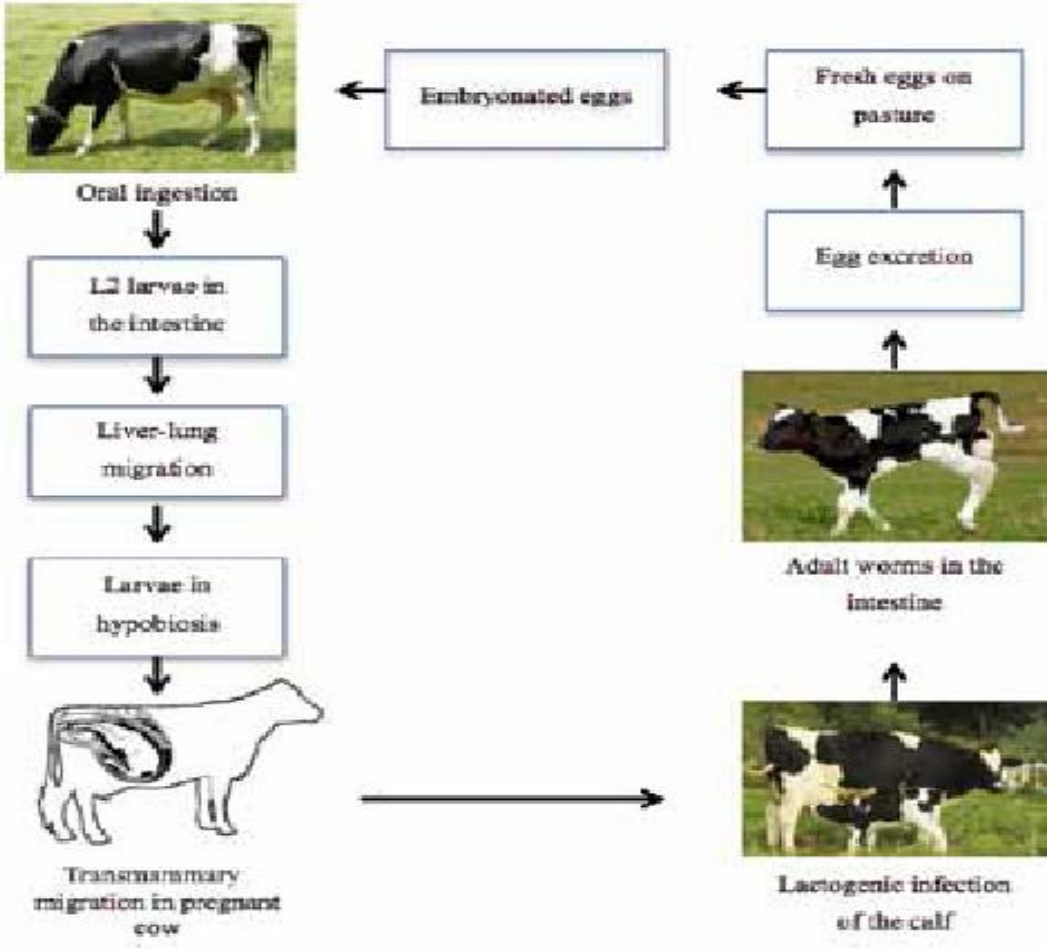
Life-cycle:

- Direct life-cycle
- Infective stage: egg containing 2nd stage larvae.

Transmission :

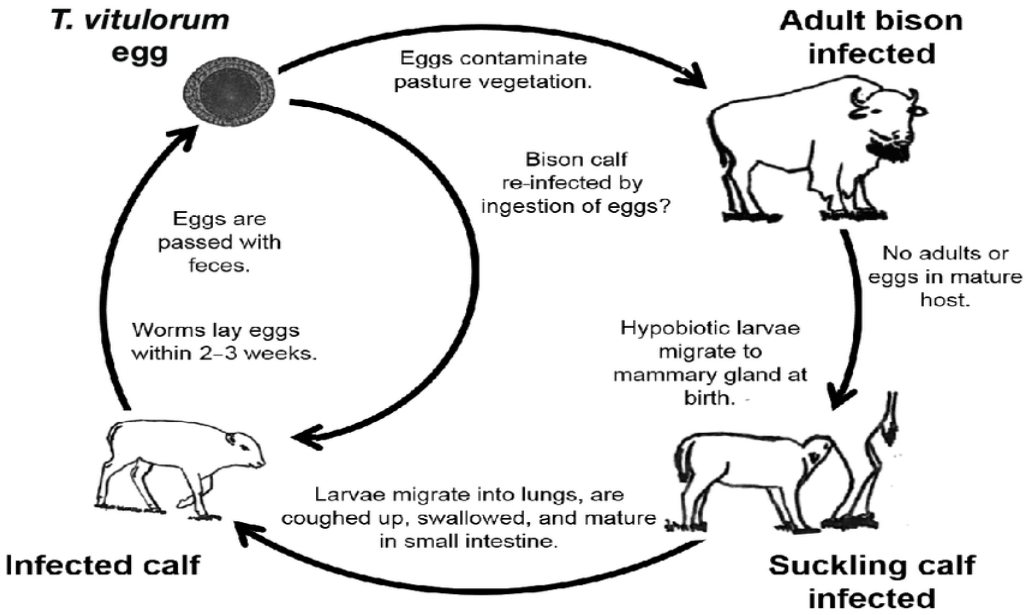
1. **Oral or ingestion of infective egg containing L_2**

2.**Transmammary/ transcolostral transmission**



Life-cycle:

- Transmammary infections constitute the major sources of infection for calves.
- Ingestion of infective eggs containing L_2 larvae by calves or adult does not lead to patent infection.
- Instead hatched out L_2 stage reaches various organs /tissues and remain dormant. Larvae start mobilizing and migrating to mammary glands during late pregnancy period. Just after parturition, the migrating larvae are shed in milk and lead to transmammary transmission up to 3-4 weeks.



Pathogenesis:

- Worms are highly pathogenic in calves (especially buffalo calves) below 6 months of age.
- Partial or complete obstruction of the lumen of gut.
- Digestive disturbances
- Anaemia
- On maturity of worms, each female produces a very large number of eggs (8 x 10^6 eggs per female worm) per day.



Intestinal Obstruction

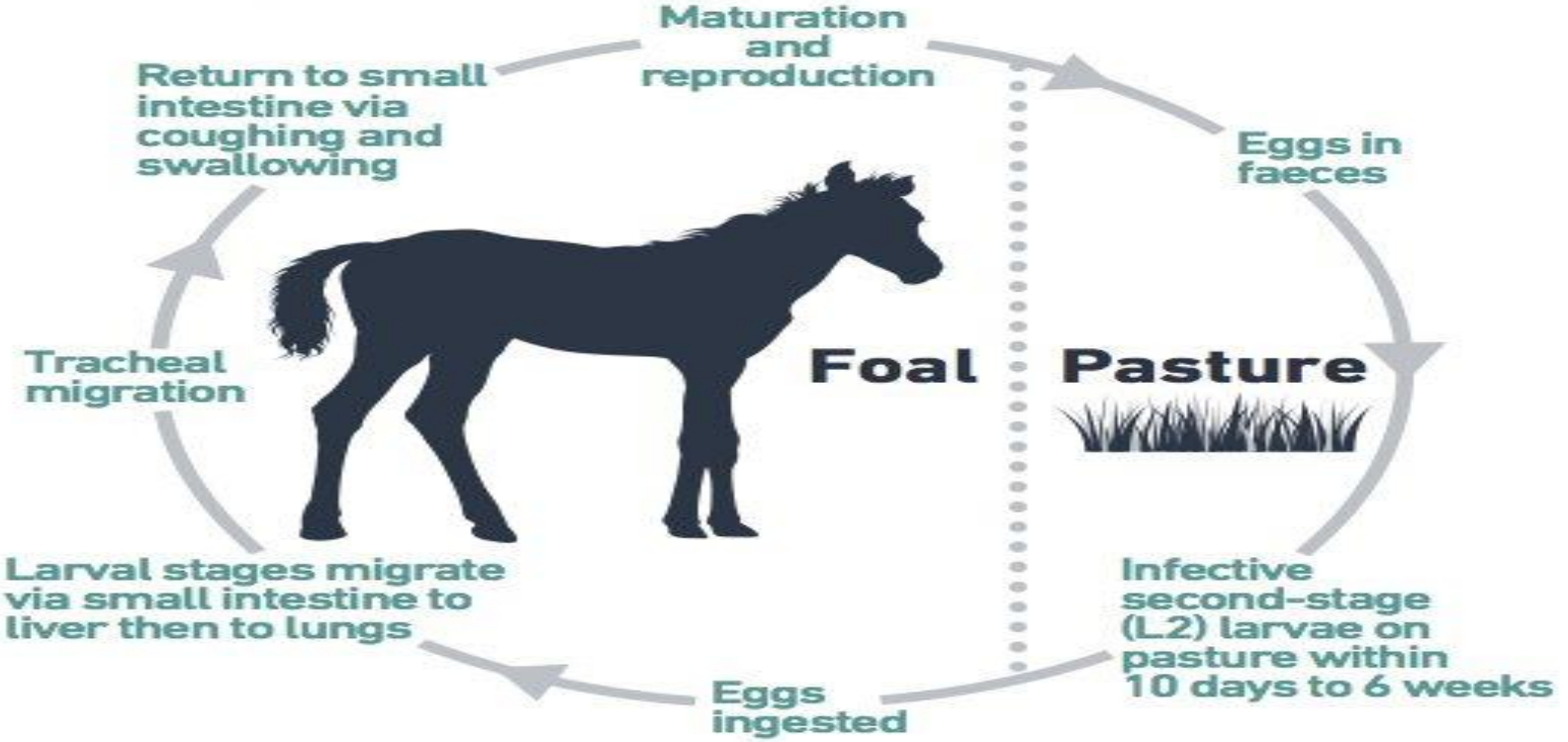
Clinical Signs

- steatorrhoea, colic, mud-coloured foul smelling faeces, intestinal obstruction in case of large number of worms, pot-belly, poor boat coat, emaciation and death.

GENUS: PARASCARIS

- PARASCARIS EQUORUM: Largest nematode of equine
- occurs in the small intestine of equines
- Three well developed lips
- Eggs areherical or sub-spherical, brownish yellow colour with thick and pitted shell.

Life cycle of ascarids in foals (*P. equorum*) – 10–15 weeks



GENUS: TOXASCARIS

- The anterior part of the body is provided with large cervical alae and is bent dorsal giving it an arrow-like appearance.
- Species of Toxascaris and also Toxocara canis of dogs have this characteristic and, therefore, called `arrow headed-worms' of cats and dogs

Toxascaris Leonina

- found in the small intestine of dog, cat and other wild felids and canids in most parts of the world
- eggs are oval, with smooth shells
- After ingestion of infective eggs by the host, the hatched-out L2 enter the intestinal wall and remain there for about 2 weeks
- the larvae moult to become L3 and soon after they become L4
- They leave the mucosa and become the adult juveniles in the lumen of the intestine and, on full maturity, the females start laying eggs
- There is no migration of larvae as in the life-cycle of Toxocara canis.

FAMILY -ANCYLOSTOMATIDAE

- “Hook worms” because of their characteristic hook like appearance form by bending of anterior ends.
- They are veracious blood sucker and found in small intestine of host.
- morbidity and mortality as a result of anaemia, protein-loosing gasteroenteropathy etc.

No.	Genus	Species	Host
1.	*Ancylostoma*	*A.caninum*	Dog and fox
		A,brazilliense	Dog and cat
		A.tubaeforme	Cat
2.	*Uncinaria*	*U.stenocephala*	Dog, cat and fox
3.	*Bunostomum*	*B. trigonocephala*	Sheep and goat
		B.phlebotomum	Cattle
4.	*Agristomum*	*A. vryburgi*	Cattle and buffalo
5.	*Gaigeria*	*G.pachyscelis*	Sheep and goat

GENUS: ANCYLOSTOMA

- *A. caninum A. duodenale A. tubaeforme A. braziliense*
- Species: A.caninum
- Host: Dog and fox
- Location: Small intestine
- Common name :Hook worm
- Morphology: **Buccal capsule is well developed and bears 3 teeth on either side of ventral margin.**
- Eggs are oval shaped with thin shell, blunt ends and usually contain 8 celled embryo. Sides are almost parallel.
- colour of the worms are varied in accordance with the presence of the blood sucked by the worm
- Disease caused - Hook worm disease, ancylostome dermatitis ('ground itch', 'water itch', 'coolie's itch') in man.

LIFE CYCLE

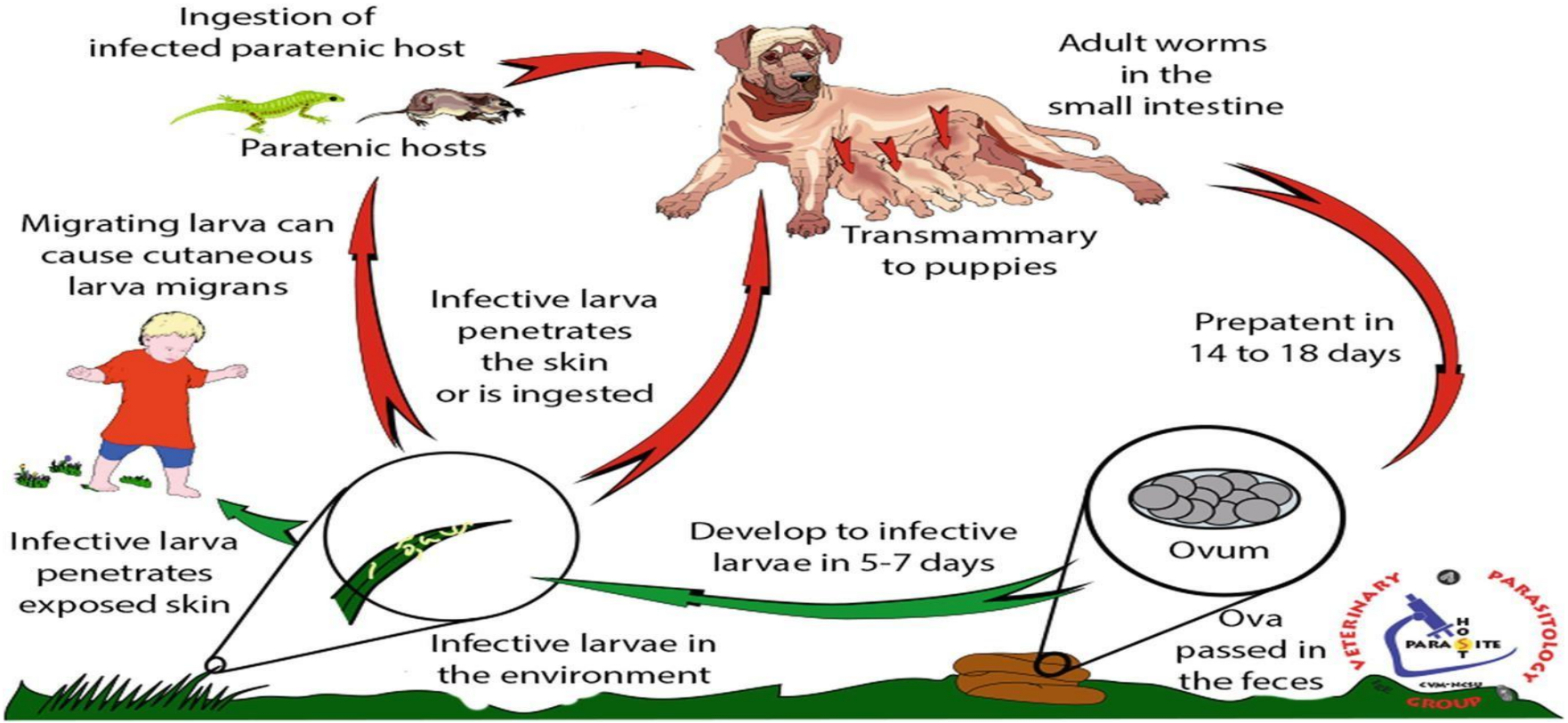
- Life cycle: Direct
- Host: dog and fox
- Transmission of infection:

1) Ingestion of L3 with feed and water
2) Skin penetration of L3
3) Transcolostral transmission
4) Transuterine transmission

The eggs ate passed out in the faeces of host.
The eggs are then embryonated and hatched.
The hatched out L1 develop to infective L3 stage
- Entrance and life cycle is similar to T. canis

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Ancylostoma caninum



Pathogenesis

- By larvae

1. When the larvae penetrate the skin of the host they may cause some kind of dermatitis which is called as ancylostome dermatitis. During the time of skin penetration the larvae may cause eczema and ulceraton.
2. The larvae enter the lungs where they cause some amount of pathogenicity comprising breaking of pulmonary capillaries which may result in pneumonia.

By adult worms

- The worms have powerful teeth and oesophagus.
- By using these apertures the worms suck blood (0.1ml/day)
- They even take parts of the mucosa. The adult worms continuously suck blood by using their teeth. The worms are vessel feeder and puncture the blood vessel. As the worms secrete anticoagulant, the blood cannot coagulate easily.
- Severe anemia is observed - microcytic hypochromic type

Clinical signs

1 . Marked anaemia which is evidenced by the pallorness of the eye-mucosa.

2. Diarrhoea is another clinical sign found in this infection. Blood - mixed watery fluid comes out.

3. Bottle jaw

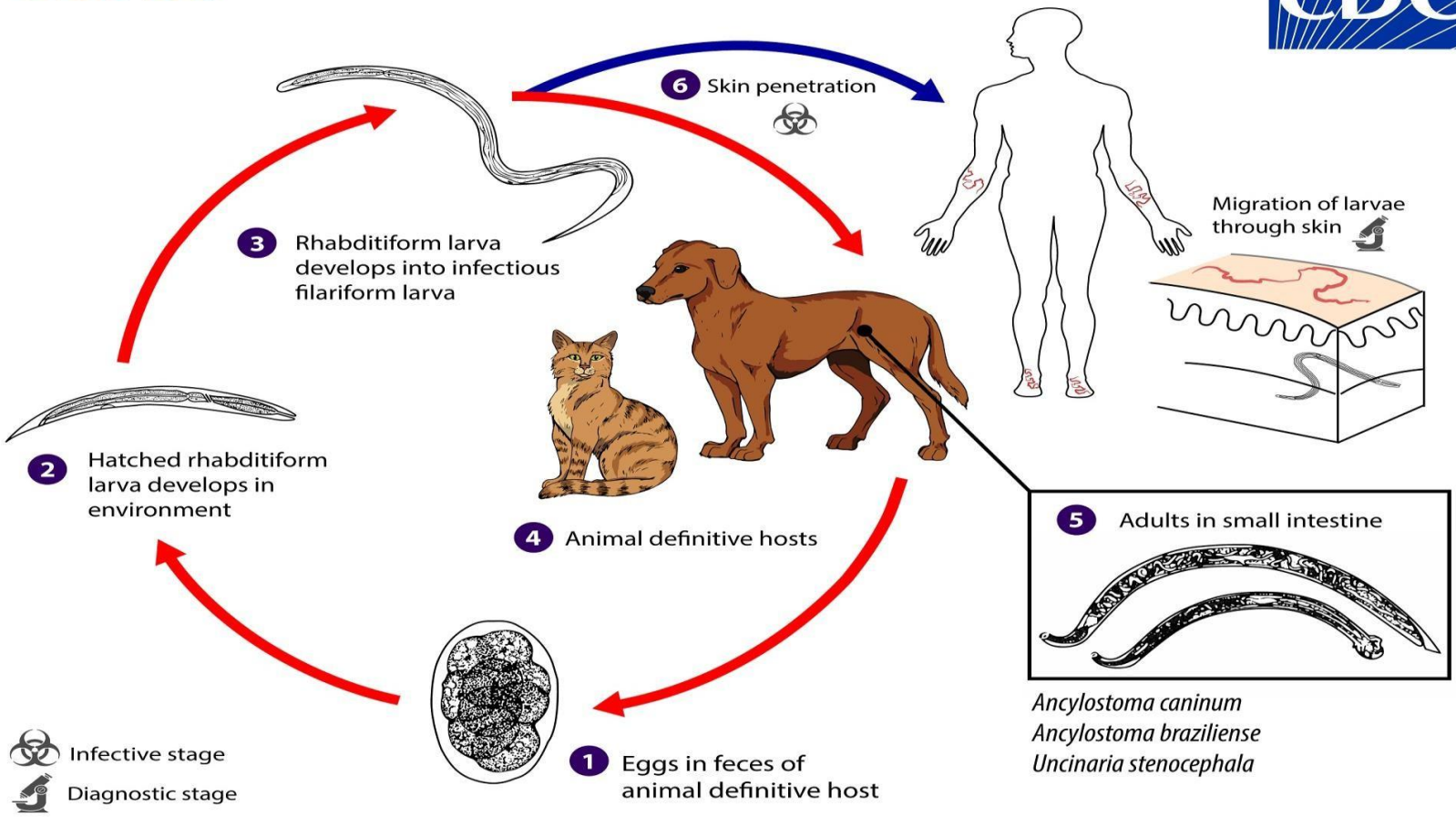
4. Progressive weakness

- Faecal examination: In positive infection, an enormous number of eggs will be observed on floatation technique.
- The eggs are of a very specific type which are blunt anteriorly and posteriorly. There is presence of only 8 embryonic cells which is the differentiating character from strongyles which has 16 embryonic cells

CUTANEOUS LARVA MIGRANS (CLM) OR CREEPING ERUPTION

- caused by larvae of *A. brazialiense* mostly
- rarely by *Uncinaria stephanocephala*, *A. caninum and the species of Necator, Bunostomum , strongyloides and Gnathostome etc.*
- larvae produce skin lesions but do not develop.
- This lesion are characterized by tortious erythematous tract with severe pruritus.
- Occasionally, the larvae may be reach lung and cause cough and pneumonia

Cutaneous Larva Migrans



GENUS: BUNOSTOMUM

- Species and host: B. trigonocephalum (sheep and goat) and B. phlebotomum (cattle and buffalo).
- Location: Small Intestine of animals.
- Common name: “Hook worm” of ruminants

B. phlebotomum	***B. trigonocephalum***
1. Occurs in cattle.	1. Occurs in sheep and goat.
2. Two pairs of subventral lancets are present in buccal capsule.	2. One pair of chitinous plates are present at the ventral margin of buccal capsule. Dorsal teeth are absent.
3. In heavy infection **bottle jaw** occurs.	3. In heavy infection **bottle jaw** occurs.

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LIFE CYCLE

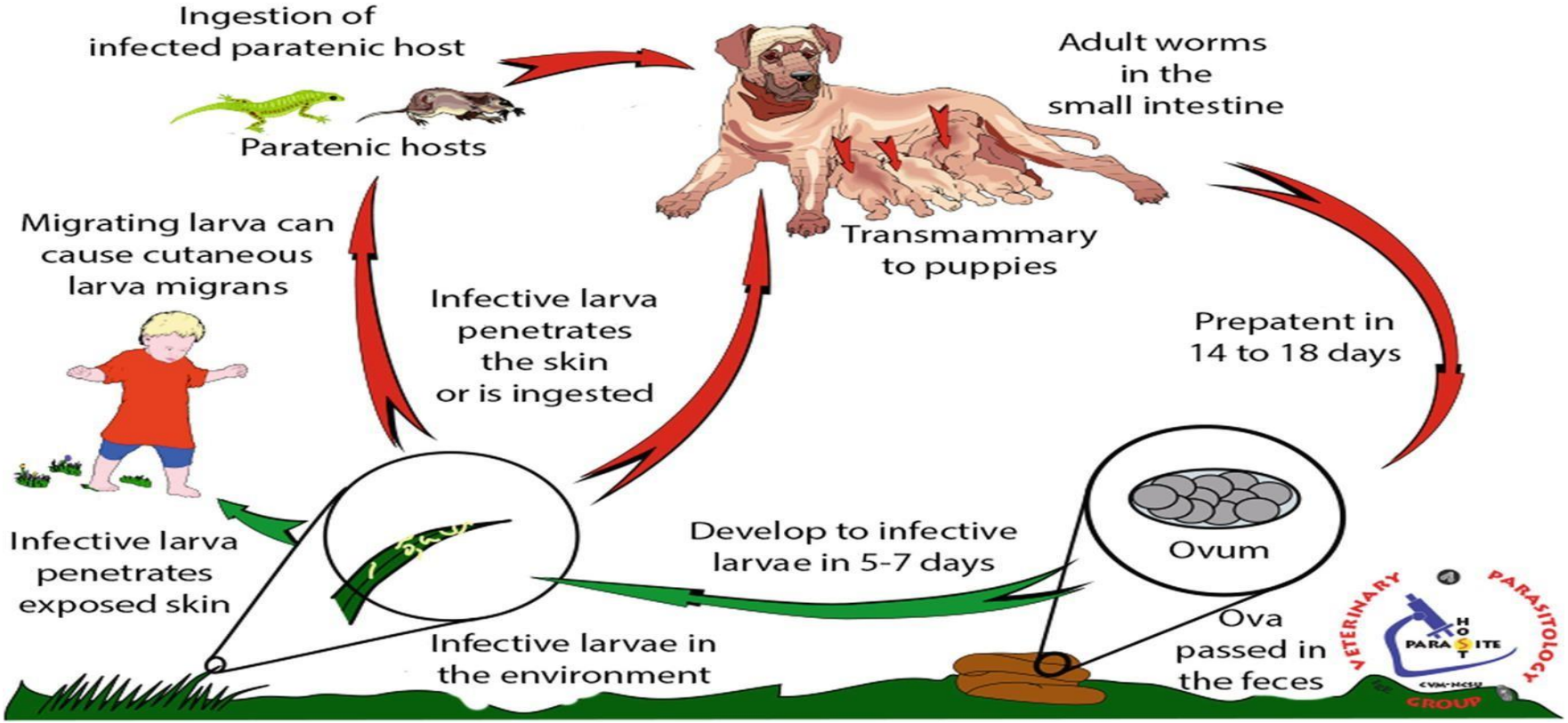
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Ancylostoma caninum



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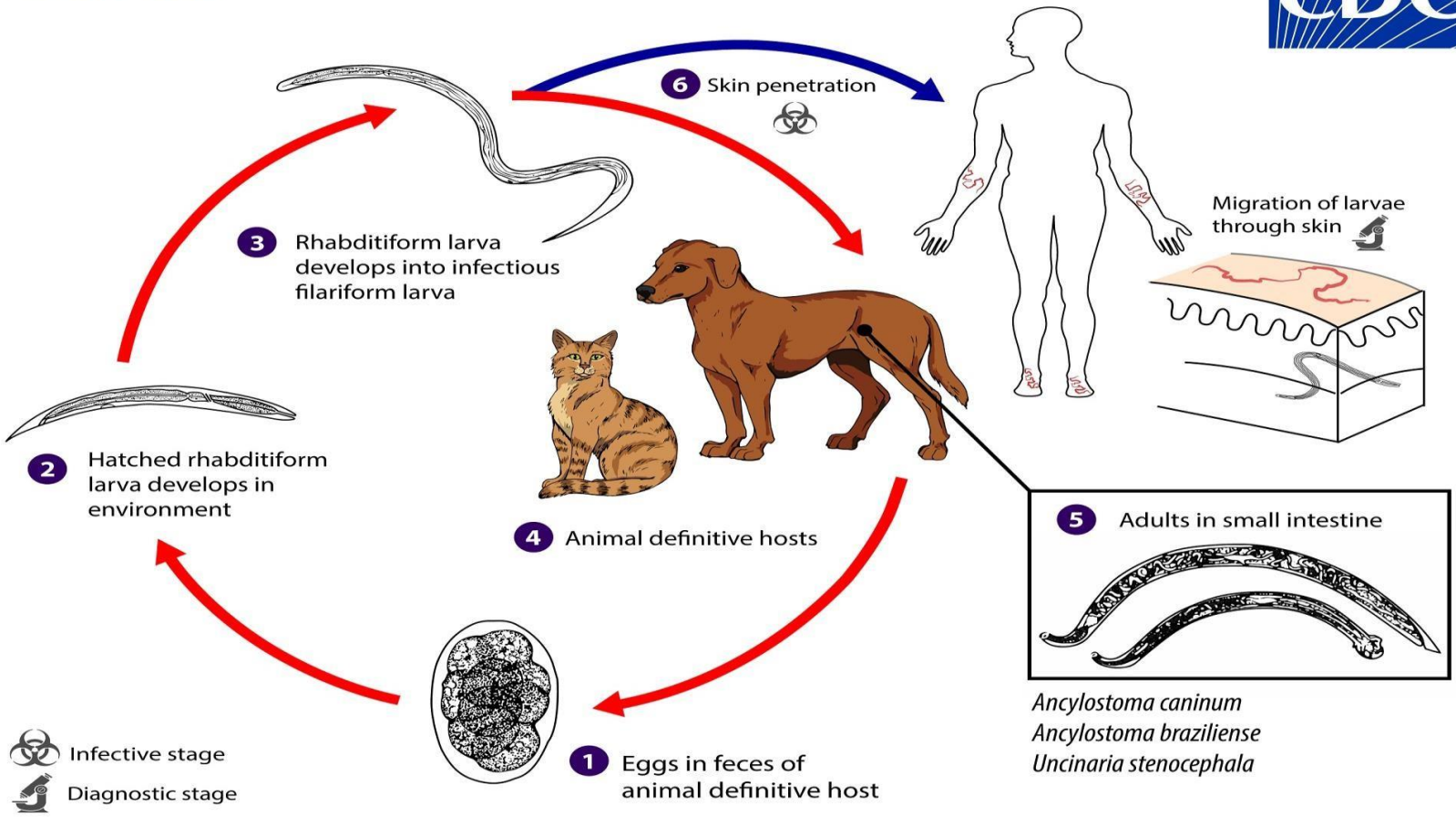
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Ancylostoma caninum
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Uncinaria stenocephala

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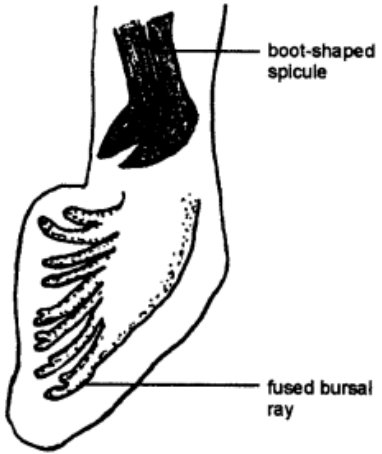
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FAMILY : DICTYOCAULIDAE

- Genus: Dictyocaulus
- located in the respiratory passages of cattle, sheep, goat, donkey etc. and hence they are called as ‘Lung worm’.
- Among them *D.filaria* is prevalent in India.
- *D. viviparus*- found in bronchi of cattle, buffalo etc.
- *D. filaria*- found in bronchi of sheep, goat etc.
- *D. arnfieldi* -found in bronchi of horse, donkey etc.
- Site / location - Bronchi and lung
- Disease caused - Lung worm disease, pulmonary nematodosis, Verminous broncitis, dictyocaulosis, husk and hoose disease.

Morphology

- white in colour and thread-like
- A small buccal capsule is present associated with four lips.
- The spicule present in males is dark brown and boot-shaped.
- Bursal rays look like fingers
- Females – amphidelphic and ovoviviparous



Life Cycle

- Direct life cycle
- Larva 3 (infective stage)
- adult parasites present in the trachea and bronchi lay eggs which are expectorated and enter the G. I. tract
- 1st stage larvae come out through the faeces. The eggs are not found in the faeces because the eggs either hatch in the lung or while passing through the alimentary tract.
- In environment, transforms to L2 & L3 which moves to herbage by their own movement or with the help of *Pilobolus* fungal spores
- after ingestion, the L3 penetrate the intestinal mucosa and reach in to the mesenteric lymph glands via lymphatic vessels and transform in to L4
- The L4 reach to the lungs via circulation and then come to the bronchioles where final moulting occurs.
- They become adult usually in the bronchi

Pathogenesis

- The parasite cause inflammation in bronchi and bronchioles.
- There will be desquamation of epithelial cells such as eosinophils, neutrophils and macrophages.
- As a result, exudates is formed which along with parasites, may block the respiratory passages and leading to atelectasis.
- Primarily, will cause emphysema, pulmonary oedema and verminous pneumonia which ultimately turn in to bacterial pneumonia
- A typical sound ('husk - hoose') is produced due to occlusion of the passage of the bronchi.

Vaccination

- Attempt was made in Europe to produce vaccine (Dictol) against lung worm, D. viviparus by using X-irradiated larvae. Two doses, each containing 1000 irradiated larvaes are given at an interval of one month which is able to confer significant amount of protection.
- Similar attempt was made in IVRI, Izzatnagar, India to produce vaccine against lung worm, D. filaria (Difil) by using gamma ray irradiated larvae containing L3 with similar success. Dose: 1000 – 2000 larva/animal repeated after 1 month and provide immunity for 1 year

FAMILY -TRICHOSTRONGYLİDAE

- are found in the alimentary tract of the grazing animals.
- The worms are mostly small, slender and devoid of the leaf crown.
- They have rudimentary buccal cavity without teeth
- Bursa strongly developed
- Genus: *Ostertagia*, *Cooperia*, *Nematodims*, *Haemonchus*, *Trichostrongylus*

Genus - Ostertagia

- Brown stomach worm
- found in the abomasum of the host (sheep, goat and cattle) and occasionally in small intestine.
- The colour of the parasite is brown.
- Anteriorly there is cephalic inflation which is striated transversely.
- Spicules are typically pigmented brown which possess two or three processes.

- O. trifurcata - spicule has long knobbed tip and behind the tip there are two spurs.
- O. circumcineta - spicule has a large knobbed tip and posterior to this, there is an acute process.
- O. ostertagi - spicule ends in three blunt hooked processes present at the end of the spicule.

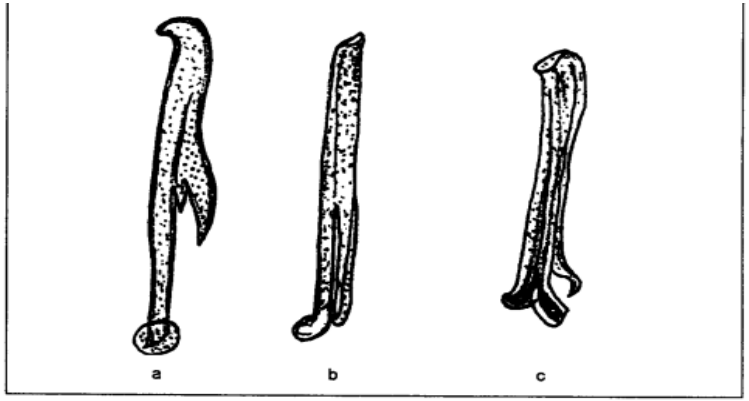


Fig. 58. Spicules of Ostertagia spp. a - O. trifurcata; b - O. circumcinata; c - O. ostertagi

- Pathological features / lesions: Gastritis, **morocco leather condition of the wall of stomach**.
- host gets the infection by ingestion of the 3rd stage larvae. Then the larvae enter the gastric gland where they undergo moulting.
- parasites cause destruction of the gastric cells
- Clinical signs 1 . Watery diarrhoea 2. Emaciation 3. Anaemia

Hypobiosis

- It is the arrested development of the larvae in adverse environmental condition.
- Hypobiosis or arrested larval development occurs in Haemonchus spp, Trichostrongylus spp, Ostertagia spp and Cooperia spp etc.
- The infective larvae survive in dormant stage in the pasture or in the host for a long time which may be several months old.
- The larvae in the host gets the signal from the environment.

GENUS -COOPERIA

- *Cooperia pectinata*
- *C.punctata*
- *C. oncophora*
- *C. curticee* - 'Watch spring like worm‘
- Site / location - Small intestine and abomasum
- Hosts - Many ruminants
- The anterior end of the parasite has cephalic swelling and posterior to swelling, longitudinal ridges are present.
- The middle part of the spicule is somewhat expanded and gives the appearance of a wing. This is the salient indentifying character of the parasite.

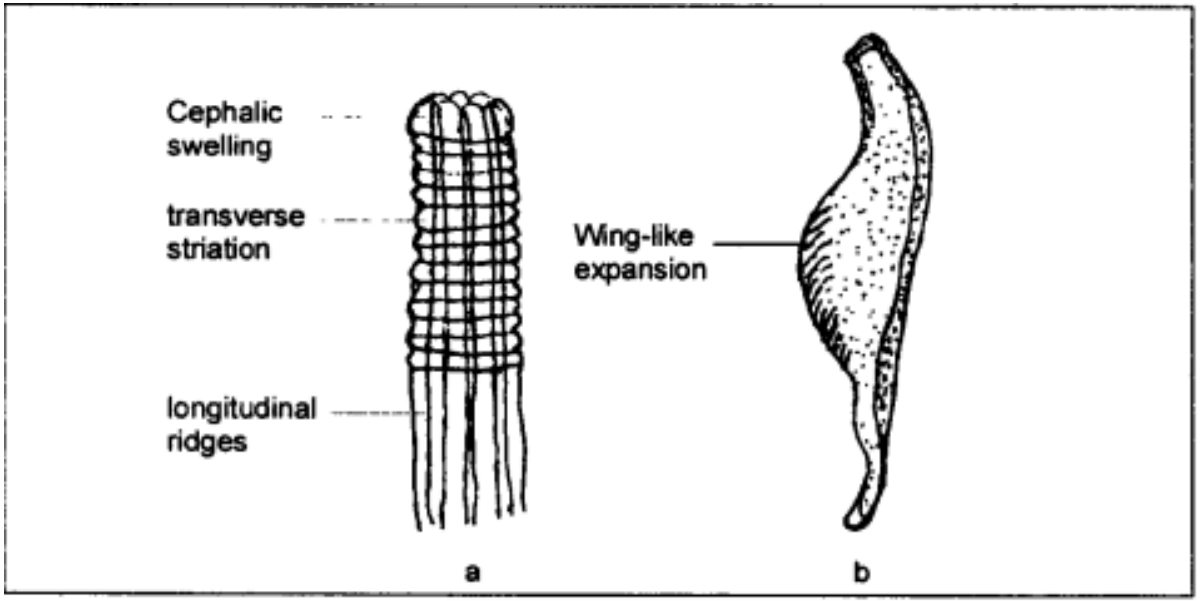


Fig. 59. a - Anterior end of Cooperia spp; b - Spicule of Cooperia spp.

Genus - Nematodirus

- found in the intestine of sheep, goat and cattle.
- The salient identifying character is mainly the spicule character. The spicules are long and slender and fused together at their tip region.

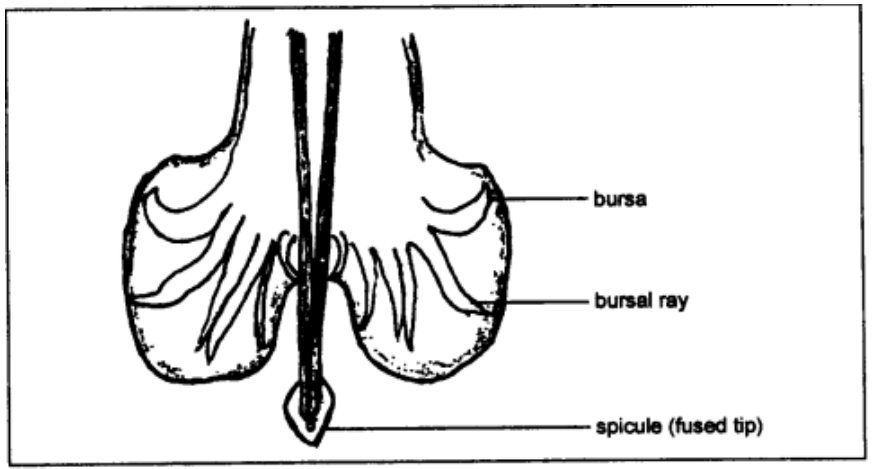


Fig. 60. Posterior end of Nematodirus spp (male)

GENUS-HAEMONCHUS

- *H. contortus*
- *H. placei*
- *H. similis*
- *H. bubalis*
- *H. longistipes*
- Species - *H. contortus*
- Site /location - abomasum
- Common name - Stomach worm, wire worm or barber's pole worm and twisted worm
- Hosts - Sheep, goat and cattle

Morphology

- The worms are small, grey or reddish in colour. As the worms are blood-suckers, the colour of the parasite is reddish or grey due to digestion of the blood.
- Small buccal cavity, prominent cervical papillae
- Red intestine is surrounded by the white ovary giving the appearance of barber's pole.
- The bursa is well developed. In the bursa three lobes are present, two lateral and one dorsal. The ray of the dorsal lobe is Y - shaped.
- The spicules are slender and barbed anteriorly

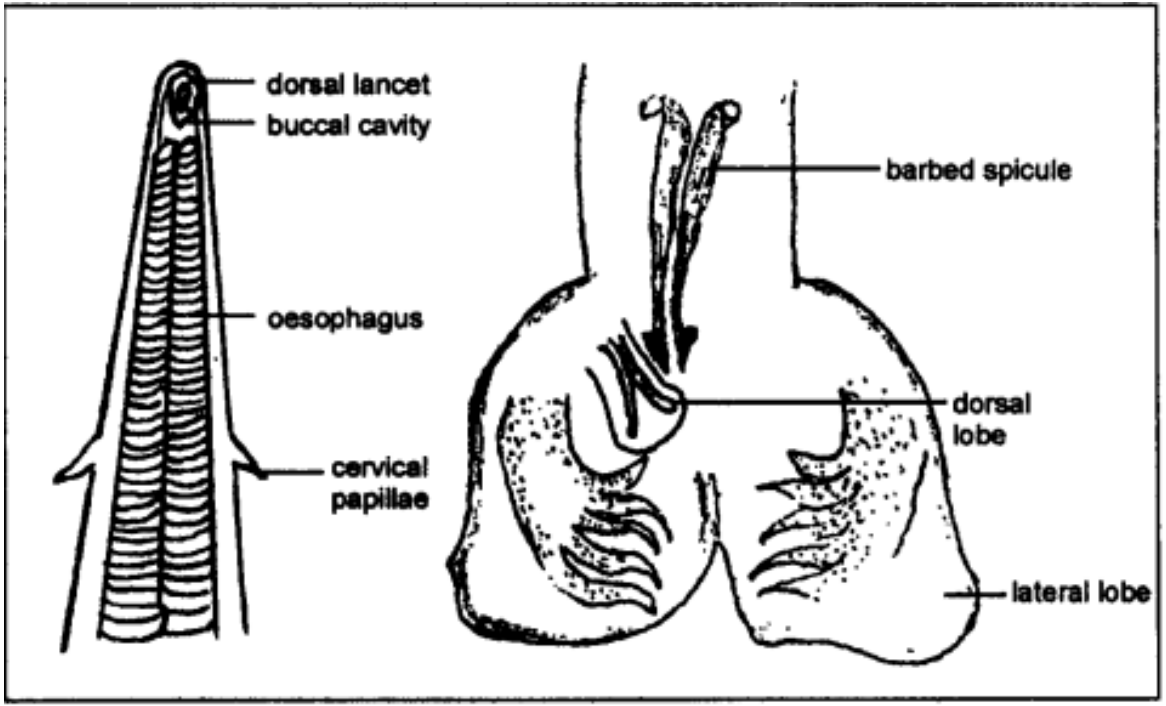
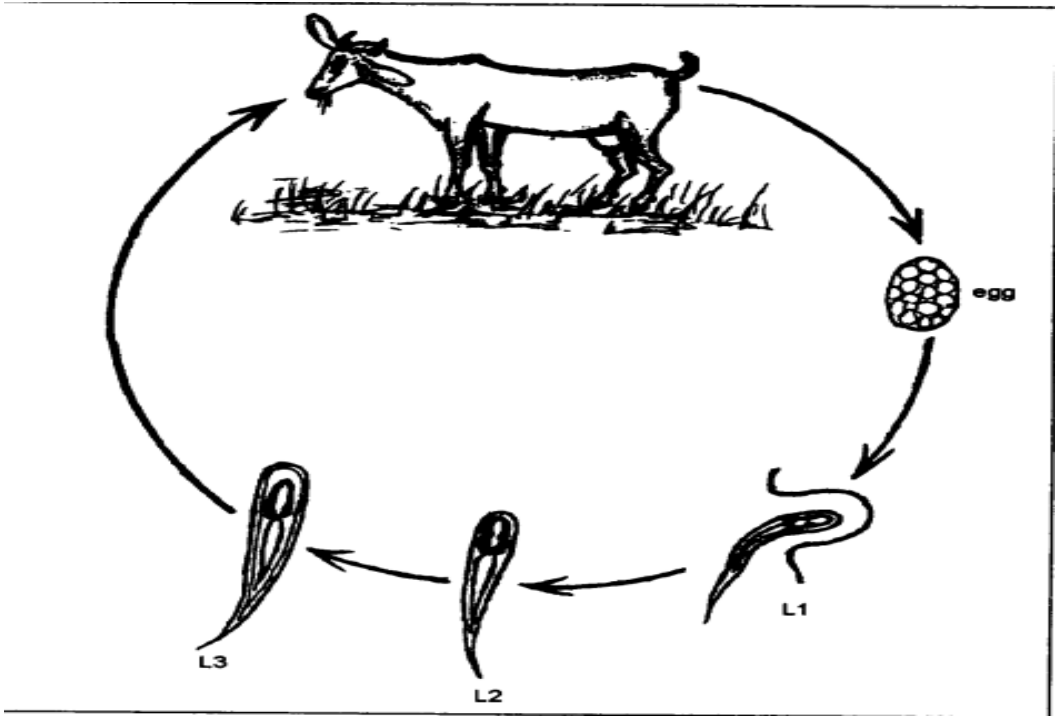


Fig. 61. Anterior end of Haemonchus spp.

Fig. 62. Bursa of Haemonchus spp.

Life cycle



- Pathological features / lesions: Abomasitis, anaemia
- Both the fourth stage larvae and adults suck blood and damage the abomasal mucosa · resulting in anaemia, hypoproteinaemia, emaciation, oedema and digestive disturbances.
- The average blood loss calculated in sheep has been 0.05 ml/parasite/day
- The worms frequently change their places of attachment leaving many bite marked area. Due to the presence of a large number of parasites in the stomach-wall, significant amount of serum protein is lost through ragged and ruptured wall of the stomach. These lead to hypoproteinimia ultimately resulting in oedema – Bottle Jaw condition

Self-cure phenomena

- Self-cure phenomena is applied to describe the immunological aspect of Haemonchus infection.
- animals which are presensitized earlier, if further infected, the larvae or the adult worms of the same species or antigenically related species which are present in the animal are expelled out. main cause is the immunogical reaction. The worms release allergens which set up a Type - 1 hypersensitivity reaction.
- Due to the immunogical reaction there is increase of histamine level in the blood. The increased level of the histamine increases the peristaltic movement. As an associated reaction the goblet cells are stimulated and these goblet cells start secretion of a large amount of mucus. The whole thing ultimately leads to massive expulsion of the parasites.

Diagnosis

- Examination of faecal sample for the presence of the eggs.
- Coproculture technique for further confirmation by indentification of the larvae.
- FAaa MAlan CHART or FAMACHA guide - The paleness of conjunctiva correlates with anaemia and PCV. There is availability of paleness chart. The paleness of the eye is tallied with paleness of chart indicating anemia and PCV

GENUS: TRICHOSTRONGYLUS

- Species: *T. colibriformis* (Bankrupt worm*)*, *T. axei* (Black scour worm), *T. orientalis*, *T. tenuis*
- Host: Ruminants, camel and rarely in horse, pig and dog.
- Location: Small intestine except T.axei (abomasum/stomach) and T.tenuis (small and large intestine)
- Buccal capsule is absent

FAMILY --STRONGYLIDAE

- Genus – Strongylus
- Important Species
- S. edentatus
- S. equinus
- S. vulgaris
- S. edentatus is called as toothless strongyle, S. vulgaris is called as double-toothed strongyle and S. equinus is called as triple- toothed strongyle, sclerostome or blood worm.
- large bursate nematodes of the equids inhabiting the large intestine. Strongylus vulgaris is of great pathogenic significance since the worms cause significant damage to the arterial system.

S. vulgaris	*S. equinus*	*S. edentatus*
1. The worms are found in the equines.	1. The worms are found in the equines.	1. The worms are found in the equines
2. Buccal capsule is oval.	2. The buccal capsule is apparently oval in outline.	2. Normal
3. A pair of ear-shaped teeth are present in the depth of the buccal capsule.	3. There is presence of a large dorsal tooth with two bifid tips at the base of the buccal capsule and two subventral teeth are also present.	3. Teeth are absent
4. These worms are smaller than other two worms.	4. These worms are larger than *S. vulgaris*.	4. These worms are larger than *S. vulgaris*.
5. The external leaf crown is fringed anteriorly.	5. The external leaf crown is not fringed.	5. The external leaf crown is not fringed.
6. Cranial mesenteric artery is affected by the larvae.	6. Not affected.	6. Not affected.
7. Nodules are not formed by the larvae on caecum and colon.	7. Nodules are formed in caecum and colon.	7. Haemorrhagic nodules are formed in caecum and colon.
8. Adults live in the large intestine.	8. The adults live in the large intestine.	The adults live in the large intestine.
9. The common name of the worms is double-toothed strongyle.	9. The common name of the worms is triple toothed strongyle, sclerostome, blood worm.	9. The common name of the worm is tooth less strongyle.

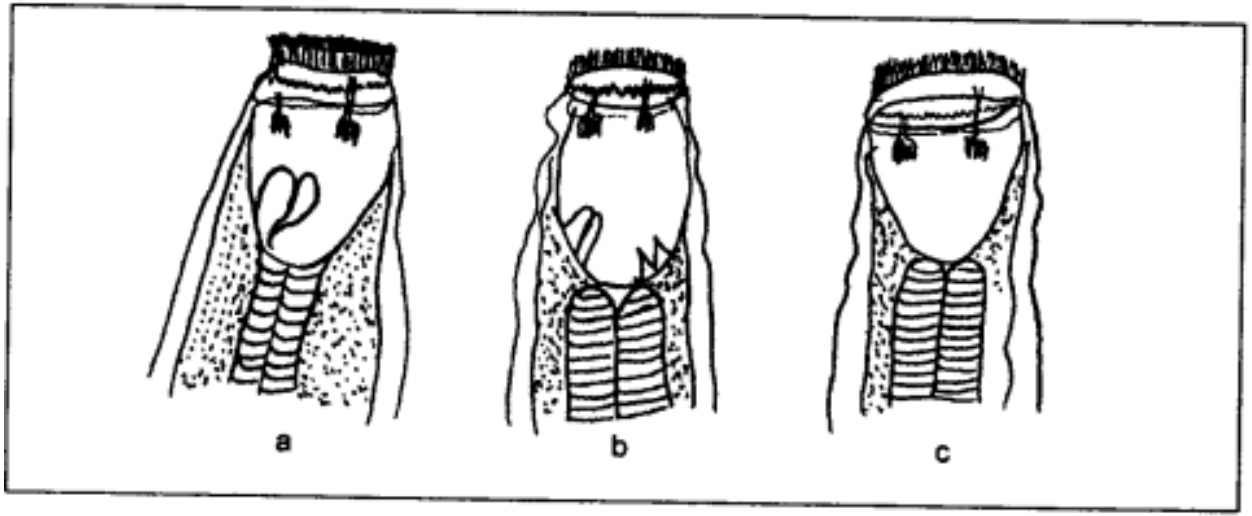


Fig. 50. a - Strongylus vulgaris; b - s. equinus; c - S. edentatus

Morphology

- Buccal capsule usually bears corona radiata (leaf-crowns) which are cuticular elements arranged in the form of a fence either on the outer margin of the mouth opening (external leaf crown) or on the inner wall of the buccal capsule (internal leaf crown).
- Due to their resemblance to fence, the worms with such leaf crowns are called pallisade worms
- The male worms possess well-developed copulatory bursa which is an umbrella-like cuticular expansion at the tail end supported by modified caudal papillae which are arranged in a definite pattern and called bursal rays.

General Life cycle

- The eggs are expelled out of the host. The eggs develop and hatch in the environment.
- After one moulting the 1st stage larvae transform into 2nd stage larva.
- In a similar way the second stage larvae further transform into 3rd stage larvae.
- The sheath of the second stage larvae is not cast off. Rather the sheath of the second stage larvae provide extra protection to the parasitic larvae.
- Now the larvae are ready for the infection to the host
- The larvae are negatively geotropic and positively phototropic to the light of low intensity.
- Development upto the 3rd stage larvae is same for all strongyle.

S. vulgaris

1. The hosts get the infection by ingestion of the infective larvae (L 3).
2. After ingestion exsheathment occurs. The larvae penetrate the intestinal wall and transform into 4th stage after moulting.
3. The larvae (4th stage) enter into the small arteries of the submucosal layer of the intestine
4. After about a week, they migrate to the anterior mesenteric artery (cranial artery) through the wall of the submucosal arterioles. Here they remain associated with formation of thrombi and aneurysms of blood vessel (verminous aneurysm) then reach the caecum and colon.
5. In the wall of the caecum and colon, nodules are formed and the parasites come into the lumen after rupture of the nodules where they get sexually matured.

S. equinus

1. The host gets infection by ingestion of the infective larvae (L3).
2. After ingestion exsheathment of the larvae occurs.
3. After exsheathment the larvae penetrate the wall of the large intestine. In the wall of the large intestine the larvae form the nodules.
4. In the nodules the larvae perform one moulting and transform into the 4^{th} stage larvae.
5. These 4^{th} stage larvae then leave the nodules and reach the peritoneal cavity.
6. From the peritoneal cavity the larvae then reach the liver after 11 days where they migrate for several days to several weeks.
7. From the liver the larvae then reach the pancreas.
8. From the pancreas the larvae reach the peritoneal cavity.

S. edentatus

1. After ingestion, exsheathment of the parasitic larvae occurs.
2. After exsheathment the larvae enter into the wall of the intestine and from the wall of the intestine, the larvae enter the liver via the hepatoportal circlilation and moult to become 4th stage larvae.
3. In the liver the larvae migrate for several days. Then from the liver the larvae reach to right abdominal flank via the hepatic ligament. Here in this vicinity the larvae form the haemorrhagic nodules. In the haemorrhagic nodules the larvae remain for few months.
4. Then the larvae reach the wall of caecum and colon where they form haemorrhagic nodules again.

Pathogenesis

- The adult worms attach themselves to the mucosa and suck blood producing anaemia of a normochromic and normocytic type.
- The larvae of S.vulgaris are more harmful as they cause endarteritis leading to the formation of thrombi and aneurysms in the anterior mesenteric artery.
- The aneurysm in the anterior mesenteric artery may cause colic by exerting pressure on the associated nerve plexuses.
- S. equinus larvae may produce haemorrhagic tracts in the liver and pancreas. Colic, anorexia and general malaise are the clinical signs in such cases.
- The larvae of S. edentatus may cause haemorrhagic nodules on the wall of the peritoneum, caecum and colon. Peritonitis, acute toxaemia, jaundice and fever may also occur

- Order - Rhabditida
- Superfamily - Rhabditoidea
- Family
  - *Strongyloididae*
  - *Rhabditidae*

FAMlLY - STRONGYLOIDIDAE

- *Strongyloides papillosus* - Found in the small intestine of sheep, goat and cattle
- *S. cati* - Found in small intestine of the cat
- *S. westeri* - Found in small intestine of pigs and horses.
- *S. ransomi* - - - Found in small intestine of pigs.
- *S. stercoralis* - Found in small intestine of human beings
- Site / location - Small intestine
- Common name: Intestinal thread worms
- Disease / pathological condition caused - Strongyloidosis, Foot rot, Cutaneous Larva migrans, larva currens

- Oesophagus is rhabditiform in free living generation and filariform in parasite generation.
- The adult parasite has noticeably long oesophagus.
- The female worm is parthenogenetic
- Mode of infection: mostly percutaneous
- Life cycle Two types of life cycle found in Strongyloides sp.
  - Homogonic
  - Heterogonic

Homogonic life cycle

1 . The eggs are expelled out of the host.

2. The eggs hatch and the larvae come out.

3. The larvae reach the infective stage.

4. The final host gets the infection by skin penetration or orally.

5. The larvae get entry into the blood circulation and transported to the lung. They penetrate the lung alveoli and gradually ascend up the upper respiratory tract.

6. Then they come down to the oesophagus and finally reach the intestine

Heterogonic life cycle

1 . The eggs are expelled out of the host.

2. The eggs hatch in the environment and the larvae come out.

3. The larvae directly develop to adult male and female.

4. These free living male and female parasite copulate and the gravid female lays the eggs.

5. The eggs hatch in the environment and the larvae come out.

6. The larvae directly develop to become the infective stage parasite.

7. The final host gets the infection by skin penetration performed by the infective larvae or by ingestion. Further development occurs as that mentioned in homogonic life cycle.

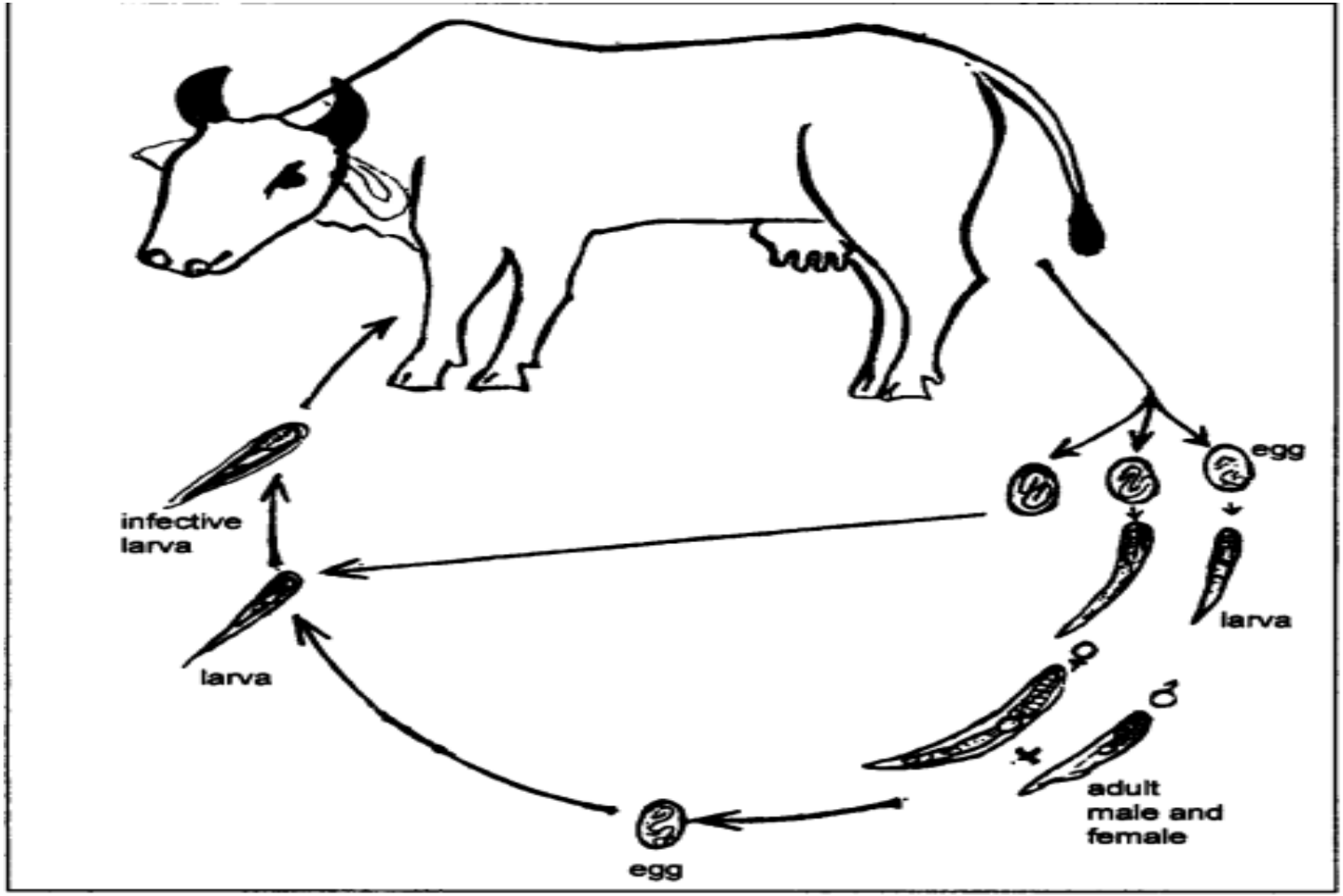


Fig. 68. Life cycle of Strongyloides spp.

- the larvae cause formation of lesion when they penetrate the skin.
- Foot rot condition caused by *Spherophorus necrophorus* is commonly found in the sheep and goat.

GENUS - OESOPHAGOSTOMUM

- important bursate nematodes inhabiting the large intestine of the ruminants and non-ruminants.
- great economic constraint in the livestock industry since these cause significant pathological feature, **pimply gut** which results in negative productivity and mortality of the animal

- *O. columbianum (found in sheep, goat)*
- *O. radiatum (found in cattle)*
- *O. venulosum (found in sheep and goat) – less pathogenic, does not cause nodule formation*
- *O. brevicaudum (found in pig)*
- *O. dentatum (found in pig)*
- Site / location - Large intestine
- Common name - Nodular worm
- Disease caused - Nodule disease, Knotty gut disease, Pimply gut disease

Morphology

- In the head region a prominent cervical alae is present.
- At the anterior margin of the head a mouth collar is present.
- A ventral cervical groove is present at the lateral region of the body.
- A cuticular inflated area situated anterior to the cervical groove is called cephalic vesicle.

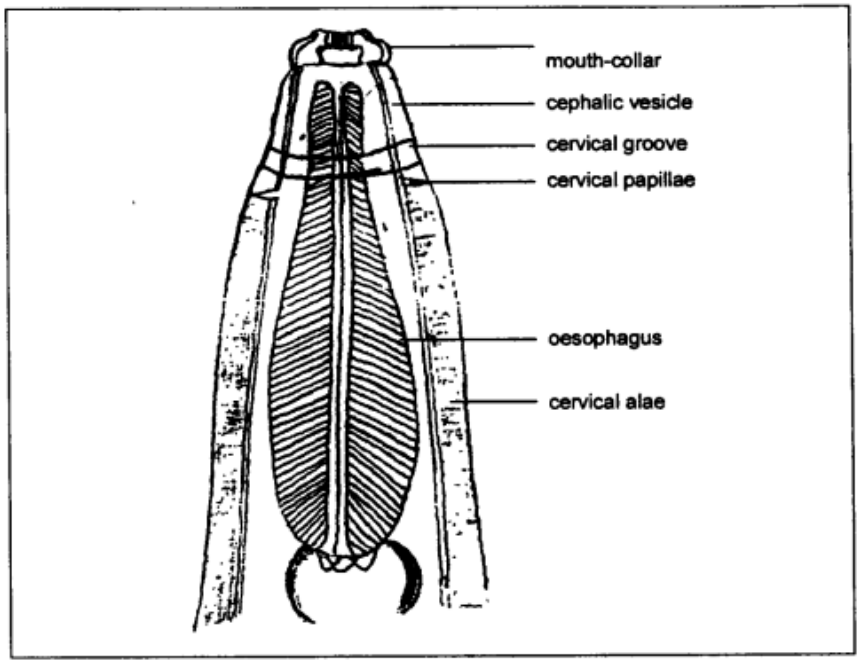


Fig. 52. Anterior end of Oesophagostomum spp.

- host gets the infection by ingestion of the infective stage larvae (L3)
- The larvae penetrate the wall of the small and large intestine (any part) and form the cyst within which the larvae remain for some time and transform into the 4th stage larvae after 4 days of infection.
- Then the larvae reach the lumen and proceed to colon where they get maturity.

Pathogenesis

- Pathological features / lesions: Deposition of fibrous tissue on the wall of the large intestine and formation of nodules.
- parasites fail to produce significant level of pathogenicity in the animals, not sensitized earlier with the parasite.
- If the sensitized animals get further infection and show significant level of pathogenicity.
- The production of nodules is the result of antigen-antibody reaction followed by infiltration of especially eosinophils, foreign body giant cells and encapsulation by fibroblasts
- The surface of the large intestine becomes hardened with tough texture and covered by a large number of nodules which are characteristically button-like. Thus the formation of the nodules occur and this noduled gut is called pimply gut or knotty gut.
- The nodules are filled with purulent exudate.

Clinical Signs

- A persistent diarrhoea with **dark green faeces** containing much mucus and blood are the initial signs in the lambs.
- Diarrhoea begins when the 4^{th} stage larvae leave the nodules and return to the lumen.
- Extreme emaciation and cachexia with atrophy of muscles, complete prostration followed by death in 1-3 days are the characteristic signs of chronic oesophagostomosis in sheep.

Genus: Chabertia

- It occurs in the colon of domestic and other ruminants
- *Chabertia ovina* is known to occur in sheep in Kumaon hills of Uttar Pradesh
- Emaciation, anaemia and diarrhoea with much mucus and blood are the clinical signs noticed

FAMILY: HETERAKIDAE

- Genus: Heterakis
- *Heterakis gallinarum*: The species occurs in the caeca of fowl, turkey and other gallinaceous birds, ducks and other birds.
- Common name: Caecal worm of Poultry

- **Life-cycle:**
  - Similar to *Ascaridia galli*.
  - Infective stage: egg containing 2nd stage larvae.
  - Transport host: Earthworm
  - Transmission:

    1. **Ingestion of infective egg containing L_2 with food or water**
    2. Eggs are sometimes ingested by earthworms, which may act as transport host. So, ingestion of earthworm containing L_2 larva

- Worms are usullay non-pathogenic but it's important role is transmission of ***Histomonas meleagridis*** **(protozoa).**
- *Histomonas meleagridis* (protozoa) causes entero-hepatitis or black head disease in turkey.
- Protozoa remain safe inside the infective eggs of the nematode against the lethal effect of the anterior part of the digestive tract of the bird on ingestion of eggs by them and reach caeca in viable state.
- Worms cause nodular typhlitis.
- Nodular typhalitis, anaemic, emaciation and diarrhoea.

Ascaridia galli
(Poultry Ascarid worm)

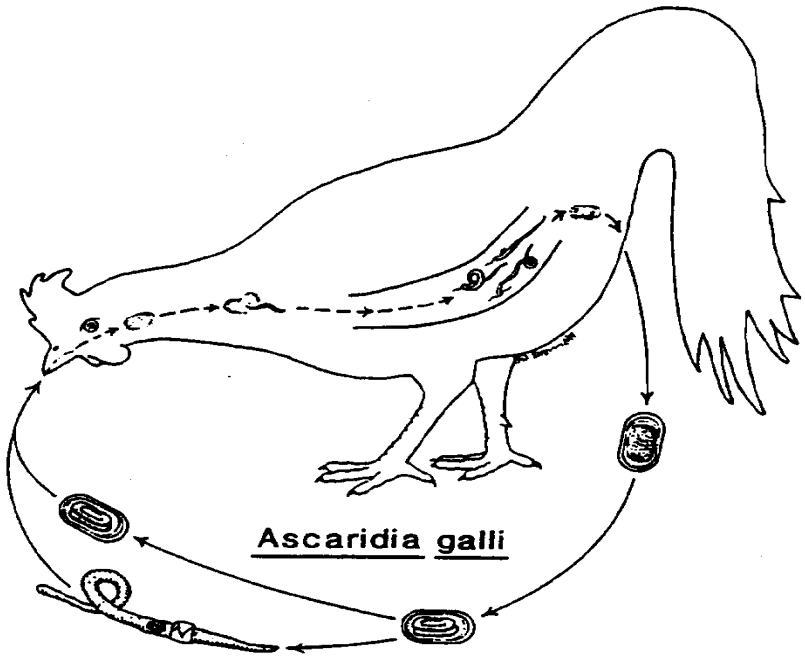
- **Final Hosts : Domestic & wild birds**
- **Location: Small Intestine**
- Largest nematode of poultry

Life-cycle:

- Direct life-cycle
- Infective stage: egg containing 2nd stage larvae.
- Transport host: Earthworm

Transmission:

1. Ingestion of infective egg containing L_2 with food or water
2. Eggs are sometimes ingested by earthworms, which may act as transport host. So, ingestion of earthworm containing L_2 larva



Pathogenesis

- Young birds under twelve weeks of age are more susceptible to infection than adult birds.
- Highly pathogenic in chickens of 1-3 months of age and chickens over three months of age are more resistant to infection.
- Dietary deficiency such as those of Vitamin A, B and B12, various minerals and proteins, predispose to heavier infections.
- Larvae cause catarrhal or haemorrhgaic enteric whereas the adult worms may cause intestinal occlusion and death.

Heterakis gallinarum	***Ascaridia galli***
1. Occurs in the caeca of fowl.	1. Occurs in the small intestine of the fowl.
2. Oesophagus has strong posterior bulb.	2. Oesophagus has no posterior bulb.
3. Earthworm may act as the transport host.	3. There is no evidence of transport host.
4. The eggs of *Heterakis gallinarum* transmit one important protozoa, *Histomonas meleagridis*, a causative agent of black head of turkey.	4. This parasite does not transmit any protozoan parasite.

FAMILY- SYNGAMIDAE

- Genus - Syngamus
- Species S. trachea
- Common name - Gape worm, forked worm, Y -shaped worm
- Host - Fowl
- Site/location - Trachea

- Buccal capsule is cup - shaped within which 6-10 teeth are present.
- Leaf crown is absent.
- Male parasite is much smaller than the female.
- The male and the female parasites are permanently copulated and give Y-shaped appearance.

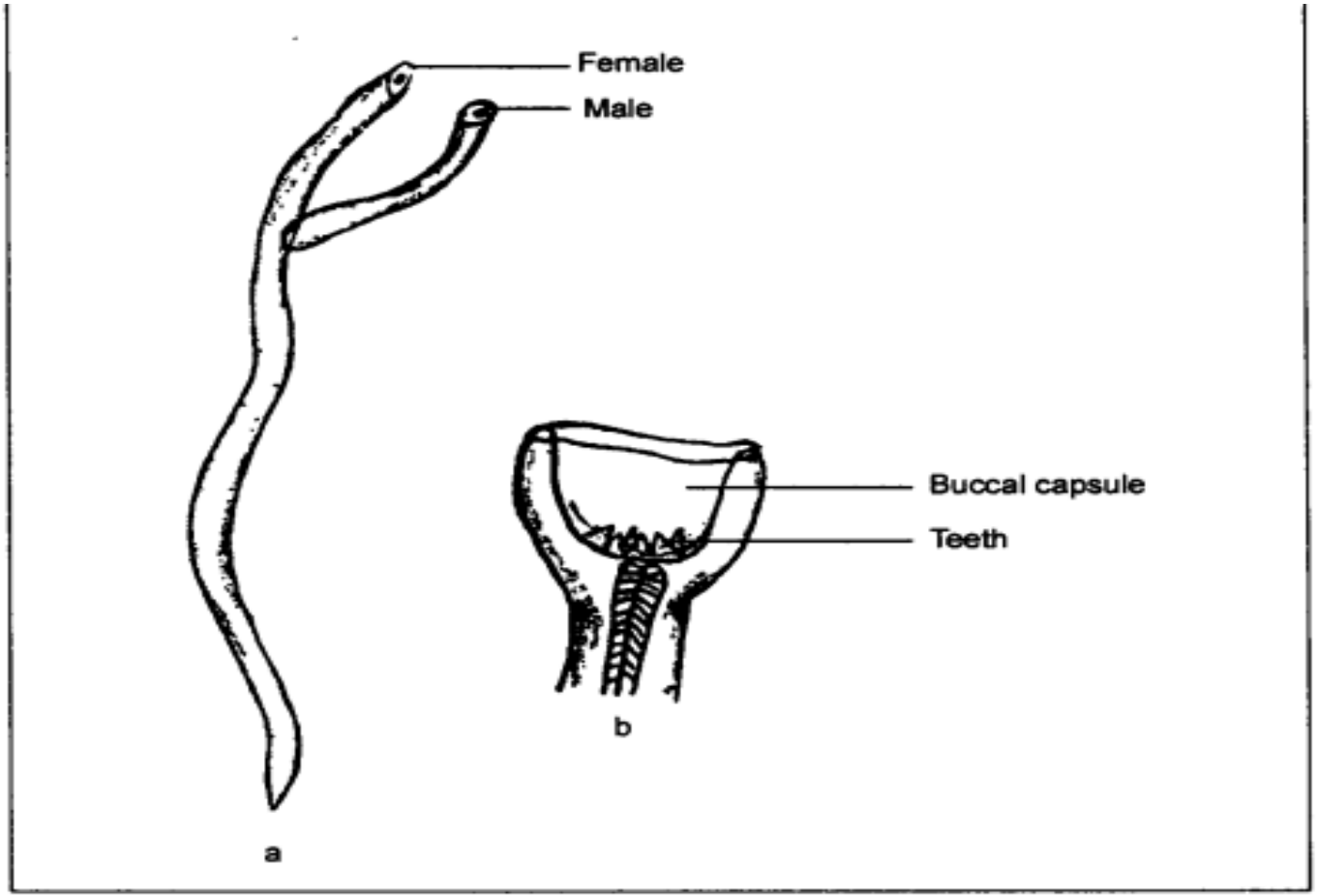


Fig. 54. a - Permanently copulated male and female of Syngamus trachea; b - anterior end of Syngamus trachea

- Pathological features / lesions: Tracheitis
- In the lumen of the trachea there occurs accumulation of large amount of mucus which leads to the obstruction of the lumen of the trachea.
- To expel out the cough the birds shake their head.
- Characteristic gaping movement is the common clinical sign for which the parasite has been named as gape worm.
- Due to occlusion of trachea the birds open their mouth and move in this state called gaping movement.

- Family - Subuluridae
- Genus - Subulura
- Species - S. brumpti
- Common name - Pin worm of fowl.

FAMILY: STEPHANURIDAE

- Genus - Stephanurus
- Host -Pig (S. dentatus) and man (S. laryngeus)
- Common Name: Kidney worm of Pig
- Site/location - Kidney (Perrirenal fat, pelvis and ureter)
- Buccal capsule is cup -shaped.
- At the basal area there is presence of six variable teeth which are cusped.

- ✓ Direct life-cycle
- ✓ Infective stage : 3rd stage larva (L_3)
- ✓ Transport host: Earthworm
- Final host (pig) gets the infection -
  - by ingestion of free L_3 with food and water
  - by the ingestion of infected earthworm (transport host)
  - Percutaneous (through skin penetration)
  - Prenatal mode of infection

Life cycle

- The host gets the infection by ingestion of larvae. Infection of the host may also occur through the skin penetration by the larvae or by ingestion of transport host (earthworm) harbouring the larvae.
- While there is oral infection third eccdysis occurs in the stomach and the fourth stage larvae come out.
- While skin penetration occurs the larvae moult in abdominal muscles.
- Whatever the route of entry is the larvae ultimately reach the liver.
- From the liver the larvae reach the peritoneum.
- From peritoneum they reach the ureter and the kidney.

- Pathological features / lesions: Nodule and oedema formation on the skin, abcess in liver and cyst in kidney
- The nodules and oedema may be formed when skin penetration by the parasites occurs.
- Abcess is formed in the liver at the time of migration by the larvae. The migrating larvae cause portal fibrosis and coagulative necrosis of liver tissues.
- In the kidney local purulent tissue reaction occurs. Later on cyst is formed.

Dioctophyma renale

- Family: Dioctophymidae
- Other name: *Eustrongylus gigas*
- Common name: Giant kidney worm of dog

- Largest nematode of domestic animals (Length of female is up to 103 cm).
- Worms are blood red in colour.
- Male worm (35-45 cm long) has single spicule and cup-shaped bursa without bursal rays.
- Barrel shaped eggs in the single cell stage are passed in the urine, either singly or in clusters or chain and the shells are pitted except at the poles.

- ✓ Indirect life-cycle
- ✓ Intermediate host: Oligochaete annelid (*Lumbriculus variegatus*)
- ✓ Infective stage : 3rd stage larva (L_3)

- Worms destroy the parenchyma of pelvis of the kidney.
- Usually right kidney invaded more frequently than the left.
- Formation of a sac–like structure in the capsule where worms are found.

- Kidney worms infection leads to
  - Dysuria with some haematuria, especially at the end of micturition.
  - Renal colic

Diagnosis

- On the basis of symptoms.
- Microscopic examination of urine reveals eggs of worm.
- Eggs are barrel–shaped, brown colour and the shells are pitted except at the poles.

- Family - Filaroididae
- Genus - Filaroides
- Species - F. osleri
- Host -Dog
- Site/location - bronchi and trachea

- Family: Metastrongylidae
- Genus: Metastrongylus
- bursate nematodes inhabiting the bronchi, bronchiole of pig
- Species - M. elongatus
- Infective stage: L3
- IH: Earthworm
- Common name: Lung worm of Pigs

- Family Protostrongylidae
- Genus Prontostrongylus
- Species - P nifescens
- Common name - Red lung worm
- Host - Goat, sheep and other related animais.
- Site/location - Bronchiole

- Genus - Mullerius
- Species Mullerius capillaris
- Common name - Hair lung worm/ Nodular lung worm
- They have indirect life cycle.
- Goats, sheep, and other wild ruminants are final hosts
- snails (Helix and, Helicella, Theba, Zebrina) and slugs (Limax, Agriolimax) act as intermediate host.

Family Oxyuridae

- Genus Oxyuris
- Species- O. equi
- Host -Equines
- Site/location - Large intestine
- Common name - Pin worm or seat worm of horse
- Infective stage: L2
- Pathological features / Lesions: Mild enteritis, anal pruritus, rat-tailed condition

FAMILY -THEIAZIIDAE

- Members inhibit the conjunctival sac, lacrimal duct and digestive tract of mammals and birds
- 1) Thelazia 2) Oxyspirura 3) Spirocerca 4) Ascarops 5) Physocephalus 6) Simondsia 7) Gongylonema

Genus: Thelazia

- eye worms of the animals
- Thelazia rhodesii- Found in the eye of cattle, sheep and goat.
- T. lacrymalis - Found in the eye of horse
- T. gulosa - Found in the eye of cattle
- T. alfortensis - Found in the eye of cattle
- T. callipaeda - Found in the eye of dog
- T. skrajabini -Found in the eye of cattle
- Intermediate host -The fly, particularly Musca convexifrons and M. larvipara act as the intermediate host of the parasite.

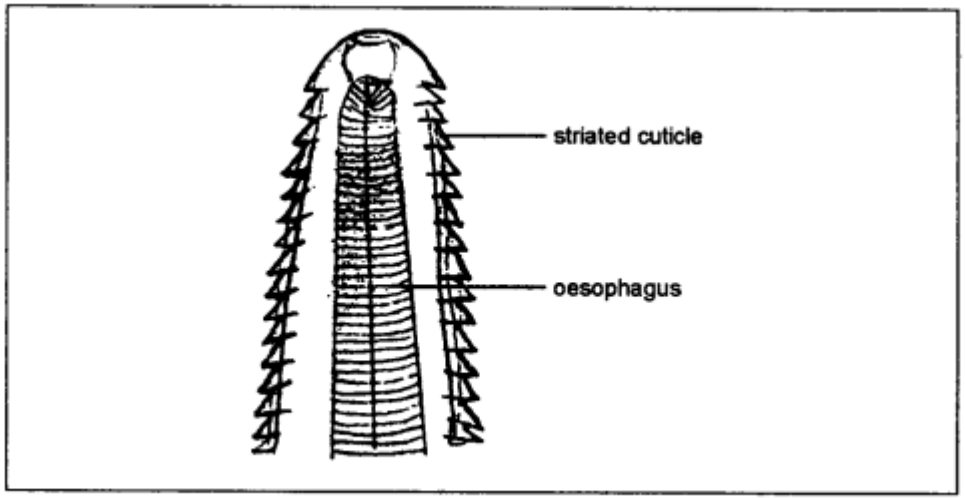


Fig. 69. Anterior end of Thelazia rhodesii spp.

- Life cycle is indirect and house flies act as intermediate hosts.
- The female are viviparous.
- The L1 are passed through the lacrimal secretion and ingested by flies.
- The infected L3 are developed in 2-4 weeks and are deposited by the flies in the eyes during feeding

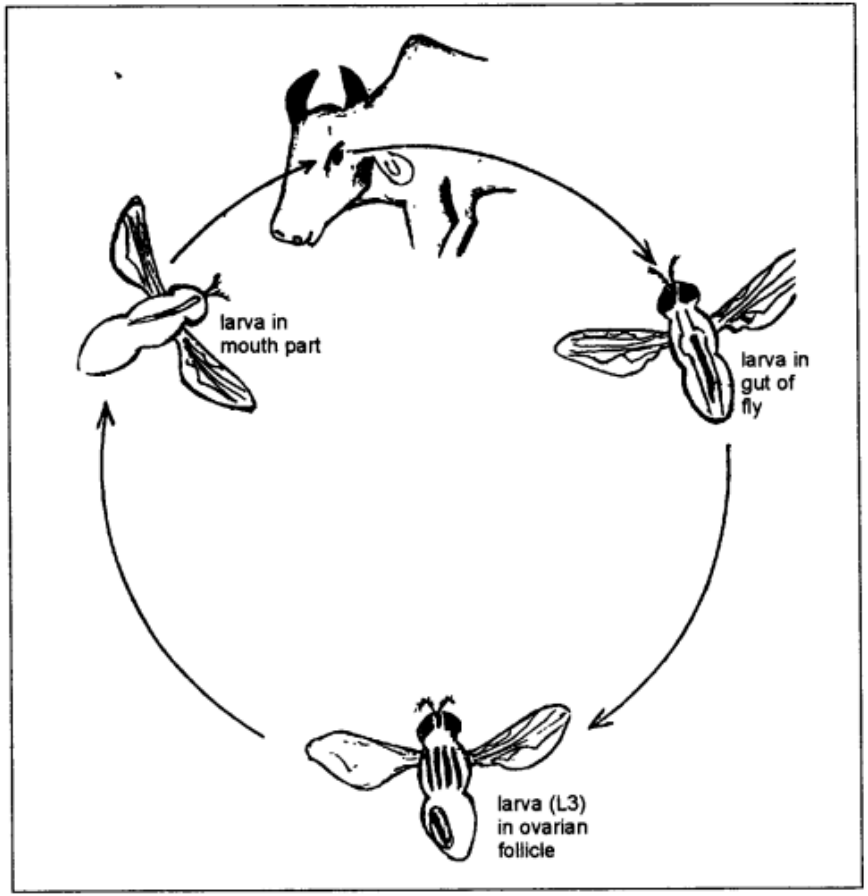


Fig. 70. Life cycle of Thelazia spp

- They damage of the eyes due to their striated cuticle and movement.
- As a result there will be- Lacrimation, Conjunction, Ulceration of the cornea, Muco purulent discharge,Corneal opacity, Keratitis ,Abscess in eyelid, Photophobia, blindness
- Levamisole and Tretamisole are choice of drug.

Spirocerca

- Species: S.lupi
- Host: Dog
- Location: In the wall of oesophagus, stomach and aorta.
- Intermediate host: Coprophagus beetles
- Common name: Oesophageal tumour worm of dog
- Worms are spirally coiled
- Funnel shaped pharynx with trilobed lip
- Tail of male bears lateral alae with 4 pairs of papillae
- Eggs are embryonated and are elongated with thicked shell.

Life Cycle

- The eggs are expelled out of the host.
- Eggs do not hatch until they are ingested by the intermediate host. The coprophagus beetle act as the intermediate host.
- Infective stage (L 3) larvae develop in the beetle.
- Sometimes the beetles are ingested by the unusual host which act as the transport host i. e. birds, reptiles, snake and lizard etc.
- The final host gets the infection by ingestion of the infected beetle or the transport hosts (parataenic hosts).
- On being ingested the larvae are released and enter the wall of the stomach and reach the artery. The larvae follow the route of the artery, like gastric artery, gastroepipoic artery, coeliac artery and then reach the thoracic aorta and then to oesophagus.

- Pathological features / lesions :Tumor formation in the aorta, oesteosarcoma, fibrosarcoma etc.
- When the parasite is present in the oesophagus it causes oesophagitis. Initially inflamation with cellular infiltration occurs.
- Sometimes the oesophagus gets ruptured and the oesophageal content is expelled from the oesophagus and enter the pleura leading to cause pleuritis.
- Nodules are formed in the luminal surface of the oesophagus and within the nodules the worms remain.
- Very dangerous complication associated with S. lupi infection in oesophagus is development of malignant tumour. The neoplastic cells may metastize in other organs.
- Osteosarcoma and fibrosarcoma are found on the wall of the oesophagus

- The main pathological feature is the formation of nodules in the aortic nodules which are filled up with the purulent exudate.
- Massive proliferation occurs in the intimal part of the aorta. The intimal surface becomes roughened and is associated with different sized plaques.
- The parasites cause formation of the nodules in the media region preferably. This condition leads to formation of stenosis and aneurysm. The aorta may get ruptured and makes the condition more severe.

- The other characteristic pathological feature is 'hypertrophic pulmonary osteoarthropathy' in dogs and 'deformative ossifying spondylitis' in different hosts.
- Treatment Diethyl carbamazine - 20 mg / Kg body wt.

- GENUS: OXYSPIRURA
- Species: O.mansoni
- Host: Birds mainly chicken, turkey etc.
- Location: Nictitating membrane of the eye.
- Common name: Eye worms of Poultry.
- Intermediate host: Cockroach

- GENUS: ASCAROPS
- Species: Ascarops strongylina
- Host: Pig and wild boar
- Common name: Stomach worm

- GENUS: PHYSOCEPHALUS
- Species: Physocephalus sexalatus
- Location: Stomach
- GENUS: SIMONDSIA
- Species: Simondsia paradoxa
- Location : Stomach
- Host: Pig and wild boar

GENUS : GONGYLONEMA

- The species of this genus is known as “gullet worm”.
- The characteristic feature include thick cuticle with transverse striated.
- This species is found in mammals and birds
- Gongylonema verrucosum- found in rumen of sheep, goat and cattle.
- G. pulchrum - found in oesophagus of sheep, goat and cattle in a zig-zag manner.
- G. ingluvicola- found in crop of fowl.
- Intermediate host - Coprophagus beetle

FAMILY -SPIRURIDAE

- Genus Habronema
- H. majus - Found in the stomach of horse
- H. muscae - Found in the stomach of horse
- Genus Draschia
- Draschia megastoma - Found in the stomach of the horse

Habronema majus	*Habronema muscae*	*Draschia megastoma*
1. Site – Stomach	1. Site – Stomach	1. Site – Stomach
2. Host – Equine	2. Host- Equine	2. Equine
3. The pharynx contains tooth.	3. The pharynx is cylindrical.	3. The pharynx is funnel-shaped.
4. The parasites are not severely pathogenic.	4. The parasites are not severely pathogenic.	4. The parasites are severely pathogenic as they cause formation of tumours in the stomach.

- larvae or maggots of the flies, Musca spp and Stomoxys spp, act as the intermediate host of the parasite.
- Further development of the larvae occurs in the pupa of the fly. In the pupa the larvae reach the infective stage.
- The fly deposits the infective larvae at or within the nostril region, lips or any existing wound.

- Pathological features / Lesions: Tumor formation in the stomach by D. megastomea infection and mild enteritis by other two species.
- Draschia megastoma causes severe damage to the host by formation of nodules. The nodules are formed by deposition of granulomatous tissues. The margins of the nodules get attached to each other and lead to cause formation of large tumours in the stomach at fundus region.
- 'cutaneous habronemiosis " 'summer sore', 'granular dermatitis' or bursati: due to the deposition of larvae L3 of Habronema and Draschia spp. in existing wound by infected flies

- FAMILY - Gnathostomatidae
- Genus – Gnathostoma
- Species - G. spinigerum
- Site - Stomach
- Definitive host - Dog and cat
- Intermediate host 1st - Cyclops
- 2nd intermediate host – Fish
- The worms penetrate the stomach wall where they cause formation of cavities. The parasites remain within the cavities resulting formation of tumour.
- CLM as well as VLM

- There is presence of a large head bulb.
- Four submedian cavities are present. Few rows (6-11 rows) of cuticular hooks are present on the head bulb.
- Cuticufar spines are present on two third of the body (anterior).

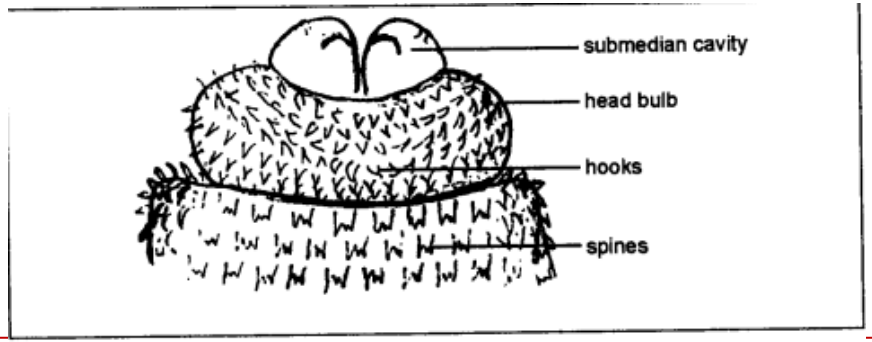


Fig. 72. Anterior end of Gnathostoma spp.

Family: Filariidae

- Genera of importance
- Dirofilaria
- Parafilaria
- Suifilaria
- Ornithofilaria
- Wuchereria
- Brugia

GENUS -DIROFILARIA

- Dirofilaria immitis
- important mosquito-transmitted canine filarial worms inhabiting the heart
- Common name – Heartworm
- in the posterior part of the male parasite. There is presence of few pairs (4-5 pairs) of ovoid papillae.
- In addition to the ovoid papillae there is presence of finger shaped papillae (2 pairs) and few minute conical papillae at the posterior tip of the worm.

- Definitive host - Dog, fox and other related animals
- Intermediate host - The mosquitoes (Anopheles, Culex and Aedes) act as the intermediate host of the parasite.
- Pathological features/ lesions: Pulmonary hypertension, congestive heart failure, haemoglobinuria, jaundice

- The parasite either in larval or adult stage get adhered to the pulmonary artery leading to cause pulmonary hypertension.
- The adult and larval stage of parasite are lodged in between the right atrium and the right ventricle.
- Due to hypertrophy of right ventricle congestive heart failure occurs. Occurrence of passive congestion is the common feature.
- Clinical signs 1. Shallow coughing 2. Haemoglobinuria 3. Jaundice 4. Pulmonary hypertension and passive congestion 5. Weakness

Knott's method

- One ml of blood from infected animal is mixed with 9 ml of 2% formalin. The mixed material is then centrifuged. The sediment is stained by methylene blue.

Parafllaria

- P. multipapillosa- These parasites are found on the skin of equines forming the haemorrhagic nodules.
- P. bovicola - These parasites are found on the skin of the cattle forming the haemorrhagic nodules.
- These nodules are unhealing type and dissappear in the winter season and again appear in the summer season. The nodules are filled with blood and the lymph which is called summer bleeding.

FAMILY - SETARIDAE

- Genus – Setaria
- S. digitata- Found in cattle and related animals
- S. labito-papillosa- Found in cattle and related animals
- S. cervi- Found in the deer
- S. equina - Found in the equines
- inhabit the peritoneal cavity.
- the larvae or the immature worms cause the cerebrospinal nematodosis.

- Disease caused - Eznootic cerebrospinal nernatodosis
- Site/location Peritonial cavity
- Pathological features/ Lesions Cerebrospinal nematodiosis associated with encephalitis, meningitis, encephalomilomalacia etc.

Genus Stephanofilaria

- S. assamensis - a causative agent of hump sore
- S. dedoesi - a causative agent of sore on the skin of cattle
- S. kaeli - a causative agent of leg sore
- S. stilesi- a causative agent of abdominal sore
- S. zaheeri- a causative agent of ear sore

- Dipetalonema
- D. perstam - Found in peritoneal cavity of man.
- D. reconditum -Found in the kidney of dogs.
- D. evansi - Found in the spermatic artery of camels.
- D. grassi-Found in the subcutaneous tissues of dogs.

Onchocerca

Family : Onchocercidae

Species:

Species	Fina host	Intermediate host	Location
Onchocerca gibsoni	Cattle and zebu	Midge (*Culicoides pungens*)	Subcutaneous & intermuscular nodules
Onchocerca gutturosa	Cattle and zebu	*Simulium ornatum*	Ligamentum nuchae & gastrosplenic ligament
Onchocerca cervicalis	Horse & mule	Culicoides nubeculosis	Ligamentum nuchae
Onchocerca armillata	Cattle & buffalo	-	Thoracic aortic wall
Onchocerca volvulus	Man	*Simulium* spp. (black fly)	Subcutaneous nodules

- LIFE CYCLE: Indirect

Species	Intermediate host	Location
Onchocerca gibsoni	Midge (*Culicoides pungens*)	Subcutaneous & intermuscular nodules
Onchocerca gutturosa	*Simulium ornatum*	Ligamentum nuchae & gastrosplenic ligament
Onchocerca volvulus	*Simulium* spp. (black fly)	Subcutaneous nodules

- Microfilariae (L_1) are taken by the flies during sucking blood from the Infected host.
- Infective larvae (L_3)develop inside the flies.
- Transmission occurs when 3rd stage larvae (L_3) infected flies suck blood of another final hosts.

Life Cycle of *Onchocerca cervicalis*

Microfilaria live on dermis of skin (larvae of neck threadworm)



Fly bites horse and ingests microfilaria; parasite develops into second stage



Infected horse sheds larvae; larvae enter fly when horse is bitten and can now be transmitted to other horses



Fly bites horse again. Second stage larvae travel to connective tissue in neck and develop into adult worm

- Dioctophyma renale Site - Kidney of dog
- Lymphatic filariasis: **Wuchereria bancrofti**

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- Site/location: Peritoneal cavity
- Pathological features/ Lesions: Cerebrospinal nematodiosis associated with encephalitis, meningitis, encephalomilomalacia etc.

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- Transmission occurs when 3rd stage larvae (L_3) infected flies suck blood of another final hosts.
- Causes Fistulous withers and Poll evil (also by Brucella spp.)

- *Dioctophyma renale*
- Site - Kidney of dog
  - I.H.: Free living oligochaete annelid, *Lumbriculus variegatus*
- Lymphatic filariasis: **Wuchereria bancrofti**

Family: Dracunculidae

- Species: Dracunculus medinensis
- Common name: Guinea worm or Dragon worm or Medina worm or Serpent worm
- Hosts: Man and dog
- Intermediate host - An aquatic arthropod called Cyclops(Mesocyclops leukarti)
- Infective stage: L3
- The female parasite is very long, about 3-4 metres in length. The difference of the length of male and female is much
- Helmet, a specific cuticular structure is the most salient morphological feature of this parasite.

- Developmental stages
- Larva 1 (In the cyclops)
- Larva 2 (In the cyclop)
- Larva 3 (In the cyclop, infective stage)
- Larva 4
- Adult

Male worms die after fertilization and female worms migrate to superficial layer of skin where they secret a toxin and lead to formation of blister in the lower part usually legs.

Pathogenesis: The parasites cause subcutaneous swelling. The swelled area is ruptured and it leads to formation of ulcer.

FAMILY -TRICHURIDAE

- Host - cattle, dog and other related animals as per different species.
- Site/location - Large intestine
- Common name - Whip worm

Morphological Characters:

- Commonly called “whip worms” due to thin **whip-like** anterior part of the body.
- Anterior part of body is long and slender whereas posterior part is thicker.
- Females are oviparous.
- Hind end of male is curled and there is **<u>one spicule</u>** that remains in spicule sheath
- Eggs are brown in colour with thickened shell, **barrel** or **lemon shaped**, with a transparent plug at either pole whereas egg of *Trichuris trichura* has **football shaped**.

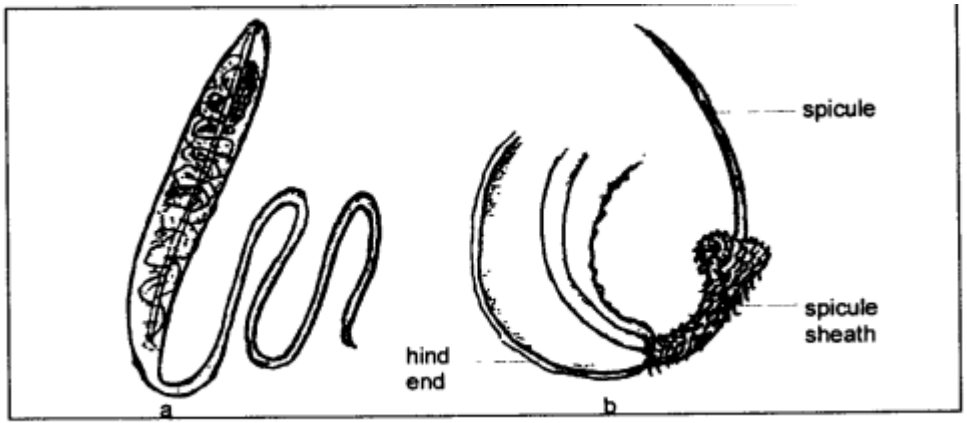


Fig. 76. Trichuris spp. a - Complete worm; b - Posterior end.

Trichuris species

Species	Host
Trichuris ovis	Sheep, goat, cattle etc.
Trichuris discolor	Cattle, buffalo, sheep & goat
Trichuris globulosa	Camel, sheep, goat, cattle etc.
Trichuris vulpis (Whip worm of dog)	Dog, cat & wild carnivores
Trichuris campanula Trichuris serrata (Whip worm of cat)	Cat
Trichuris suis (Whip worm of pig)	Pig
Trichuris trichiura (Whip worm of man)	Man

- Final hosts get the infection
  - by the ingestion of egg containing L_1 with feed /water/soil.
  - Fertilized female worms produce numerous eggs (3,000-10,000 per day) which are excreted with faeces of infected host.

Family : Trichinellidae

- Species: Trichinella spiralis
- Sometimes referred to as the “Pork worm” due to it being found commonly in undercooked pork products.
- Hosts : Man, Pig, rat, dog & wild animals (Leopard, tiger, wild boar etc.)
- Location: Small Intestine

Morphological Characters:

- male is 1.4-1.6 mm long whereas female worm is 3-4 mm long.
- Male has neither a copulatory spicule nor a spicule sheath.
- Female is larviparous.
- It is an Auto-heteroxenous parasite.
- Trichinella is most specialized species have no period of free existence at all
- Auto-heteroxenous parasite (Same vertebrate animal acts as definitive and intermediate host of a parasite).
- Infective stage: First Stage Larvae (L1)

- Final host (pig) gets the infection –
  - by ingestion of the muscle containing the first stage larvae (L1) during predation or carrion feeding.
  - Man gets infection due to eating of raw or undercooked pork containing encapsulated L1
  - Pig get infection by the ingestion of L1 infected pork scraps or occasionally rats.
  - Rat is probably most highly infected natural host.

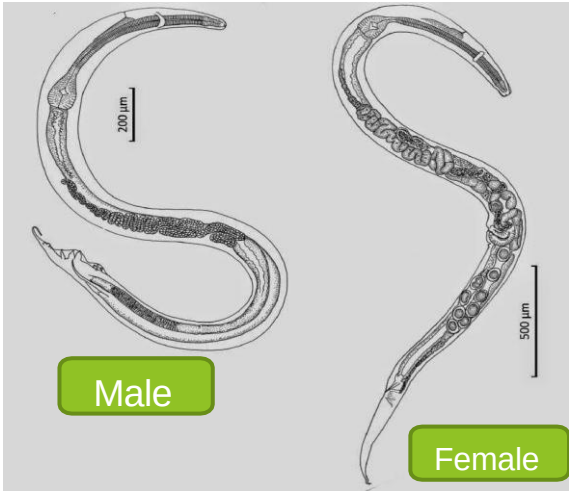
Life cycle

- After copulation, the male parasite dies and the female parasite burrows the wall of intestine and lays L1 .
- First stage larvae via blood reach to the striated (Skeletal) muscles where they are encapsulated by the host, grow and assume characteristic coiled position.
- During this activity the larvae get entrance in the blood circulation via lymphatic vessel and the larvae enter the different musculatures like subcostal muscle, tongue and diaphragm. The affected muscle cell is called 'nurse cell'.
- Trichinellosis is a meat-borne helminthic zoonosis
- Trichinoscope instrument is used in diagnosis of trichinellosis
- Treatment: Benzimidazoles

Capillaria

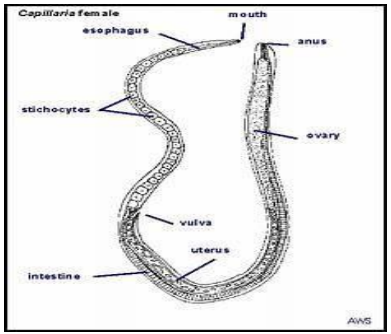
Morphological Characters:

- Closely related to *Trichuris* species
- Anteriorly thinner whereas gradually become thicker posteriorly.
- Male worm has single spicule.
- Female worm is oviparous.
- Eggs are colourless, more barrel-shaped, with the sides nearly parallel and the bipolar plugs do not project as far in comparision to *Trichuris* species eggs.



Capillaria

Species	Host	Location
Capillaria caudinflata	Fowl and pigeons	Duodenum and Ileum
Capillaria annulata	-do-	Crop & oesophagus
Capillaria hepatica	Rat and mouse, occasionally dog, cat & man	Liver
Capillaria aerophila	Dog, foxes and coyotes	Trachea and bronchi





Life-cycle:

- Direct or indirect life-cycle depending upon the species.
- Earth worm acts as intermediate host for *Capillaria annulata, Capillaria caudinflata* and *Capillaria plica*.
- Fish acts as intermediate host for *Capillaria philippinensis.*

- **Transmission:**
  - Hosts get infection by the ingestion of food contaminated with eggs shed by cannibalistic host or from a dead decomposed infected carcass.
  - Ingestion of infected earthworm (*Capillaria annulata*, *Capillaria caudinflata* and *Capillaria plica*)
  - Ingestion of infected fish (*C. philippinensis*)

PHYLUM: ACANTHOCEPHALA

- thorny-headed worms
- Hetero sexual intestinal worm
- No alimentary canal
- Life cycle: Indirect
- The eggs contain 'acanthor' larvae which are provided with an anterior circlet of hooks.
- The acanthor larvae hatch out. from the eggs in intestine of anthropods and enter body cavity or haemocoel.
- The larvae change to acanthella larvae which mature to become infective larvae called cystacanth.

- *Macracanthorhynchus hirudinaceus:* small intestine of pigs and wild boars
- *Filicollis anatis* : It occurs in the small intestine of duck, goose and wild aquatic birds
- *Oncicola canis* : The worms are found in the intestine of dog, cat and other carnivores

Protozoology

- Protozoology is the study of protozoa.
- The word protozoa is derived from the Greek words – “Proto” means first and “Zoa” means animals.
- The first animal life which appeared on this earth belonged to this category.
- Protozoa was discovered by Antoni Van Leeuwenhoek (Dutch scientist) and also known as Father of Protozoology.
- Protozoa are an unicellular, microscopic and eukaryotic organism having a distinct nucleus enclosed in a membrane.
- bacteria is also unicellular but there is a clear cut ditTerence between the protozoa and bacteria that the bacteria is unicellular but it does not have any distinct nucleus.

- Body of protozoa is consisted of two parts-
  - Cytoplasm
  - Nucleus
- Cytoplasm - it is an extra nuclear part which is divided into two parts-
  - Ectoplasm- external hyaline portion of the cytoplasm which helps in locomotion and sensation.
  - Endoplasm- inner granular part of cytoplasm. it contains food vacuoles, membranes organelles (mitochondria, Golgi apparatus and endoplasmic reticulum).

- **Nucleus :-** it is found in endoplasm. Usually one nucleus is found but some protozoa have two nucleus (*Balantidium coli*, *Giardia* spp. etc.). Nucleus is composed of nuclear membrane, nucleoplasm, chromatin granules and karyosome (endosome) or nucleolus.
  - Endosome is devoid of DNA whereas nucleolus contains DNA.
  - Two types of nucleus found-
    - ✓ Vesicular nucleus – most of the protozoa are having vesicular type nucleus except ciliates.
    - ✓ Compact nucleus- it contains large amount of chromatin materials and small amount of nucleoplasm. Example- macronucleus of *Balantidium coli*.
- Some protozoa may have two similar nuclei (Giardia and Hexamita species) or two dissimilar nuclei (Balantidium coli).
- In dissimilar nuclei species, larger nucleus (macronucleus) governs cytoplasmic functions whereas smaller vesicular nucleus (micronucleus) helps reproductive functions of the protozoa.

Nutrition

I. Holophytic nutrition – plant like nutrition where organisms can synthesize the carbohydrates by the chlorophyll present in the chromatophores. Examples- free living protozoa like Euglena, Volvox etc.

II. Holozoic nutrition – food materials are ingested by means of pinocytosis or phagocytosis or through a cytostome and taken into the phagosome or food vacuoles for digestion. Examples- *Entamoeba* spp. and *Balantidum coli*.

III. Saprozoic nutrition- food materials are absorbed by means of osmosis through their surface membrane . Example – *Eimeria, Babesia , Theileria, Trypanosoma* spp.

Locomotion

- **Pseudopodia (false foot)** – it is temporary locomotary organelle formed from the projection of ectoplasm. It is also help in engulfing the food materials. Example- Entamoeba spp.
- **Flagella** – flagellum is a whip like filamentous structure originated from the blepharoplast. The part of the flagellum which remains inside the body is known as axoneme and the outside portion is called as free flagellum. Examples- Tritrichomonas foetus, Giardia spp. etc.
- In some protozoa, the flagellum attached to the body of the protozoa and form an undulating membrane which helps in movement . Examples- Trypanosoma , Giardia spp. etc.

- **Cilia-** Elongated hair-like structure and shorter than flagella and usually present throughout the body margin. Example – *Balantidium coli.*
- **Gliding-** Due to absent of locomotary organelle, some protozoa may move by gliding (members of Phylum Apicomplexa and class sporozoa i.e. *Toxoplasma, Sarcocystis, Eimeria, Isospora, Cryptosporidium, Hepatozoon,Theileria, Babesia, Besnoitia* etc.

- Excretory System: Metabolic waste product excreted out either through the body surface membrane by osmosis or by means of contractile vacuole which plays an osmoregulatory function.

REPRODUCTION IN PROTOZOA

- Reproduction in protozoa may be either asexual or by both asexual and sexual.
- Asexual reproduction :-
  - Binary fission: commonest mode of asexual reproduction, Nucleus divides first, and then cytoplasmic division occurs.
  - Schizogony (Multiple fission): First nucleus divides several times, then cytoplasm. The dividing forms with a multinucleated mass and surrounded by a distinct wall known as Schizont and daughter forms called merozoites.

- **Budding:** Two or more daughter forms are produced from the parent cell and grow to full size.
- **Edodyogeny (Internal budding):** Two daughter cells are formed within the parent cells. It occurs in case of *Toxoplasma*
- **Endopolygeny-** Many daughter cells are formed within the parent cells. e.g. *Toxoplasma* and *Sarcocystis* spp.

Sexual Reproduction

- Conjugation - Exchange of nuclear materials from the micronucleus takes place in conjugation e.g. Ciliates.
- Syngamy - Two gamete fuse to form a zygote called syngamy.

✓ Two similar size gametes i.e. isogametes and process of their fusion called isogamy.

✓ Two dissimilar size gametes i.e. anisogametes and it fusion called anisogamy.

- In anisogamy, the smaller gamete is a male gamete known as microgamete and the larger one is a female gamete known as macrogamete which are produced from microgametocyte and macrogametocyte, respectively.

- Sporogony is an asexual process of multiple fission and sporogony normally follows syngamy.

✓ In sporogony, zygote forms a number of sporozoites within the walls of a cyst commonly known as oocyst

Mode of transmissions of protozoan parasites

- Direct :-

1. Ingestion of contaminated feed & drinks – oocyst, cyst etc.of Giardia, Entamoeba & B.coli
2. Ingestion of infected meat containing the stages of the parasites. - Trypanosoma & Sarcocystis.
3. Through (genital route) – coitus - Tritrichomonas & Trypanosoma equiperdum
4. Congenital route – Toxoplasma gondii
5. Through crop milk - Trichomonas gallinae

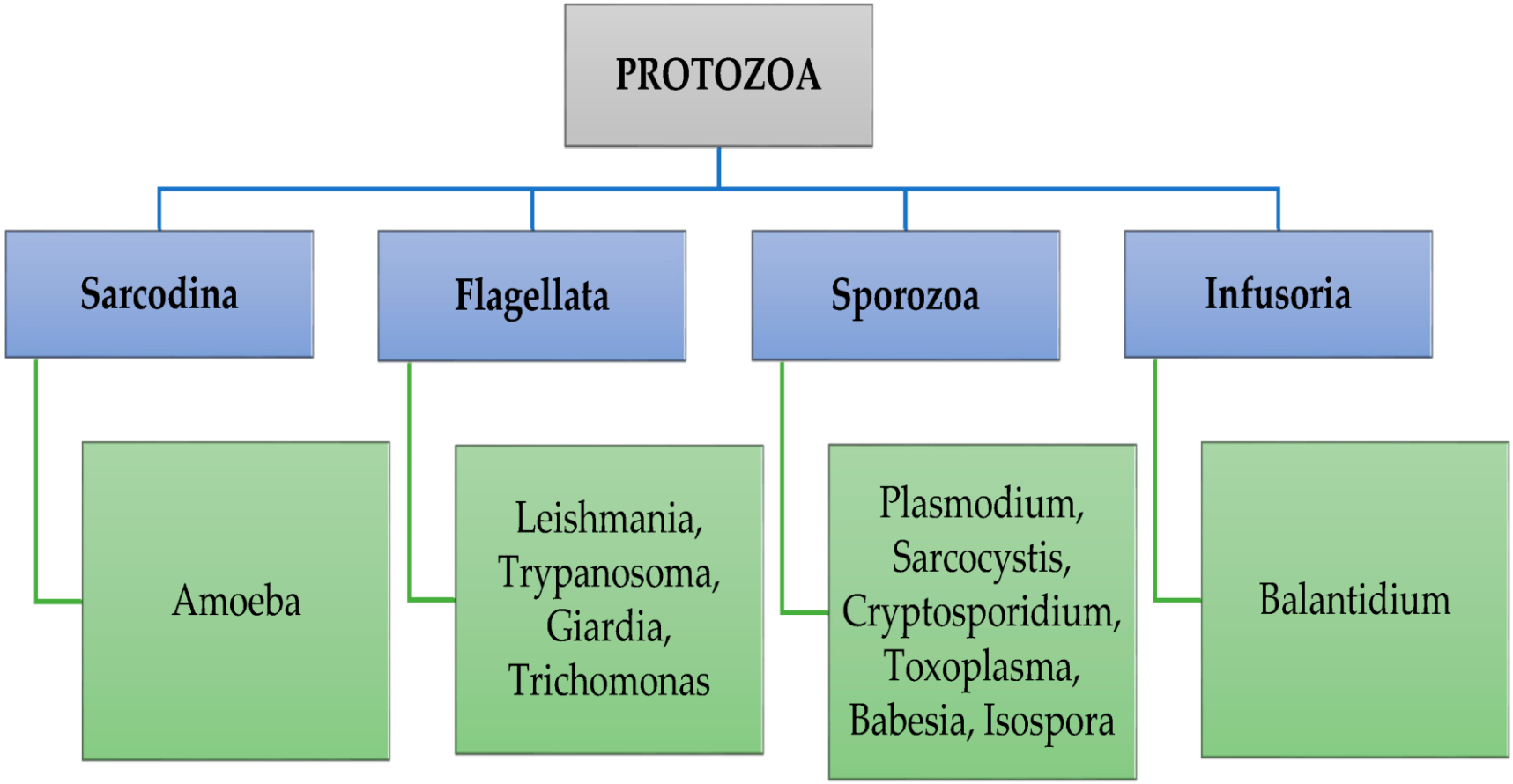
Indirect :-

A) Through vector

(i) Mechanical transmission : Intermittent feeding habit of vector – Trypanosomes

(ii) Biological transmission : Leishmania, Malaria

- *Theileria –Transtadial (stage to stage)*
- *Babesia –Transovarian*
- *Histomonas - Through the eggs of Helminthe, Heterakis gallinarum*
- *Hepatozoon,Sarcocystis & Toxoplasma - Ingestion of infected I/H etc.*


PROTOZOA
Sarcodina
Flagellata
Sporozoa
Infusoria
Amoeba
Leishmania, Trypanosoma, Giardia, Trichomonas
Plasmodium, Sarcocystis, Cryptosporidium, Toxoplasma, Babesia, Isospora
Balantidium

I. PHYLUM :	SARCOMASTIGOPHORA	Flagella or. pseudopodia or both as locomotor organelles; single nucleus; mostly no cyst formation.
1 Subphylum :	MASTIGOPHORA	One or more flagella in trophozoite;. reproduction asexual by binary fission.
Class:	ZOOMASTIGOPHOREA	Chromatophores absent; one or more flagella.
(1) Order:	KINETOPLASTIDA	Kinetoplast located near flagellar kinetosomes; mostly parasitic.
Family:	TRYPANOSOMATIDAE	Body . leaf-like or rounded; single flagellum.
Genera:	*TRYPANOSOMA, LEISHMANIA*	

- PHYLUM : SARCOMASTIGOPHORA
- SUB-PHYLUM: MASTIGOPHORA
- CLASS : ZOOMASTIGOPHOREA
- one or more thread-like flagella and may also have pseudopodia.
- In some forms a flagellum may pass along the body and remain attached to it by an undulating membrane.

ORDER: KINETOPLASTIDA
FAMILY: TRYPANOSOMATIDAE

- Important Genus: Trypanosoma, Leishmania
- Haemoflagellates
- leaf like in shape containing single nucleus.
- Having Single flagellum attached to the body by undulating membrane
- The single flagellum arises from the basal granule or blepharoplast and passes anteriorly to become free in front of the body.
- Kinetoplast posterior to the basal granule.
- Trypanosoma have no months, feed by absorption of food in solution in their environment through the pellicle.
- Have 4 developmental stages during their life cycles.
- “Mastigote” a Greek word that means whip (flagellum), has been used as new terminology of 4 types of developmental stages.

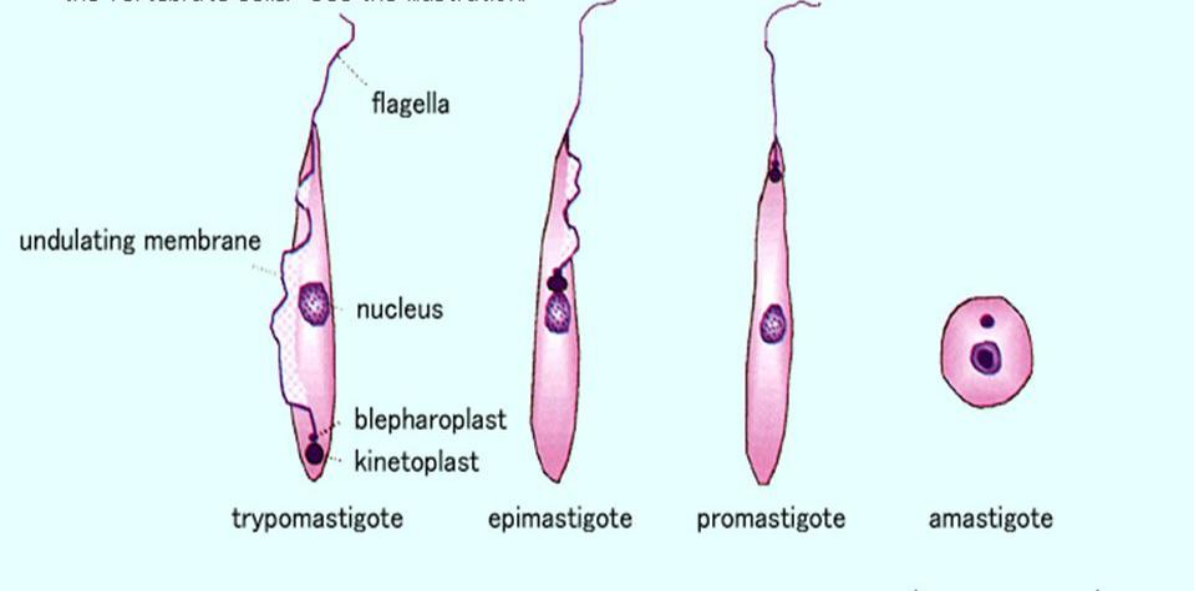
I. Trypomastigote stage (Trypanosome stage - With complete undulating membrane and free flagellum): Kinetoplast present posterior to the nucleus near posterior end and undulating membrane well developed. It found in both vertebrates and arthropods.

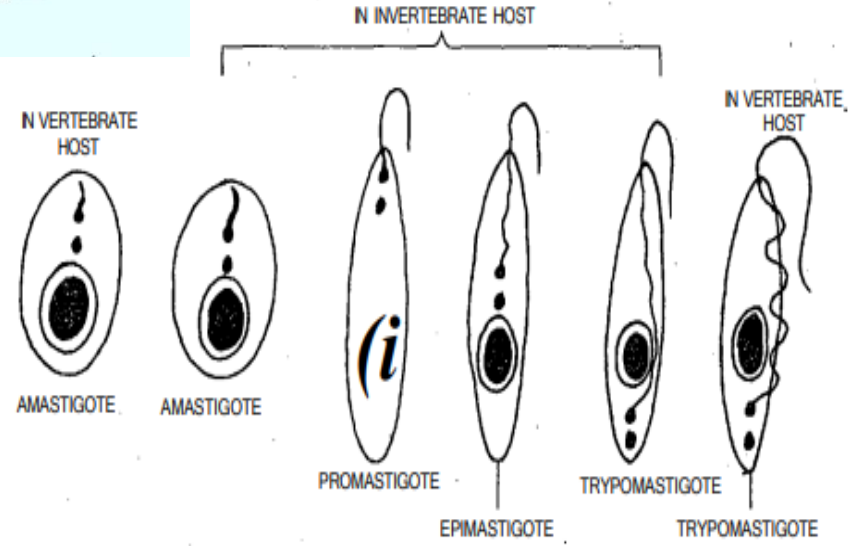
II. Epimastigote stage (Crithidial stage - (with small free flagellum and short undulating membrane): Kinetoplast and axoneme are present anterior to the nucleus and undulating membrane (U.B.) short and found principally in arthropods.

III. Promastigote stage (Leptomonad stage - (with only a short free flagellum): Kinetoplast present at the anterior tip of the body, U.B. absent and found in arthropods or plants.

IV. Amastigote stage (Leishmania stage - without flagellum): Rounded, Kinetoplast present at right angles to the nucleus and found in vertebrate and arthropods.

- Out of 4- developmental stages, only 1-2 stages are found in the life-cycle of parasite.


flagella
undulating membrane
nucleus
blepharoplast
kinetoplast
trypomastigote
epimastigote
promastigote
amastigote

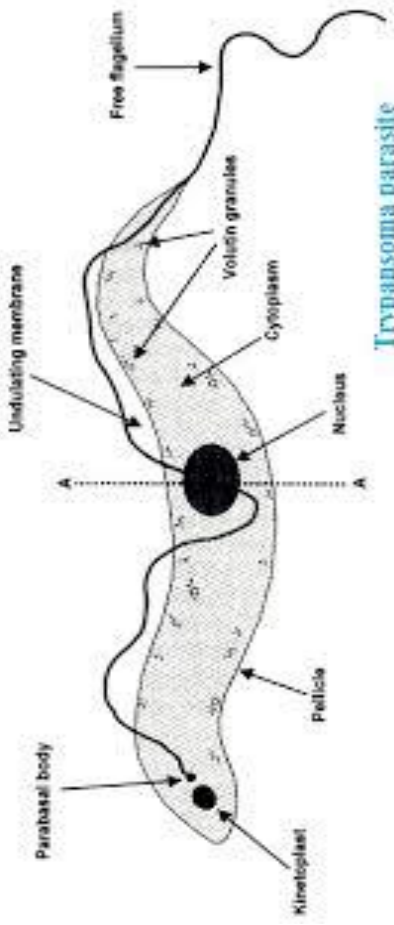

IN INVERTEBRATE HOST
IN VERTEBRATE HOST
IN VERTEBRATE HOST
AMASTIGOTE
AMASTIGOTE
PROMASTIGOTE
EPIMASTIGOTE
TRYPOMASTIGOTE
TRYPOMASTIGOTE

GENUS -TRYPANOSOMA

- Mostly Extracellular or intercelluler parasites found in blood and tissue fluids except *Trypanosoma cruzi* which is a intracellular parasites occurs within the cells of reticuloendotheilial system and in the cardiac muscles.
- *Trypanosoma* species are transmitted from one vertebrate host to another either cyclical or mechanical through blood sucking arthropods except *Trypanosoma equiperdum* which is transmitted during sexual coitus.
- Sexual process absent and trypanosomes multiply by binary or multiple fission *(T. lewisi)*

Morphology:

- Typically trypanosomes are elongated leaf-like .
- **Single Vesicular type nucleus at the centre of the body .**
- **Single Flagellum originated from the blepharoplast at the posterior end of the body .**
- **DNA containing elongated organelle known as kinetoplast present at just posterior to blepharoplast.**
- **A typical structure arises from the blepharoplast which is called as axoneme. It is a neuromotor apparatus consisting of few fibrils which form the axial structure of flagella**
- **Flagellum attached to the body of trypanosome formed undulating membrane.**



- Lifecycle
- Developmental stages
- Trypomastigote
- Epimastigote
- Amastigote

Transmission

- Transmitted by blood sucking arthropods usually an insect either cyclically or mechanically depending upon the development of parasites-

- Cyclical transmission: through the vectors in which trypanosomes multiply.
- Two types according to developmental site inside the vector-

✓ Anterior station development (Salivaria): Epimastigote form develop into infective metacyclic forms with a glycoprotein surface coat (infective form) in the fore gut of vectors and form inoculated into vertebrates host during blood sucking of vector.

✓ Salivaria found in *T. congolense*, *T. brucei*, *T. rhodesiense*,*T. gambiense* and *T. vivax*

- **Posterior station development (Stercoraria):**

✓ Multiplication occurs in the midgut of insects and metacyclic trypomastigotes forms are passed in faeces of arthropods.

✓ Infection of vertebrates host occurs by the contamination of the skin. e.g. *T. Cruzi*, *T. theileri* and *T. melophagnum*

Mechanical transmission

- No developmental cycle occurs in the vector and trypanosomes survive for a short period in the proboscis of vector.
- *Trypanosoma evansi* is transmitted by interrupted feeding habit of *Tabanus* , *Stomoxys* flies.
  - *Trypansoma equiperdum* also mechanically transmitted by sexual coitus.

List of Trypanosomes

Species	Final host	Vector	Disease/ symptoms
Trypanosoma evansi	**Horse, dog, camel, cattle, dog, sheep, goat, wild & Lab. animals.**	***Tabanus* (Chiefly), Stomoxys and Lyperosia.**	○ **Surra** ○ **Tibarsa (in Camel)**
Trypanosoma equinum	**Equines**	***Tabanus* spp.**	**Mal de caderas (Weakness of hind quarters leading to staggering gait).**
Trypanosoma equiperdum	**Transmitted mechanically by coitus**	**Equines**	**Venereal disease called Dourine and lesions known as Dollar spots.**
Trypanosoma theileri	**Tabanid flies**	**Cattle**	**Non-pathogenic**

List of Trypanosomes

Species	Vector	Final host	Disease/ symptoms
Trypanosoma gambiense	Tsetse fly (*Glossina* spp.)	Man, cattle, sheep, goat, horse, dog and cat	Gambian sleeping sickness in West coast Africa.
Trypanosoma rhodesiense	Tsetse fly (*Glossina* spp.)	Man, cattle, sheep, goat, horse , dog, cat and laboratory animals	East African sleeping sickness (Zambia, Zimbabwe, Sudan, Tanzania and Botswana)
Trypanosoma cruzi	Reduviid bugs (*Triatoma* spp.) – Kissing bug	Mostly children and dog	Chagas disease in South America (oedematous face)
Trypanosoma Congolense	Tsetse fly (*Glossina* spp.)	Cattle, sheep, goat, horse, dog and cat	Nagana disease in cattle

- **Venereal transmission** through coitus. e.g. *Trypanosoma equiperdum*.
- *T. theileri* (cattle), *T. melophaginum* (Sheep), *T. lewisi* (Rat) and *T. avium* (Birds) are non-pathogenic trypanosomes.
- Kinetoplast is absent in *Trypanosoma equinum*.
- *T. melophagium* is transmitted *by Melophagus ovinus* (Sheep ked).

- *T. theileri* is largest (60 – 70 µm in length)Trypanosome.
- Smallest of the African trypanosome sp. is *T. congolense* (9-18µm in length).

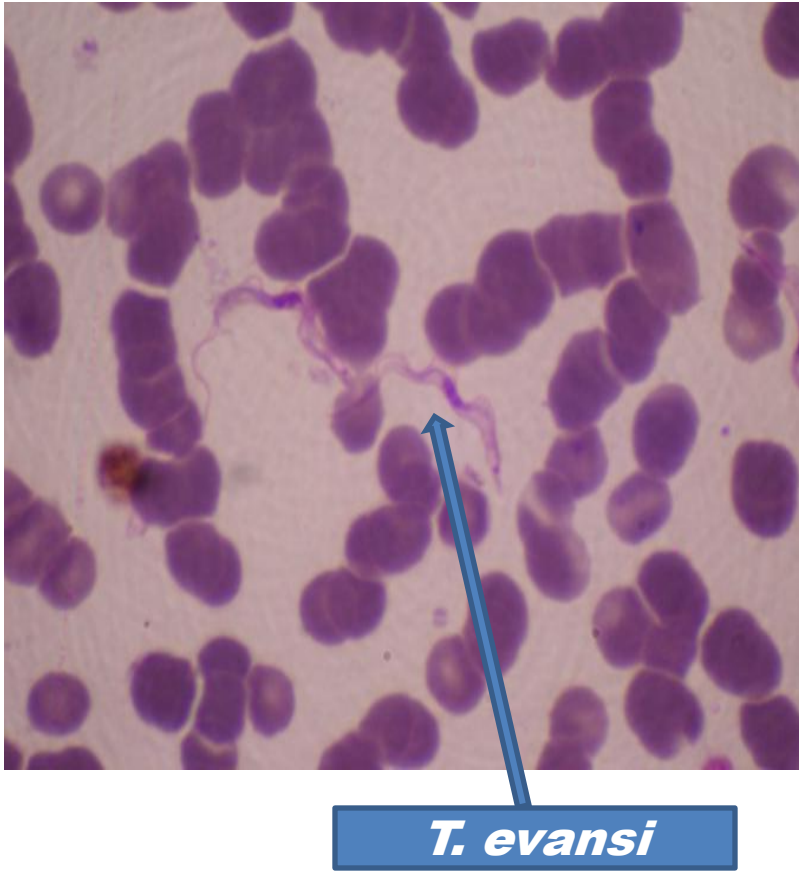
- Vector of *Trpanosoma lewisi* (rats) is *Ceratophyllus fasciatus* (rat flea) and may cause death in nursling rats.
- N' Dama, Lagone, Lagune and Bacosi are humpless breed of West African cattle showed trypanotolerance (resistant against *Trypanosoma* spp.)

- Trypanosomes were among the first parasitic protozoa to be cultivated *in vitro*.

Trypanosoma evansi

- *Trypanosoma evansi* was the first pathogenic trypanosome isolated from infected equids in the Dera Ismail Khan District of Punjab in 1880 by a British Veterinarian, Griffith Evans.

- *Trypanosoma evansi* is an emerging zoonotic parasite and first case was reported from India in 26th September, 2004 from Chandrapur district of Maharashtra.



- **Location:** It is an extracellular/ intercellular flagellate protozoa found in blood plasma and lymph.
- **Hosts:** Euryxenous haemoprotozoan parasite found in camel, horse, dog, cattle, buffaloes, goat, pig, dog, wild and laboratory animals. Most severe disease occurs in camel, horses and dogs but camels are highly susceptible to trypanosomosis.

Transmission

- It is mechanically transmitted by interrupted feeding of biting flies i.e. *Tabanus* (mainly), *Stomoxys* and *Lyperosia* spp.
- Successful transmission can occur if the transfer of the parasites takes palace within few minutes after bite because parasites do not survive in the proboscis of the flies for more than 10-15 minutes.
- Dogs may get the infection by ingestion of tissues from infected fresh meat/carcasses.

- **Multiply by longitudinal binary fission in the blood of hosts.**
- The antigens responsible for relapse populations are the variant antigens which are located on the surface of the organisms, but may also be found in the plasma of the infected animals. **During multiplication, tryapansosmes change their Variant Surface Glycoprotein (VSG) surface coat and forms trypanosomes with variant surface antigenic type.**
- ***T. evansi*** **does not multiply in the vector and transmitted within short period due to interrupted feeding habit of their vector.**

Trypanosoma evansi

- It caused disease is known as Surra means rotten.
- Chronic form of disease persists about 3 years in camel and hence in India it is locally called Tibersa.
- Office International des Epizooties (OIE) mentions the trypanosomosis disease under list B diseases of significance in horses.

- Pathogenesis : It caused disease called Trypanosomosis or Surra .
- A. Progressive anaemia may be due to
  - Haemolysin released by the parasites which leads to haemolysis of RBCs.
  - Increased erythrophagocytosis.
  - Haemodilution due to increased production of immunoglobulin .
  - Inhibition of erythropoiesis

B. Hypogylecmia – due to malfunction of adrenal, pancreas and thyroid glands, the metabolism of carbohydrate hampered.

- Trypanosomes also consume large quantity of blood sugar (glucose) and has been estimated as 0.9 mg per 100 million *Trypanosoma evansi* per hour which leads to hypoglycemia.

C. Undulating fever- changes of glycoprotein surface coat due to production of antibody which leads to lesser number of trypanosomes in host. This undulating form of parasitaemia results in the symptoms of Undulating fever.

D. Cell degeneration and inflammatory cells **infiltration- it may occurs in myocardium. Skeletal muscle which results separation and degeneration of muscle fiber, oedema and emaciation.**

- **In surra, progressive anaemia, intravascular coagulation and asphyxia (hypoglycemia) are the cause of infected animal death.**

Trypanosoma evansi

It caused most sever diseases in camels, horses and dogs.



Symptoms :

In Horse -

Progressive anaemia, urticarial plaques on neck and flanks, Intermittent fever, Oedema of leg and lower part of the body, conjunctivitis, emacition , oedema of eyelids etc.

- **Intermittent fever, anorexia, Anaemia, oedema of the limbs and dependent regions, dehydration, lethargy, weight loss, urticarial plaques in neck and flank regions, abortion and incoordination, followed by paralysis of the hind limbs.**



Emaciation



Urticarial plaques



Testicular oedema



Abortion

Trypanosoma evansi

Symptoms :

In Camel -

❖Chronic form of disease persists about 3 years in camel and hence in India it is locally called Tibersa.

❖Symptoms include weakness, emaciation, anaemia, intermittent fever, oedema of leg and dependent part of body, abortion, disappearing of hump etc

Trypanosoma evansi

In Dog -

It causes fever, anorexia, bilateral corneal opacity, weakness, staggering gait and oedema of larynx leads to changes of voice similar to those found in rabies.

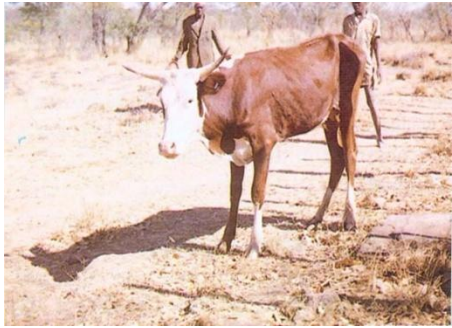


Corneal opacity

Trypanosoma evansi

Cattle & Buffalo:-

Per-acute, acute, sub-acute and chronic form of diseases occur in cattle and buffaloes.



In Cattle & Buffaloes- Intermittent fever, emaciation, weakness, conjunctivitis, oedema of legs and lower parts of body, circling movement, head pressing against hard objects, paralysis of hind quarter, micturition etc.

Trypanosoma evansi

- Surra mostly occurs subcilinically in cattle and buffaloes. These are considered to be the main reservoir of the infection for equines.

- Stress of any kind i.e. transportation, malnutrition, concurrent infection and vaccination of Rinderpest and F.M.D. may be responsible for per acute and acute form of the disease.
- Surra generally occurs in buffaloes in comparison to cattle.

Epidemiology of *Trypanosoma evansi*

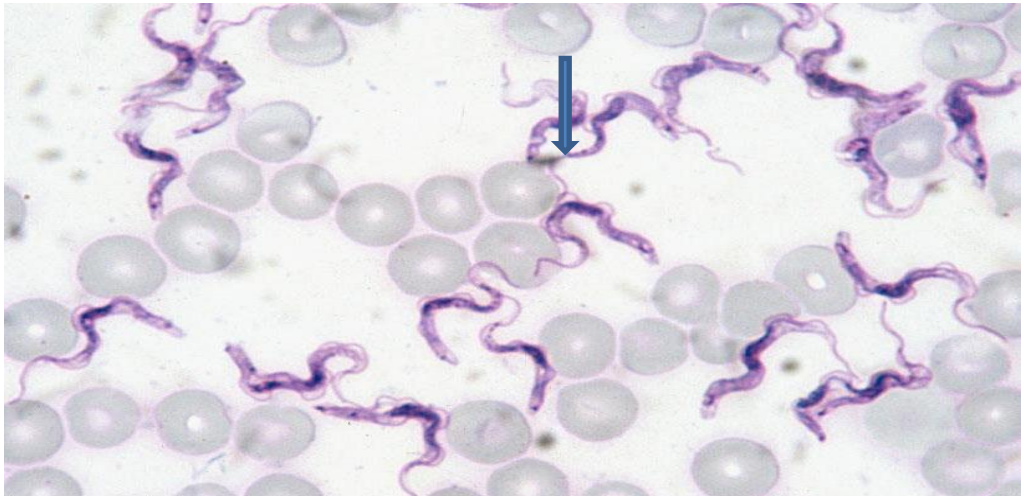
- Worldwide infection is reported.

- **In India, surra occurs mostly in post-rainy season (August – October) when the fly breeding is peak and lowest incident in April – May.**

Diagnosis of *Trypanosoma evansi*

- On the basis of history of prevalence of vectors and herd record etc.
- Microscopic examination- blood sample should be collected from the suspected animals at the of pyrexia. Various methods like-

  i. Wet blood smear examination- for diagnosis of living trypanosomes .



Diagnosis of *Trypanosoma evansi*

- Blood sample should be collected in Alsever's solution if diagnosis to be delayed .

Alsever's solution Composition-

Dextrose- 2.05 %

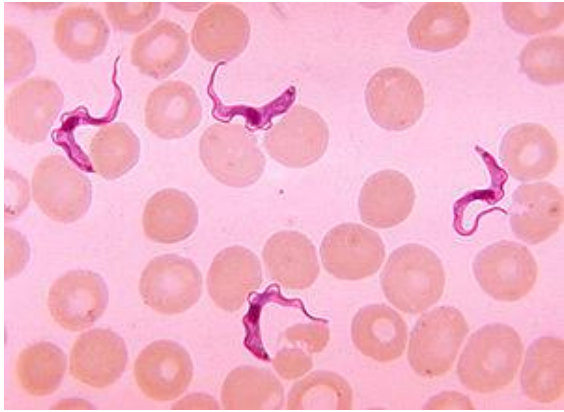
Sodium citrate – 0.8 %

Citric acid – 0.055%

Sodium chloride – 0.42 %

Diagnosis of *Trypanosoma evansi*

❖Dry blood smear examination- both thin and thick (in light infection) smears are prepared and stained with Giemsa or Leishman stain to detect trypanosomes.



❖Quantitative buffy coat (QBC) method - Trypanosomes are detected on the surface of buffy coat or W.B.C. layer.

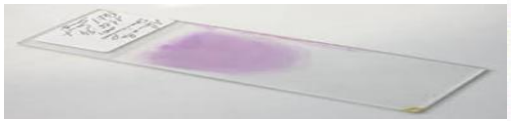
Diagnosis of *Trypanosoma evansi*

Animal inoculation method-

- 0.5 ml suspected blood inoculated intraperitoneally in laboratory animals like albino mice to diagnosis of latent or sub-clinical infection of trypanosomes.

- In positive case, the trypanosomes will be found of 2-3 days post-inoculation in the blood of albino mice.







Diagnosis of *Trypanosoma evansi*

Chemical test-

- Stilbamidine test- in this method, 0.3% solution of stilbamidine isothionate chemical is mixed with one drop of serum of suspected animal. In positive cases, an opalescence of precipitate will be appeared in 1-2 minutes. It is used for bovine only.

- Mercuric chloride test- One drop serum of suspected animal is mixed with 1 ml of mercuric chloride (1:30000) solution. In positive infection, a white precipitated will be appeared in a few seconds. It is reliable for camel only.

Diagnosis of *Trypanosoma evansi*

❖Serological tests - Complement fixation test, Card agglutination test, ELISA, Fluorescent antibody test etc. are used for the detection of trypanosomes.

❖Molecular test- Polymerase chain reaction (PCR) is now -a -days more reliable and sensitive test.

Treatment of *Trypanosoma evansi*

- Combination of Quinapyramine chloride –
- 1.0 g (**Prophylactic**) + Q. Sulphate – 1.5 g (**Curative**) @ 0.025 ml/kg. b. wt. Through S/C is drug of choice. A single injection gives protection up to 70 days.



- Diminazene aceturate – it is used as curative @ 3.5 mg/kg body weight S/C or I/M or I/V.



Treatment of *Trypanosoma evansi*

3. Isometamidium chloride – 0.5 (curative) - 1 mg/kg (prophylactic) body weight deep I/m.

➢Quinapyramine chloride and Isometamidium chloride work as chemoprophylaxis.

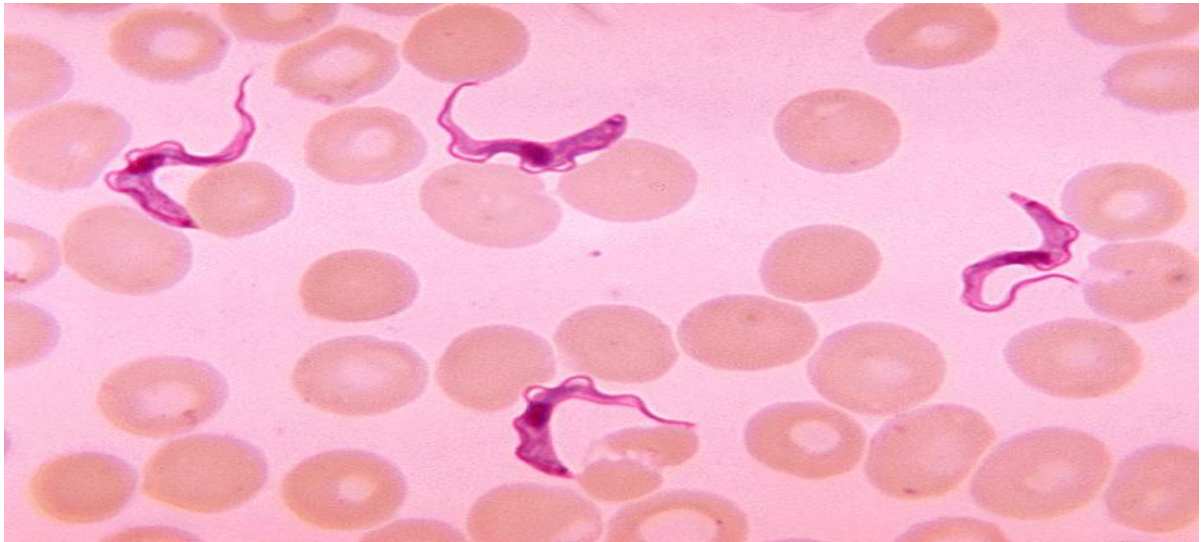
Supportive therapy - Administration of 25% dextrose solution is recommended as a supportive therapy because trypanosomosis produce hypoglycemia.

Control of *Trypanosoma evansi*

- using chemoprophylaxis drugs like Isometamidium chloride and Quinapyramine chloride in endemic areas before onset of rainy season..
- By controlling vector- Vector like *Tabanus* fly etc. can be controlled by destroying their breeding ground, using insecticides in and around animal shed, proper disposal of faeces etc.
- By developing genetically resistant breed like N' Dama cattle which is a trypanotolerant breed..

Trypanosoma equiperdum

- Final hosts- Horse and Donkey.
- Transmission- It is transmitted mechanically by coitus.



Trypanosoma equiperdum

- Disease- It caused venereal disease called Dourine/ Equine Syphilis/ breeding Paralysis
- Dourine term is derived from Arabic word which means “unclean”
- Disease is prevalent in Africa, America, Russia and
- in the parts of Asia.
- Dourine disease is now eradicated from India.

Trypanosoma equiperdum

Disease occurs in three phases-

- **1st phase (Stage of oedema) - swelling and oedema of penis, scrotum, prepuce and surrounding skin in stallion. In mare , profuse fluid discharge is detected.**
- **2nd phase (Urticarial phase) – develop** oedematous plaques **of 2-5 cm in diameter** under the skin known as **Dollar spots** because it appear as a silver dollar had inserted under the skin.
- 3rd phase (Stage of paralysis) – It is characterized by anaemia, emaciation, weakness, in-coordination, paralysis and recumbancy followed by death.

Trypanosoma equiperdum

- **Diagnosis- On the basis of symptoms (urticarial swelling) and detection of organisms in the fluid of genetalia.**

Treatment and Control –

❖Diminazene aceturate (Berenil) or Antrycide.

❖Slaughtering of infected horses.

❖The Dourine Act, 1910 is an Indian Act that was passed to prevent the spread of dourine, a contagious disease that affects breeding equids

- Trypanosomes have antigenic variation due to variant surface glycoproteins (VSG).

- The surface coat of trypanosomes is a 12-15 mm thick layer made up of about 10^7 identical molecules of approximately 60 kDa which are closely packed to cover the entire surface. These molecules are variant surface glycoproteins (VSGs).

- Changing antigenic characters of trypanosomes in vertebrate's hosts, the development of an effective vaccine against trypanosomes is difficult.

Trypanosoma equinum

- Horse acts as final host and *Tabanus* sp. acts as vector
- It causes Mal de caderas (Weakness of hind quarters) in horse.
- Symptom includes staggering gait, reumbancy, conjunctivitis and oedema in eyelids.

- *Trypanosoma Congolense*
- Small form 9 – 18 µm, smallest of African Trypanosomes.
- No free flagellum. Undulating membrane inconspicous.
- Cause ‘Nagana’ (a zulu word meaning to be in low or in depressed spirit)
- Host : Domestic animals & wild game animals.
- Transmission : Cyclically by Glossina & mechanically by biting flies.

- Trypanosoma Cruzi
- Main pathogenic species in stercoraria, causing American human trypanosomasis or ‘Chagas’ disease in South America
- Xenodiagnosis is done for chagas disease
- Xenodiagnosis – Feeding of Triatomid bugs on suspected patient or allowed bugs to feed on the patient's blood through a membrane. Laboratory reared and T. cruzi free triatomes are used and if the suspected materials is positive, metacyclic trypanosomes are found 7-10 days latter in the dropping of the bugs

Important diseases caused by *Trypanosoma* *spp*

Name of *Trypanosoma sp*	Name of disease	Vector
Trypanosoma evansi	Surra	*Tabanus, Stomoxys, Lyperosia*
Trypanosoma congolense	Nagana	*Glossina sp*
Trypanosoma equiperdum	Dourine	The organisms are transmitted by coitus.

Name of *Trypanosoma sp*	Name of disease	Vector
Trypanosoma equinum	Mal de caderus	Tranmitted mechanically by biting flies.
Trypanosoma rhodesiense	Acute form of African sleeping sickness	*Glossina sp*
Trypanosoma gambiense	Chronic form of African sleeping sickness	*Glossina sp*

T. theileri: largest trypanosome

LEISHMANIA

- Family: Trypanosomatidae
  - **It is an obligatory intracellular parasite found in the macrophages of man, dog and a wide variety of wild animals.**
  - **During the life cycle two developmental stages occurs i.e. Amastigote and Promastigote stage.**
  - spread by sandflies of the genus Phlebotomus
  - **Common name: Sand flies / Owl midges/ Month flies**

- Leishmann (1903) and Donovan (1903) first isolated Leishmania donovani in London and Madras respectively.
- Leishmania tropica was first demonstrated by Borovsky (1898) and Wright (1903).

1. Amastigote stage (Leishmania stage): Oval or round in shape, Kinetoplast at right angle to the nucleus, rudimentary flagellum inside the body and found in vertebrate host.
2. Promastigote stage (Leptomonad stage): Spindle shaped, Kinetoplast present at the anterior tip of the body, Undulating membrane absent and found in culture and invertebrate host (vector).

- Species of importance
- L. donovani
- L. braziliensis
- L. mexicana mexicana
- L. tropica
- L. major
- L. chagasi
- Hosts - Human beings and dogs
- Site - macrophages and endothelial cells

GENUS: *LEISHMANIA*

Species	Host	Vector	Disease
L. donovani	Man & Dog	*Phlebotomus argentipes*	Kala-azar or Dum-dum fever or Visceral leishmaniosis
Leishmania tropica	Man, dog & rodents	*Phlebotomus papatasi* or *P. sergenti*	Cutaneous leishmaniosis or Oriental sore or Delhi boil or Old world Cutaneous leishmaniosis

Life-cycle

- Amastigote stage found within the macrophages of Vertebrate hosts.
- During blood sucking of *Phlebotomus* spp. ingest leucocytes and large mononuclear cells containing amastigote stage (Leishman-Donovan bodies or L-D bodies).
- Amastigote transforms into promastigote stage in the mid gut of *Phlebotomus* spp. and multiply by binary fission in the gut .

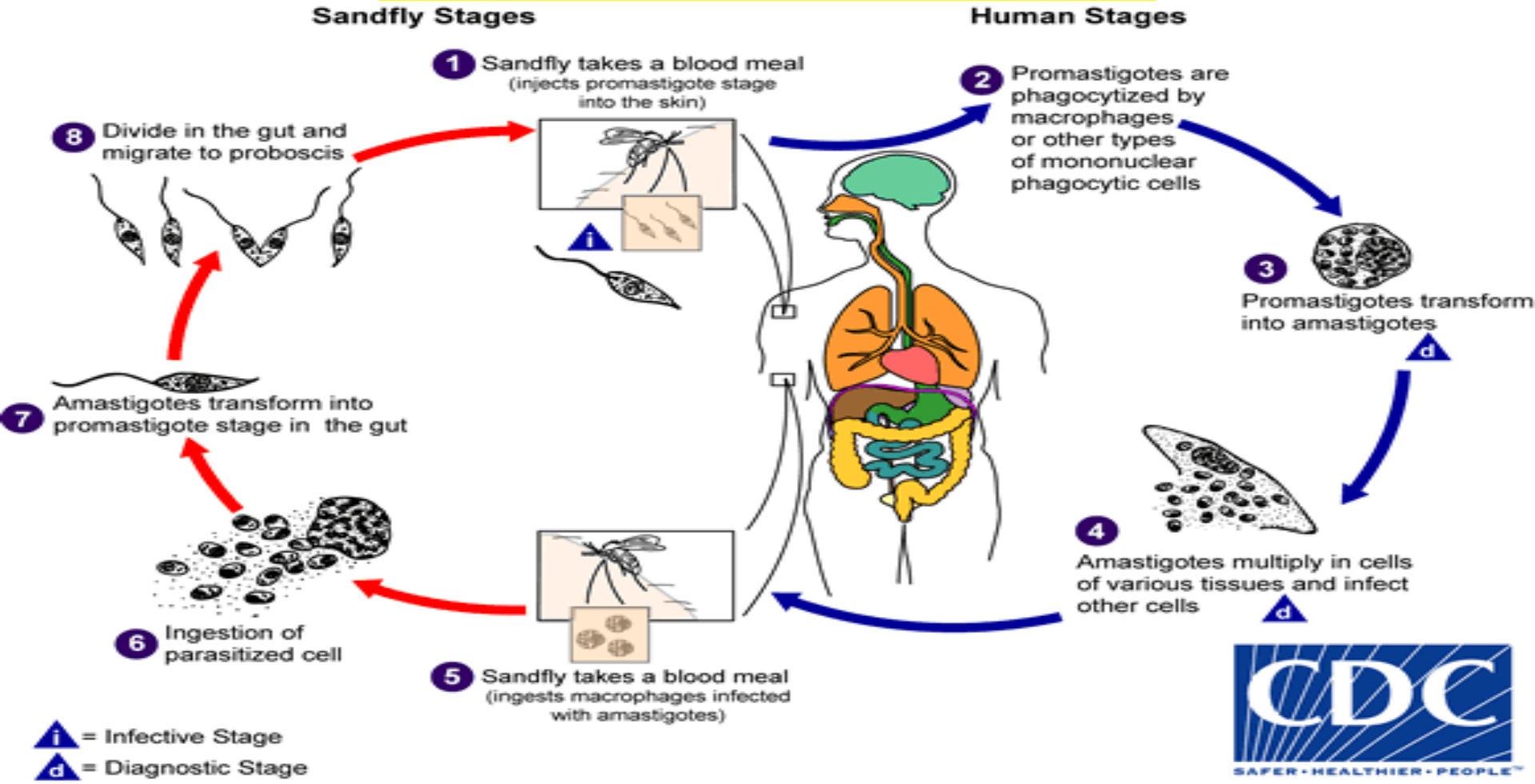
GENUS: *LEISHMANIA*

Transmission:

- When infected sand fly attempts to feed, a plug of organisms may be dislodged and injected into vertebrate hosts.
- Infection may also occur when infected sand flies are crushed on the skin.

- Promastigotes enter in the macrophages of the host and reverts to amastigotes form which multiply there by binary fission.

Life- cycle of *Leishmania* spp.



Leishmania donovani

- it was reported by William Leishman in the year 1903 in the spleen smear of a solider who died in fever at Dum Dum (Kolkata). In the same year, Charles Donovan found the same parasite in the spleen biopsy of a patient in India.
- For this, the parasite has been named as *Leishmania donovani* and the disease is known as Dumdum Fever .
- Disease - Visceral leishmaniosis or Kala-azar or Dumdum fever.
- Also caused by *L. infantum*

Visceral leishmaniosis

It is caused by *Leishmania donovani*.

Pathogenesis-

- Amastigote stage multiply in macrophages of spleen, liver, bone marrow, lung, kidney, lymph node and skin and destroy the macrophages.
- Anaemia develops due to the blockages of reticuloendothelial system.
- Ulceration of digestive tract with enlargement of liver and spleen in advanced stage of infection.

Visceral leishmaniosis

Symptoms -

- Irregular Intermittent fever, diarrhoea, dysentery, distended abdomen due to splenomegaly, hepatomegaly, anaemia, emaciation and darkening of face skin.

Visceral leishmaniosis

Symptoms -

- Darkening of skin of the face particularly around the mouth, forehead, hand, feet and abdomen, hence the disease is called as Kala azar (Black fever).
- **Heavy skin pigmentation which darkens the physical appearance (the reason for naming black fever).**
- Dogs initially develop spectacles due to depletion of hair around the eye and this is followed by generalized loss of body hair, ucers and eczema.

Visceral leishmaniosis in Dog

Symptoms -

- Dogs initially develop spectacles due to depletion of hair around the eye and this is followed by generalized loss of body hair, ucers and eczema.



Visceral leishmaniosis

Post Kala-azar Dermal Leishmaniods (PKDL) :-

- It is a sequel of visceral leishmaniosis and develops about 2-10 years after recovery from the disease.

- Recovery cases of Kala azar after treatment show whitish spots as lentil sized nodules in the skin particularly on the face and neck. The nodules are called Post Kala-azar Dermal Leishmanoids (PKDL).

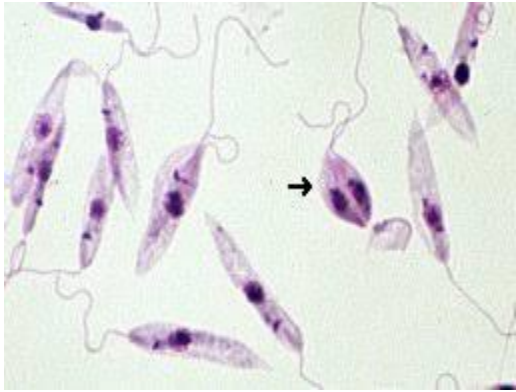
Diagnosis of visceral leishmaniosis

- On the basis of symptoms
- Post-mortem findings like enlargement of spleen, liver and lymph node, anemia and emaciation.
- Blood smear examination to demonstrate amastigotes stage of parasite.



Amastigotes

- Culture of blood in NNN (Novy, MacNeal and Nicolle) media to get enormous number of promastigotes stage of parasite.



Promastigotes

Diagnosis of visceral leishmaniosis

- Examination of biopsy materials collected **from spleen, bone marrow and lymph node.**
- **Serological tests like CFT, IHA, IFA, ELISA etc. used for diagnosis.**

- **Montenegro test (Skin test)** **is a sensitive and specific test.**

Visceral leishmaniosis

Treatment -

- Pentavalent antimony compound like Pentavalent Sodium stibogluconate @ 2- 5 ml I/M on alternate day - 10 injections are given.
- Pentamidine isothionate @ 4 mg/kg body weight I/M
- Amphotericin B @ 5-10 mg/kg body weight I/V
- **Miltefosine**
- **Paramomycin**

Visceral leishmaniosis

Control-

- Treatment of infected hosts.
- Control of vectors i.e sand flies by using insecticides, destroying breeding places, clearing decaying vegetation etc.

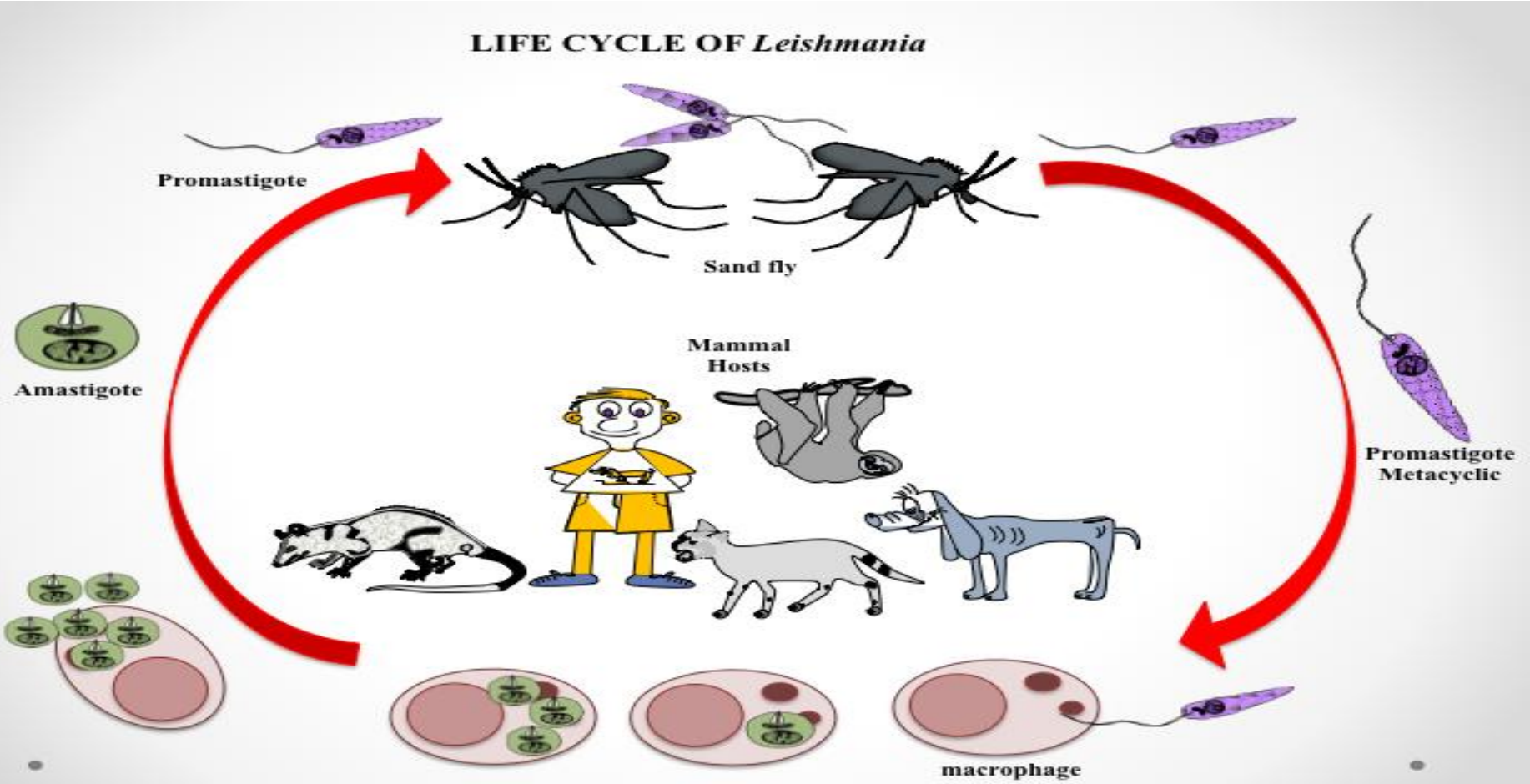
Vaccine –

Leishmune vaccine is a native fructose-mannose-ligand antigen complex developed against *L. donovani* in dog.

Leishmania tropica

- Final hosts - Man
- Reservoir hosts - Dog & rodents.
- Vector - *Phlebotomus papatasi* or *P. sergenti* (Sand fly).
- Location - Macrophages/ reticuloendothelial (RE) cells of skin of man, dog , rodent and other wild animals.
- Caused disease- Cutaneous leishmaniosis or Oriental sore or Delhi boil or Old world Cutaneous leishmaniosis .
- Also caused by *L. major*

Life- cycle of *Leishmania tropica*



Cutaneous leishmaniosis

Symptoms and pathogenesis:

- **First reddish papules develop at the site of infected phlebotomus fly bite in man or dog.**
- **Later , there will be the formation of ulcer.**
- **Multiple lesions (ulcers) may coalesce and forma a large lesion.**
- **The disease is not fatal and may heal within 2-12 months.**
- **Healing of wounds results into scar formation usually in face, nose, ear and eye leading to disfigurement or wrinkling of face.**

Diagnosis of Cutaneous leishmaniosis

- Microscopic detection of amstigotes stage in smear prepared from the edge of lesions (Ulcers).
- Demonstartion of Promastigote in the cultivation of biopsy or post-mortem materials on NNN (Novy, MacNeal and Nicolle) medium.





- Biopsy of local lymph nodes
- Various serological tests are used in the diagnosis.

Cutaneous leishmaniosis

Treatment :-

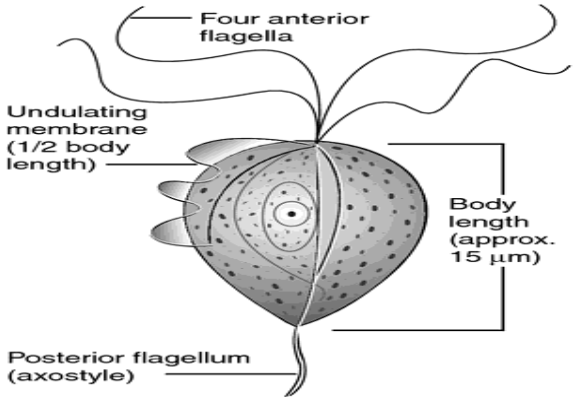
- Lithium antimony thiomalate and Berberine sulphate are used in the treatment of cutaneous leishmaniosis.

Order – Trichomonadida

- Having 4-6 flagella and one trailing flagella attached to undulating membrane
- One or 2 nuclei, asexual reproduction generally by binary fission
- found in alimentary canal, reproductive tract
- Two family present under this order, Family: Monocercomonadidae and Trichomonadidae
- Some pathogenic forms found in genera Tritrichomonas, Trichomonas, Giardia and Hexamita

Family- Trichomonadidae

- Usually found in digestive tract or some of the organisms may also present in the reproductive tract.
- Body is pyriform shaped with rounded anterior end and pointed posterior ends.
- Parasites have 3-5 flagella, undulating membrane, axostyle , costa and uninucleated.



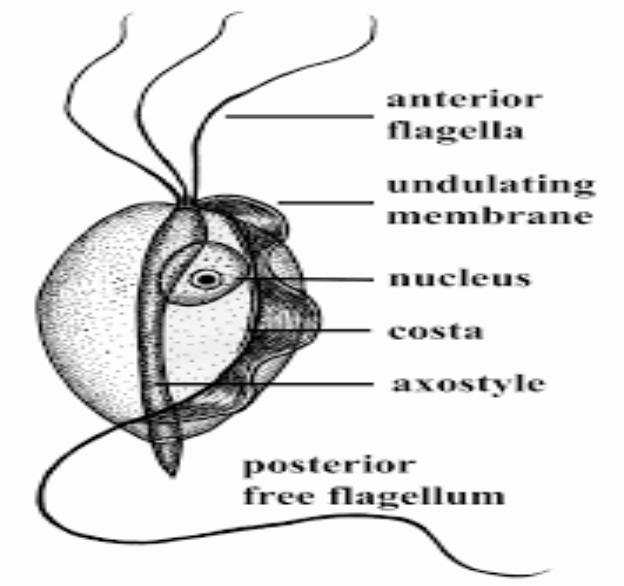
Family : Trichomonidae

Genus and Species	Host	Location
Tritrichomonas foetus	**Cattle, buffalo, pig, horse etc.**	**Reproductive tract**
Trichomonas gallinae	**Pigeon, turkeys etc.**	**Upper digestive tract**
Trichomonas vaginalis	**Man**	**Vagina and urethra**

Tritrichomonas foetus

Morphological characters :-

- Body is usually pear shaped.
- It has three anterior flagella and a posterior flagellum that runs along the undulating membrane and then continues as a free flagellum.
- A hyaline rod like structure known as axostyle which run through the midline of the cell and emerges posteriorly.
- It has characteristic vigorous jerky movement.
- Multiplication by longitudinal binary fission.
- Sexual multiplication or cyst formation absent.



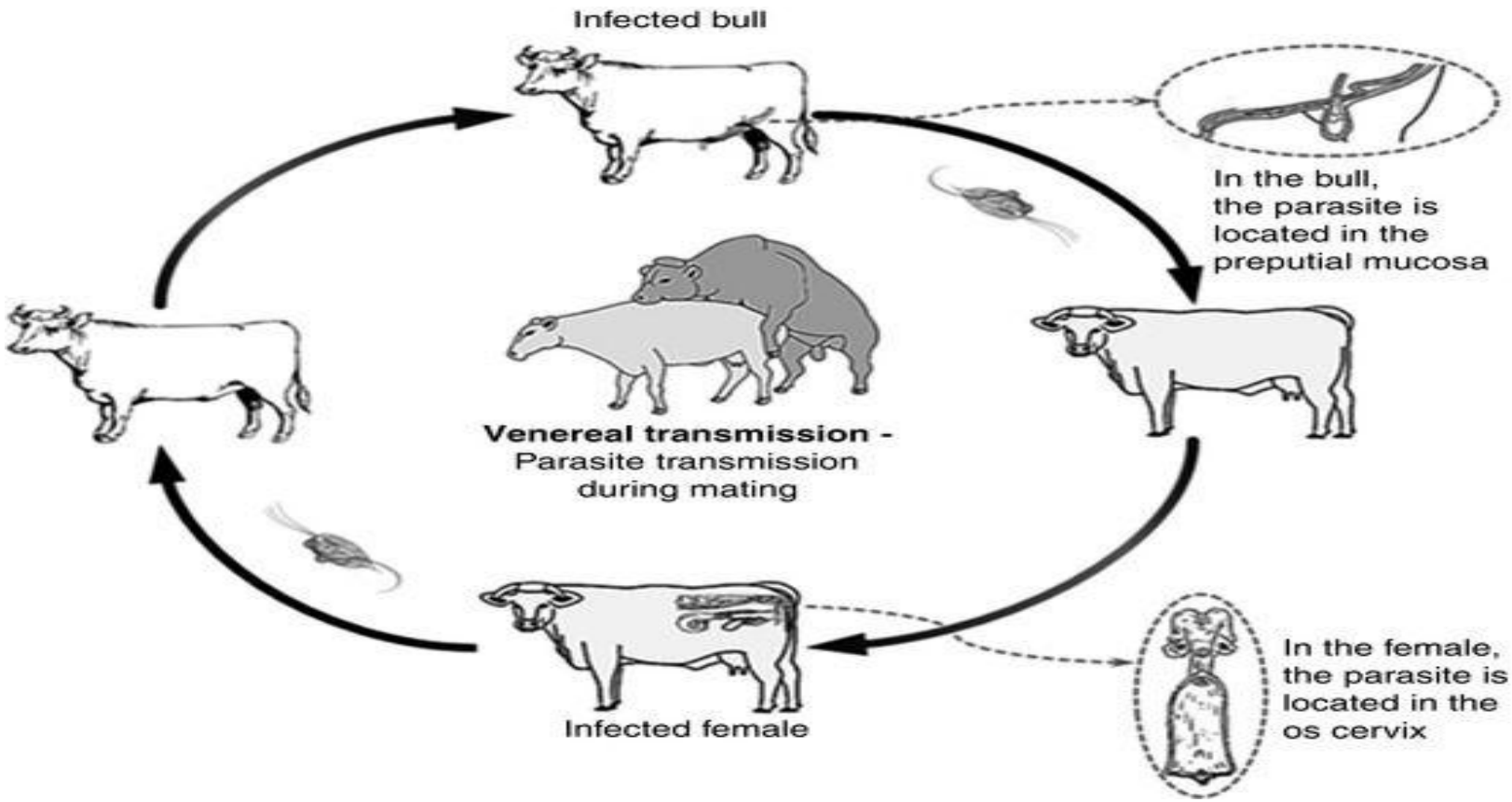
Host : It is mainly pathogenic in cattle but may also occur in buffalo, horse, pig and deer.

Location: vagina and uterus in cow whereas preputial cavity in bull.

Transmission:

- Organisms mainly transmitted through coitus

- During Artificial insemination and gynecological examination, the parasites may transmitted.
- Bulls, once infected, remain a permanent source of infection whereas in cows, the infection is self-limiting and parasites may gradually disappear.


Infected bull
In the bull,
the parasite is
located in the
preputial mucosa
Venereal transmission -
Parasite transmission
during mating
Infected female
In the female,
the parasite is
located in the
os cervix

Tritrichomonas foetus

Pathogenesis:

- It causes the **specific venereal disease**, **bovine trichomonosis** or **bovine trichomonad abortion in cattle**.

Cows:

- Vaginitis, endometritis, placentitis with detachment of the placental membranes and death of the foetus which lead to an early abortion usually 8-16 weeks after the infected service.

Tritrichomonas foetus

Pathogenesis:

Cows:

- Sometimes foetus and foetal membrane retained leading to purulent endometritis.
- When cervix is closed and corpus luteum is retained, then closed pyometra develops and uterus may contains several liters of greyish-white fluid swarming with trichomonads, which will give the appearance of pregnancy.
- In long standing case, the trichomonads may disappear from the uterine fluid so disappear is self-limiting in cows.

Pathogenesis:

Bulls:

- Small red nodules in the mucous membrane.
- Mucopurulent discharge from the preputial cavity.
- Above signs disappeared from 1-2 weeks after the infection.
- Spontaneous recovery is rare and bulls remain permanently infected

Tritrichomonas foetus

Symptoms:

Cows:

- Early abortion(usually 8-16 weeks after conception).
- Vaginal discharge, mucopurulent endometritis, anestrous, irregular hear period.

Bulls :

- Pain during micturition, disinclination to serve cows and preputial discharge.

Tritrichomonas foetus

Diagnosis:

- Herd history (early abortion, failure of conception, increase vaginal discharge and incidence of pyometra in the herd etc.).



- Microscopic examination of vaginal discharge or washing, uterine discharge, preputial discharge, stomach contents of aborted foetus, amniotic fluids etc. reveled *T. foetus* with characteristic vigorous jerky movement.

- Serological test like cervical mucus agglutination ands skin test`

Tritrichomonas foetus

Treatment:

- Since the infection in self-limiting in cows, infected animals should be given breeding rest to cure the infection.
- Use of Acriflavin ointment in infected bull with the help of pudendal anesthesia.
- Berenil or Dimetridazole is also used in the treatment

Tritrichomonas foetus

control:

- Infected bulls must be either castrated or slaughtered.
- Avoid breeding between susceptible cow and infected bull and vice–versa.
- Aborted cows should be given breeding rest for three consecutive estrous periods.

Trichomonas gallinae

Host : Pigeons , turkey and chicken.

Location: Upper digestive tract

- Organism has only four anterior flagella.
- Organism transmitted from adult pigeons to their offsprings through infected pigeons crop milk.
- Adults pigeons cat as carrier but nestling pigeons (squabs) are highly susceptible.
- It causes yellow necrotic lesions (yellow buttons) in the mouth, oesophagus, crop and proventriculus.

Trypanosoma evansi

It caused most sever diseases in camels, horses and dogs.

Symptoms :

In Horse -

Progressive anaemia, urticarial plaques on neck and flanks, Intermittent fever, Oedema of leg and lower part of the body, conjunctivitis, emacition , oedema of eyelids etc.



- **Intermittent fever, anorexia, Anaemia, oedema of the limbs and dependent regions, dehydration, lethargy, weight loss, urticarial plaques in neck and flank regions, abortion and incoordination, followed by paralysis of the hind limbs.**



Emaciation



Urticarial plaques



Testicular oedema



Abortion

Trypanosoma evansi

Symptoms :

In Camel -

❖Chronic form of disease persists about 3 years in camel and hence in India it is locally called Tibersa.

❖Symptoms include weakness, emaciation, anaemia, intermittent fever, oedema of leg and dependent part of body, abortion, disappearing of hump etc

Trypanosoma evansi

In Dog -

It causes fever, anorexia, bilateral corneal opacity, weakness, staggering gait and oedema of larynx leads to changes of voice similar to those found in rabies.

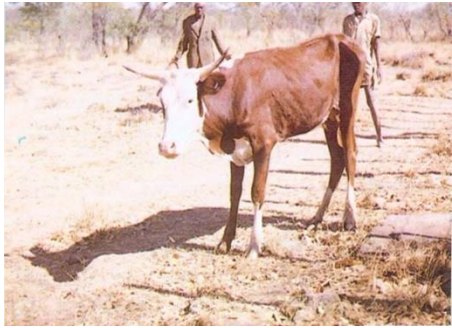


Corneal opacity

Trypanosoma evansi

Cattle & Buffalo:-

Per-acute, acute, sub-acute and chronic form of diseases occur in cattle and buffaloes.



In Cattle & Buffaloes- Intermittent fever, emaciation, weakness, conjunctivitis, oedema of legs and lower parts of body, circling movement, head pressing against hard objects, paralysis of hind quarter, micturition etc.

Trypanosoma evansi

- Surra mostly occurs subcilinically in cattle and buffaloes. These are considered to be the main reservoir of the infection for equines.

- Stress of any kind i.e. transportation, malnutrition, concurrent infection and vaccination of Rinderpest and F.M.D. may be responsible for per acute and acute form of the disease.
- Surra generally occurs in buffaloes in comparison to cattle.

Epidemiology of *Trypanosoma evansi*

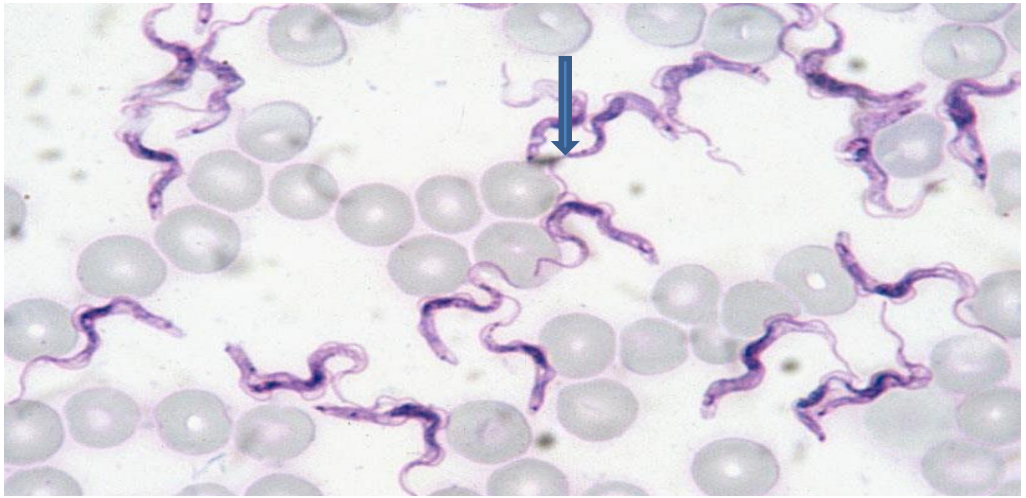
- Worldwide infection is reported.

- **In India, surra occurs mostly in post-rainy season (August – October) when the fly breeding is peak and lowest incident in April – May.**

Diagnosis of *Trypanosoma evansi*

- On the basis of history of prevalence of vectors and herd record etc.
- Microscopic examination- blood sample should be collected from the suspected animals at the of pyrexia. Various methods like-

  i. Wet blood smear examination- for diagnosis of living trypanosomes .



Diagnosis of *Trypanosoma evansi*

- Blood sample should be collected in Alsever's solution if diagnosis to be delayed .

Alsever's solution Composition-

Dextrose- 2.05 %

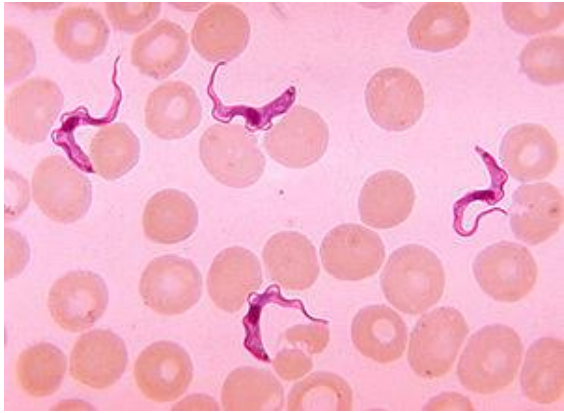
Sodium citrate – 0.8 %

Citric acid – 0.055%

Sodium chloride – 0.42 %

Diagnosis of *Trypanosoma evansi*

❖Dry blood smear examination- both thin and thick (in light infection) smears are prepared and stained with Giemsa or Leishman stain to detect trypanosomes.



❖Quantitative buffy coat (QBC) method - Trypanosomes are detected on the surface of buffy coat or W.B.C. layer.

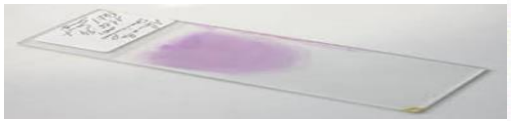
Diagnosis of *Trypanosoma evansi*

Animal inoculation method-

- 0.5 ml suspected blood inoculated intraperitoneally in laboratory animals like albino mice to diagnosis of latent or sub-clinical infection of trypanosomes.

- In positive case, the trypanosomes will be found of 2-3 days post-inoculation in the blood of albino mice.







Diagnosis of *Trypanosoma evansi*

Chemical test-

- Stilbamidine test- in this method, 0.3% solution of stilbamidine isothionate chemical is mixed with one drop of serum of suspected animal. In positive cases, an opalescence of precipitate will be appeared in 1-2 minutes. It is used for bovine only.

- Mercuric chloride test- One drop serum of suspected animal is mixed with 1 ml of mercuric chloride (1:30000) solution. In positive infection, a white precipitated will be appeared in a few seconds. It is reliable for camel only.

Diagnosis of *Trypanosoma evansi*

❖Serological tests - Complement fixation test, Card agglutination test, ELISA, Fluorescent antibody test etc. are used for the detection of trypanosomes.

❖Molecular test- Polymerase chain reaction (PCR) is now -a -days more reliable and sensitive test.

Treatment of *Trypanosoma evansi*

- Combination of Quinapyramine chloride –
- 1.0 g (**Prophylactic**) + Q. Sulphate – 1.5 g (**Curative**) @ 0.025 ml/kg. b. wt. Through S/C is drug of choice. A single injection gives protection up to 70 days.



- Diminazene aceturate – it is used as curative @ 3.5 mg/kg body weight S/C or I/M or I/V.



Treatment of *Trypanosoma evansi*

3. Isometamidium chloride – 0.5 (curative) - 1 mg/kg (prophylactic) body weight deep I/m.

➢Quinapyramine chloride and Isometamidium chloride work as chemoprophylaxis.

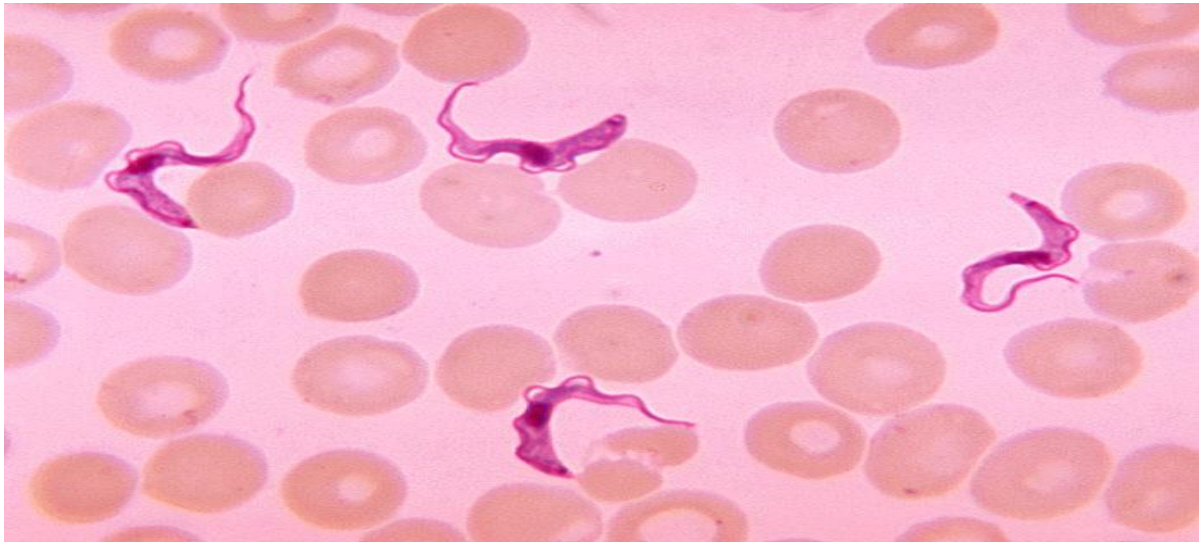
Supportive therapy - Administration of 25% dextrose solution is recommended as a supportive therapy because trypanosomosis produce hypoglycemia.

Control of *Trypanosoma evansi*

- using chemoprophylaxis drugs like Isometamidium chloride and Quinapyramine chloride in endemic areas before onset of rainy season..
- By controlling vector- Vector like *Tabanus* fly etc. can be controlled by destroying their breeding ground, using insecticides in and around animal shed, proper disposal of faeces etc.
- By developing genetically resistant breed like N' Dama cattle which is a trypanotolerant breed..

Trypanosoma equiperdum

- Final hosts- Horse and Donkey.
- Transmission- It is transmitted mechanically by coitus.



Trypanosoma equiperdum

- Disease- It caused venereal disease called Dourine/ Equine Syphilis/ breeding Paralysis
- Dourine term is derived from Arabic word which means “unclean”
- Disease is prevalent in Africa, America, Russia and
- in the parts of Asia.
- Dourine disease is now eradicated from India.

Trypanosoma equiperdum

Disease occurs in three phases-

- **1st phase (Stage of oedema) - swelling and oedema of penis, scrotum, prepuce and surrounding skin in stallion. In mare , profuse fluid discharge is detected.**
- **2nd phase (Urticarial phase) – develop** oedematous plaques **of 2-5 cm in diameter** under the skin known as **Dollar spots** because it appear as a silver dollar had inserted under the skin.
- 3rd phase (Stage of paralysis) – It is characterized by anaemia, emaciation, weakness, in-coordination, paralysis and recumbancy followed by death.

Trypanosoma equiperdum

- **Diagnosis- On the basis of symptoms (urticarial swelling) and detection of organisms in the fluid of genetalia.**

Treatment and Control –

- Diminazene aceturate (Berenil) or Antrycide.
- Slaughtering of infected horses.
- The Dourine Act, 1910 is an Indian Act that was passed to prevent the spread of dourine, a contagious disease that affects breeding equids

- Trypanosomes have antigenic variation due to variant surface glycoproteins (VSG).

- The surface coat of trypanosomes is a 12-15 mm thick layer made up of about 10^7 identical molecules of approximately 60 kDa which are closely packed to cover the entire surface. These molecules are variant surface glycoproteins (VSGs).

- Changing antigenic characters of trypanosomes in vertebrate's hosts, the development of an effective vaccine against trypanosomes is difficult.

Trypanosoma equinum

- Horse acts as final host and *Tabanus* sp. acts as vector
- It causes Mal de caderas (Weakness of hind quarters) in horse.
- Symptom includes staggering gait, reumbancy, conjunctivitis and oedema in eyelids.

- *Trypanosoma Congolense*
- Small form 9 – 18 µm, smallest of African Trypanosomes.
- No free flagellum. Undulating membrane inconspicous.
- Cause ‘Nagana’ (a zulu word meaning to be in low or in depressed spirit)
- Host : Domestic animals & wild game animals.
- Transmission : Cyclically by Glossina & mechanically by biting flies.

- Trypanosoma Cruzi
- Main pathogenic species in stercoraria, causing American human trypanosomasis or ‘Chagas’ disease in South America
- Xenodiagnosis is done for chagas disease
- Xenodiagnosis – Feeding of Triatomid bugs on suspected patient or allowed bugs to feed on the patient's blood through a membrane. Laboratory reared and T. cruzi free triatomes are used and if the suspected materials is positive, metacyclic trypanosomes are found 7-10 days latter in the dropping of the bugs

Important diseases caused by *Trypanosoma* *spp*

Name of *Trypanosoma sp*	Name of disease	Vector
Trypanosoma evansi	Surra	*Tabanus, Stomoxys, Lyperosia*
Trypanosoma congolense	Nagana	*Glossina sp*
Trypanosoma equiperdum	Dourine	The organisms are transmitted by coitus.

Name of *Trypanosoma sp*	Name of disease	Vector
Trypanosoma equinum	Mal de caderus	Tranmitted mechanically by biting flies.
Trypanosoma rhodesiense	Acute form of African sleeping sickness	*Glossina sp*
Trypanosoma gambiense	Chronic form of African sleeping sickness	*Glossina sp*

T. theileri: largest trypanosome

LEISHMANIA

- Family: Trypanosomatidae
  - **It is an obligatory intracellular parasite found in the macrophages of man, dog and a wide variety of wild animals.**
  - **During the life cycle two developmental stages occurs i.e. Amastigote and Promastigote stage.**
  - spread by sandflies of the genus Phlebotomus
  - **Common name: Sand flies / Owl midges/ Month flies**

- Leishmann (1903) and Donovan (1903) first isolated Leishmania donovani in London and Madras respectively.
- Leishmania tropica was first demonstrated by Borovsky (1898) and Wright (1903).

1. Amastigote stage (Leishmania stage): Oval or round in shape, Kinetoplast at right angle to the nucleus, rudimentary flagellum inside the body and found in vertebrate host.
2. Promastigote stage (Leptomonad stage): Spindle shaped, Kinetoplast present at the anterior tip of the body, Undulating membrane absent and found in culture and invertebrate host (vector).

- Species of importance
- L. donovani
- L. braziliensis
- L. mexicana mexicana
- L. tropica
- L. major
- L. chagasi
- Hosts - Human beings and dogs
- Site - macrophages and endothelial cells

GENUS: *LEISHMANIA*

Species	Host	Vector	Disease
L. donovani	Man & Dog	*Phlebotomus argentipes*	Kala-azar or Dum-dum fever or Visceral leishmaniosis
Leishmania tropica	Man, dog & rodents	*Phlebotomus papatasi* or *P. sergenti*	Cutaneous leishmaniosis or Oriental sore or Delhi boil or Old world Cutaneous leishmaniosis

Life-cycle

- Amastigote stage found within the macrophages of Vertebrate hosts.
- During blood sucking of *Phlebotomus* spp. ingest leucocytes and large mononuclear cells containing amastigote stage (Leishman-Donovan bodies or L-D bodies).
- Amastigote transforms into promastigote stage in the mid gut of *Phlebotomus* spp. and multiply by binary fission in the gut .

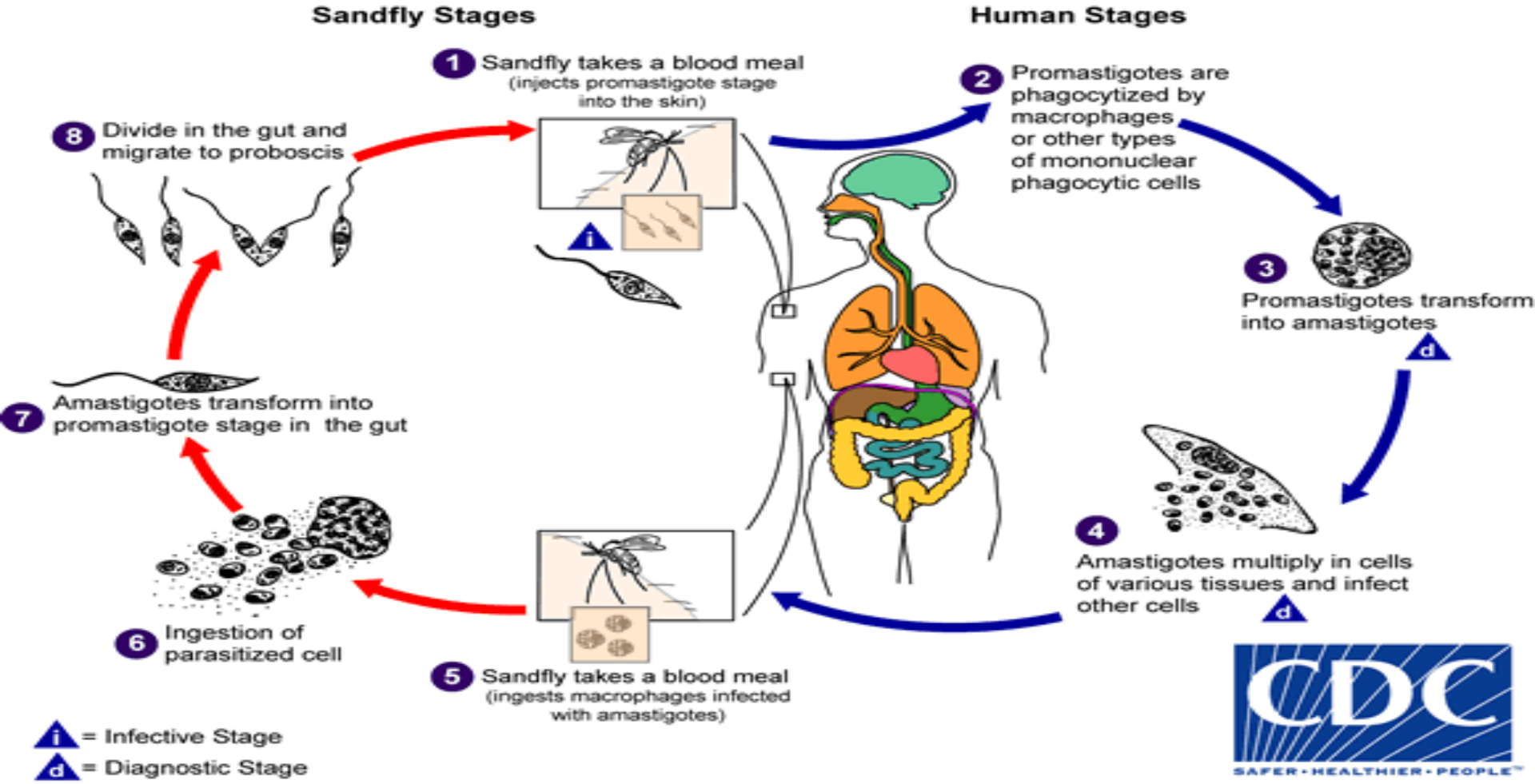
GENUS: *LEISHMANIA*

Transmission:

- When infected sand fly attempts to feed, a plug of organisms may be dislodged and injected into vertebrate hosts.
- Infection may also occur when infected sand flies are crushed on the skin.

- Promastigotes enter in the macrophages of the host and reverts to amastigotes form which multiply there by binary fission.

Life- cycle of *Leishmania* spp.



Leishmania donovani

- it was reported by William Leishman in the year 1903 in the spleen smear of a solider who died in fever at Dum Dum (Kolkata). In the same year, Charles Donovan found the same parasite in the spleen biopsy of a patient in India.
- For this, the parasite has been named as *Leishmania donovani* and the disease is known as Dumdum Fever .
- Disease - Visceral leishmaniosis or Kala-azar or Dumdum fever.
- Also caused by *L. infantum*

Visceral leishmaniosis

It is caused by *Leishmania donovani*.

Pathogenesis-

- Amastigote stage multiply in macrophages of spleen, liver, bone marrow, lung, kidney, lymph node and skin and destroy the macrophages.
- Anaemia develops due to the blockages of reticuloendothelial system.
- Ulceration of digestive tract with enlargement of liver and spleen in advanced stage of infection.

Visceral leishmaniosis

Symptoms -

- Irregular Intermittent fever, diarrhoea, dysentery, distended abdomen due to splenomegaly, hepatomegaly, anaemia, emaciation and darkening of face skin.

Visceral leishmaniosis

Symptoms -

- Darkening of skin of the face particularly around the mouth, forehead, hand, feet and abdomen, hence the disease is called as Kala azar (Black fever).
- **Heavy skin pigmentation which darkens the physical appearance (the reason for naming black fever).**
- Dogs initially develop spectacles due to depletion of hair around the eye and this is followed by generalized loss of body hair, ucers and eczema.

Visceral leishmaniosis in Dog

Symptoms -

- Dogs initially develop spectacles due to depletion of hair around the eye and this is followed by generalized loss of body hair, ucers and eczema.



Visceral leishmaniosis

Post Kala-azar Dermal Leishmaniods (PKDL) :-

- It is a sequel of visceral leishmaniosis and develops about 2-10 years after recovery from the disease.

- Recovery cases of Kala azar after treatment show whitish spots as lentil sized nodules in the skin particularly on the face and neck. The nodules are called Post Kala-azar Dermal Leishmanoids (PKDL).

Diagnosis of visceral leishmaniosis

- On the basis of symptoms
- Post-mortem findings like enlargement of spleen, liver and lymph node, anemia and emaciation.
- Blood smear examination to demonstrate amastigotes stage of parasite.



Amastigotes

- Culture of blood in NNN (Novy, MacNeal and Nicolle) media to get enormous number of promastigotes stage of parasite.



Promastigotes

Diagnosis of visceral leishmaniosis

- Examination of biopsy materials collected **from spleen, bone marrow and lymph node.**
- **Serological tests like CFT, IHA, IFA, ELISA etc. used for diagnosis.**

- **Montenegro test (Skin test)** **is a sensitive and specific test.**

Visceral leishmaniosis

Treatment -

- Pentavalent antimony compound like Pentavalent Sodium stibogluconate @ 2- 5 ml I/M on alternate day - 10 injections are given.
- Pentamidine isothionate @ 4 mg/kg body weight I/M
- Amphotericin B @ 5-10 mg/kg body weight I/V
- **Miltefosine**
- **Paramomycin**

Visceral leishmaniosis

Control-

- Treatment of infected hosts.
- Control of vectors i.e sand flies by using insecticides, destroying breeding places, clearing decaying vegetation etc.

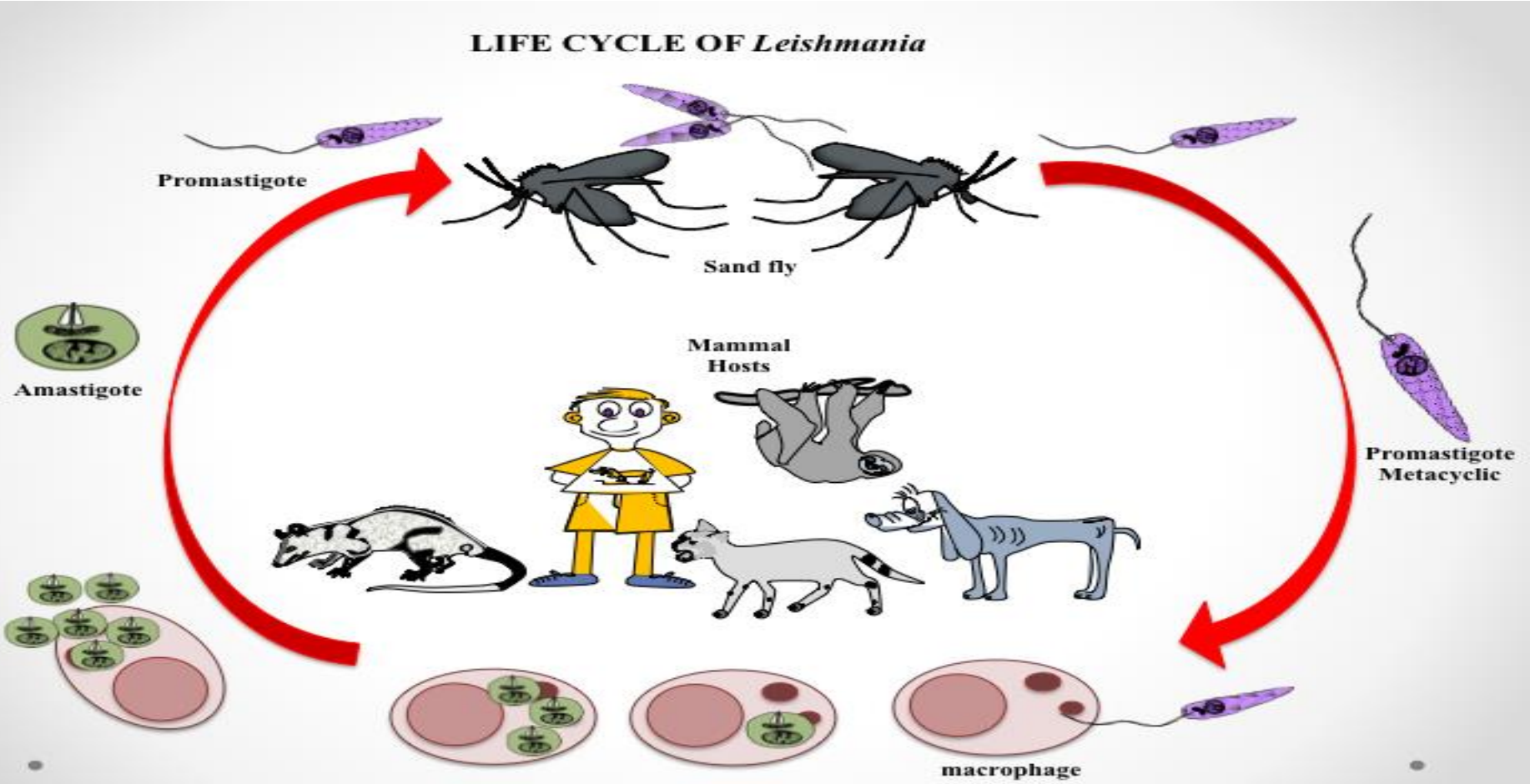
Vaccine –

Leishmune vaccine is a native fructose-mannose-ligand antigen complex developed against *L. donovani* in dog.

Leishmania tropica

- Final hosts - Man
- Reservoir hosts - Dog & rodents.
- Vector - *Phlebotomus papatasi* or *P. sergenti* (Sand fly).
- Location - Macrophages/ reticuloendothelial (RE) cells of skin of man, dog , rodent and other wild animals.
- Caused disease- Cutaneous leishmaniosis or Oriental sore or Delhi boil or Old world Cutaneous leishmaniosis .
- Also caused by *L. major*

Life- cycle of *Leishmania tropica*



Cutaneous leishmaniosis

Symptoms and pathogenesis:

- **First reddish papules develop at the site of infected phlebotomus fly bite in man or dog.**
- **Later , there will be the formation of ulcer.**
- **Multiple lesions (ulcers) may coalesce and forma a large lesion.**
- **The disease is not fatal and may heal within 2-12 months.**
- **Healing of wounds results into scar formation usually in face, nose, ear and eye leading to disfigurement or wrinkling of face.**

Diagnosis of Cutaneous leishmaniosis

- Microscopic detection of amstigotes stage in smear prepared from the edge of lesions (Ulcers).
- Demonstartion of Promastigote in the cultivation of biopsy or post-mortem materials on NNN (Novy, MacNeal and Nicolle) medium.





- Biopsy of local lymph nodes
- Various serological tests are used in the diagnosis.

Cutaneous leishmaniosis

Treatment :-

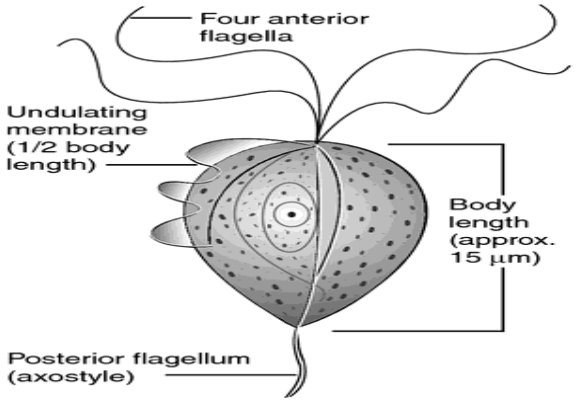
- Lithium antimony thiomalate and Berberine sulphate are used in the treatment of cutaneous leishmaniosis.

Order – Trichomonadida

- Having 4-6 flagella and one trailing flagella attached to undulating membrane
- One or 2 nuclei, asexual reproduction generally by binary fission
- found in alimentary canal, reproductive tract
- Two family present under this order, Family: Monocercomonadidae and Trichomonadidae
- Some pathogenic forms found in genera Tritrichomonas, Trichomonas, Giardia and Hexamita

Family- Trichomonadidae

- Usually found in digestive tract or some of the organisms may also present in the reproductive tract.
- Body is pyriform shaped with rounded anterior end and pointed posterior ends.
- Parasites have 3-5 flagella, undulating membrane, axostyle , costa and uninucleated.



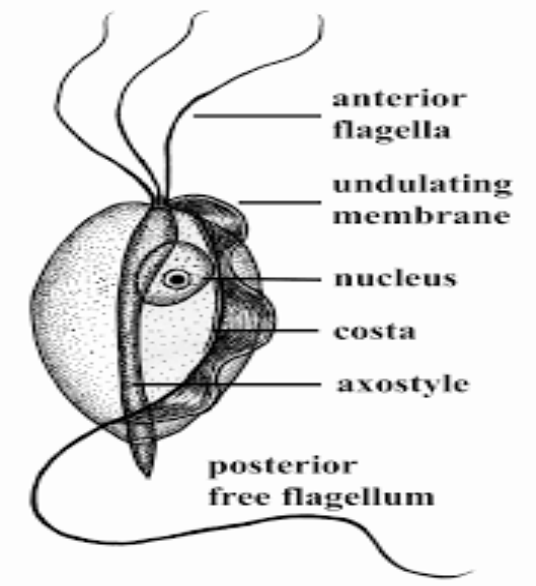
Family : Trichomonidae

Genus and Species	Host	Location
Tritrichomonas foetus	**Cattle, buffalo, pig, horse etc.**	**Reproductive tract**
Trichomonas gallinae	**Pigeon, turkeys etc.**	**Upper digestive tract**
Trichomonas vaginalis	**Man**	**Vagina and urethra**

Tritrichomonas foetus

Body is usually pear shaped.

- It has three anterior flagella and a posterior flagellum that runs along the undulating membrane and then continues as a free flagellum.
- A hyaline rod like structure known as axostyle which run through the midline of the cell and emerges posteriorly.
- **It has characteristic vigorous jerky movement.**
- Multiplication by longitudinal binary fission.
- Sexual multiplication or cyst formation absent.



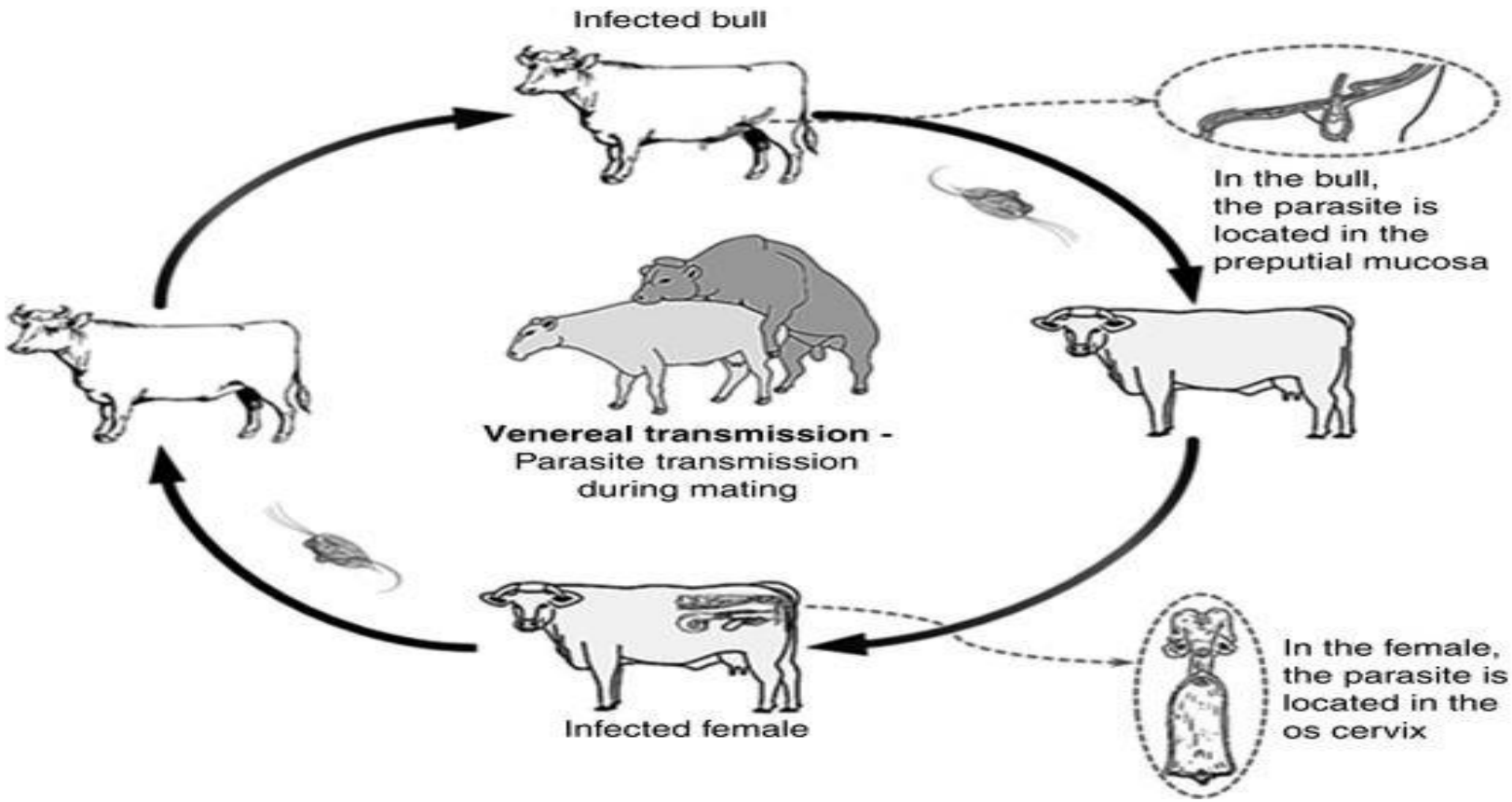
Host : It is mainly pathogenic in cattle but may also occur in buffalo, horse, pig and deer.

Location: vagina and uterus in cow whereas preputial cavity in bull.

Transmission:

- Organisms mainly transmitted through coitus

- During Artificial insemination and gynecological examination, the parasites may transmitted.
- Bulls, once infected, remain a permanent source of infection whereas in cows, the infection is self-limiting and parasites may gradually disappear.


Infected bull
In the bull,
the parasite is
located in the
preputial mucosa
Venereal transmission -
Parasite transmission
during mating
Infected female
In the female,
the parasite is
located in the
os cervix

Tritrichomonas foetus

Pathogenesis:

- It causes the **specific venereal disease**, **bovine trichomonosis** or **bovine trichomonad abortion in cattle**.

Cows:

- Vaginitis, endometritis, placentitis with detachment of the placental membranes and death of the foetus which lead to an early abortion usually 8-16 weeks after the infected service.

Tritrichomonas foetus

Pathogenesis:

Cows:

- Sometimes foetus and foetal membrane retained leading to purulent endometritis.
- When cervix is closed and corpus luteum is retained, then closed pyometra develops and uterus may contains several liters of greyish-white fluid swarming with trichomonads, which will give the appearance of pregnancy.
- In long standing case, the trichomonads may disappear from the uterine fluid so disappear is self-limiting in cows.

Pathogenesis:

Bulls:

- Small red nodules in the mucous membrane.
- Mucopurulent discharge from the preputial cavity.
- Above signs disappeared from 1-2 weeks after the infection.
- Spontaneous recovery is rare and bulls remain permanently infected

Tritrichomonas foetus

Symptoms:

Cows:

- Early abortion(usually 8-16 weeks after conception).
- Vaginal discharge, mucopurulent endometritis, anestrous, irregular hear period.

Bulls :

- Pain during micturition, disinclination to serve cows and preputial discharge.

Tritrichomonas foetus

Diagnosis:

- Herd history (early abortion, failure of conception, increase vaginal discharge and incidence of pyometra in the herd etc.).



- Microscopic examination of vaginal discharge or washing, uterine discharge, preputial discharge, stomach contents of aborted foetus, amniotic fluids etc. reveled *T. foetus* with characteristic vigorous jerky movement.

- Serological test like cervical mucus agglutination test

Tritrichomonas foetus

Treatment:

- Since the infection in self-limiting in cows, infected animals should be given breeding rest to cure the infection.
- Use of Acriflavin ointment in infected bull with the help of pudendal anesthesia.
- Berenil or Dimetridazole is also used in the treatment

Tritrichomonas foetus

control:

- Infected bulls must be either castrated or slaughtered.
- Avoid breeding between susceptible cow and infected bull and vice–versa.
- Aborted cows should be given breeding rest for three consecutive estrous periods.

Trichomonas gallinae

Host : Pigeons , turkey and chicken.

Location: Upper digestive tract

- Organism has only four anterior flagella.
- Organism transmitted from adult pigeons to their offsprings through infected pigeons crop milk.
- Adults pigeons cat as carrier but nestling pigeons (squabs) are highly susceptible.
- **It causes yellow necrotic lesions (yellow buttons) in the mouth, oesophagus, crop and proventriculus.**

FAMILY: MONOCERCOMONADIDAE

- ***Histomonas meleagridis:*** found in the caeca and liver and causes histomonosis, 'infectious enterohepatitis', or 'black head disease' in chicken, turkey, peafowl, guineafowl, pheasant, partridge and quail.
- Organisms are amoeboid (pleomorphic) with a single nucleus and single flagellum.

- Four stages of parasites have been recognized :-
- Invasive stage : found in early caecal and hepatic lesions or periphery of old lesions
- Vegetative stage: near center of the lesions
- Resistant stage: extracellular
- flagellar stage: lumen of caeca

Transmission

- Transmission takes place in birds by ingestion of embryonated eggs of the caecal worm (*Heterakis gallinarum*) containing *Histomonas meleagridis* organism.
- Infection of birds may also occur by the ingestion of earthworm which is transport host for *Heterakis* eggs and larvae.

- Histomonosis produces foul smelling yellowish exudates forming a hard caseous plug in caecum and formed circular necrotic foci with yellow depressed centre (bulls eye appearance) in liver.
- Yellow/ Sulphur colored diarrhea
- cyanotic discoloration of the skin of the head and wattles from which black head name arises but it is not a constant feature of the disease.
- Treatment: Furazolidone, Dimetridazole, Nithiazide and 2-amino 5-nitrothiozole drugs are used in treatment.

Family: Hexamitidae

Genus: *Hexamita* and *Giardia*

Giardia:

- ✓ Life-cycle : – Direct
- ✓ Reproduction :- By binary fission
- ✓ Transmission: through the ingestion of cysts contaminated food or water.

- Two developmental stages - trophozoite and cyst.
- Trophozoite : Pyriform to elliptical in shape and bilaterally symmetrical.
  - Anterior end is rounded and posterior end is pointed.
  - A large adhesive disc is present on the ventral side whereas dorsal side convex.
  - It has two anterior nucleus, two median axostyle and eight flagella arranged in two pairs
- Cyst:
  - Cysts are oval or elliptical in shape with 2 or 4 nuclei and a number of fibrillar remnants of the trophozoite organelles.

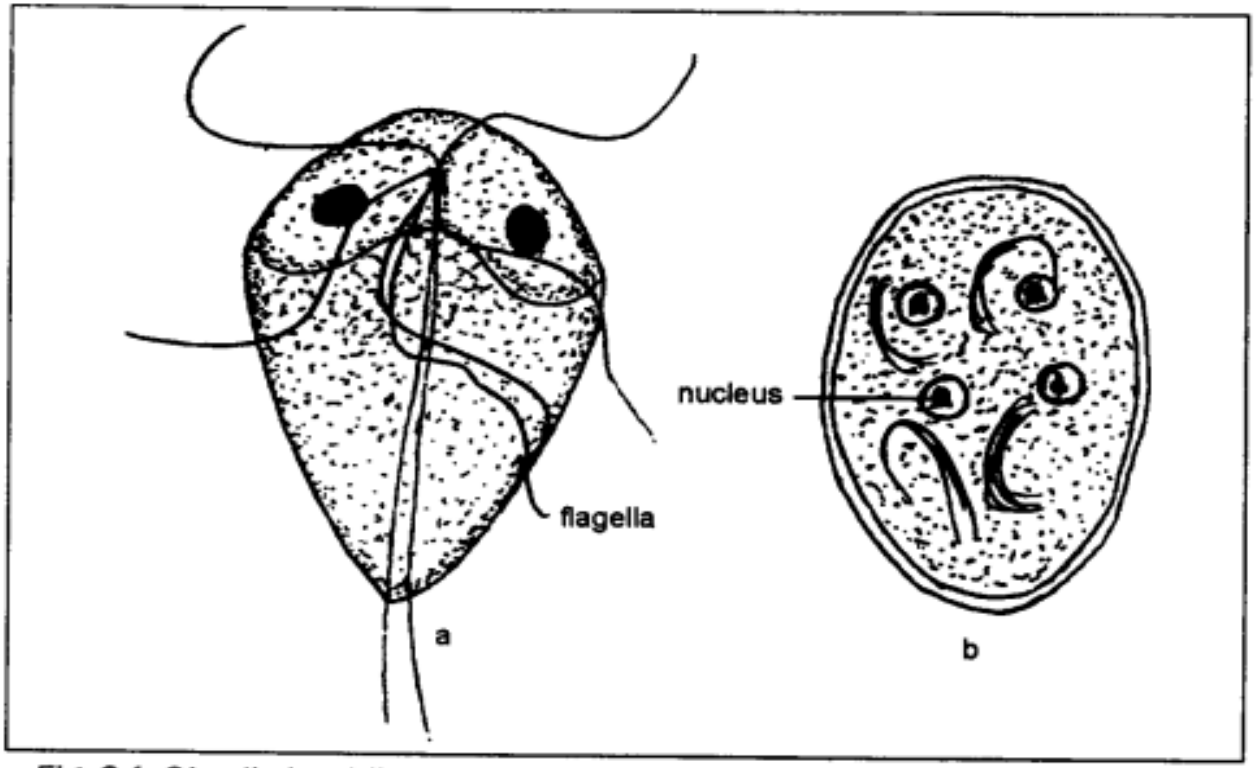


Fig. 94. Giardia lamblia. a - Giardia lamblia in intestine; b - Encysted Giardia lamblia

Genus: *Giardia*

Species	Hosts	Location
Giardia intestinalis* or *Giardia lamblia	**Man, monkey and pig**	**Upper digestive tract**
G. canis	**Dog**	
G. bovis	**Ox**	
G. cati	**Cat**	
G. caprae	**Goat**	

- Pathogenesis: Chronic diarrhoea in man especially children. Interference in fat digestion which results deficiency in the fat soluble vitamins.
- Clinical signs : Giardiosis (beaver fever) results diarrhoea, dysentery and steatorrhoea (fats comes with stool) and deficiency of fat soluble vitamin. Journey sickness - After returning from a long distance of journey, diarrhea or dysentry occur called as lambliasis.
- Treatment: Metroniodazole,Tinidazole, Chloroquine etc.

Hexamita meleagridis

- Pyriform shaped, two similar nuceli, out of eight flagella, six flagella anteriorly directed in two groups of three in each and two caudal flagella, two axostyles but adhesive disc absent.
- Host and location: It occurs in the duodenum and small intestine of young turkey, peafowl, quail, partridge, duck and also chicken.
- Transmission: Organisms transmitted through contaminated feed and drinking water.

- Pathogenesis:
  - Young turkey up to two months of age are most susceptible whereas old birds act as symptomless carrier.
  - It causes catarrhal enteritis in the small intestine and intestinal contents become thin, watery and foamy.
- Clinical signs:
  - Hexamitosis disease is known as Infectious catarrhal enteritis in turkey poults.
  - Symptoms include foamy and watery diarrhoea, loss of body weight, nervousness and death of affected birds.

- PHYLUM: APICOMPLEXA CLASS : SPOROZOA
- There are two sub-classes, Coccidia and Piroplasmia with one Order under each, Eucoccidiida and Piroplasmida, respectively.
- Order Eucoccidiida has three sub-orders, (1) Eimeriina with three families, Eimeriidae, Cryptosporidiidae and Sarcocystidae (2) Haemosporina with one family, Plasmodiidae and (3) Adeleina with two families; Klossiellidae and Haemogregarinidae.
- Order Piroplasmida has two families, Babesiidae and Theileriidae

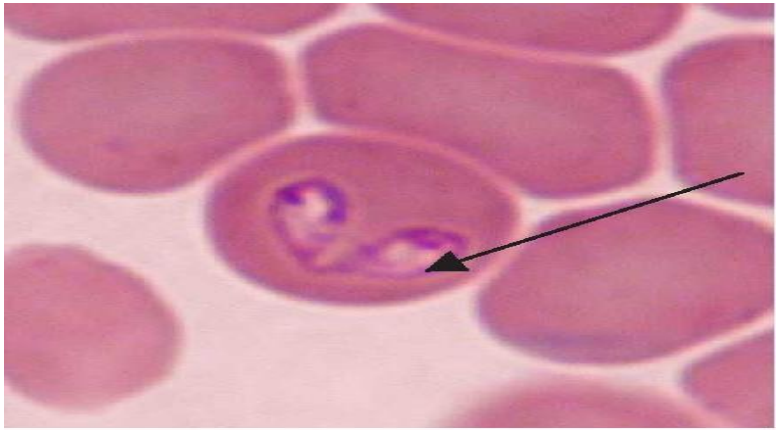
Babesia

- Subclass - Piroplasmia
- Order - Piroplasmida
- Family - Babesiidae
- GENUS- BABESIA
- tick-transmitted haemoprotozoan parasites occurring particularly in the RBC (intracellular).
- A major part of the animal population are at the risk of the disease, Babesiosis (Red water fever).
- ***Babesia* parasite has been observed first time by Babes in 1888 from blood of African cattle.**
- The vector *(Boophilus annulatus*) of *Babesia bigemina* was first discovered by Smith and Kilbourne in the year 1893.

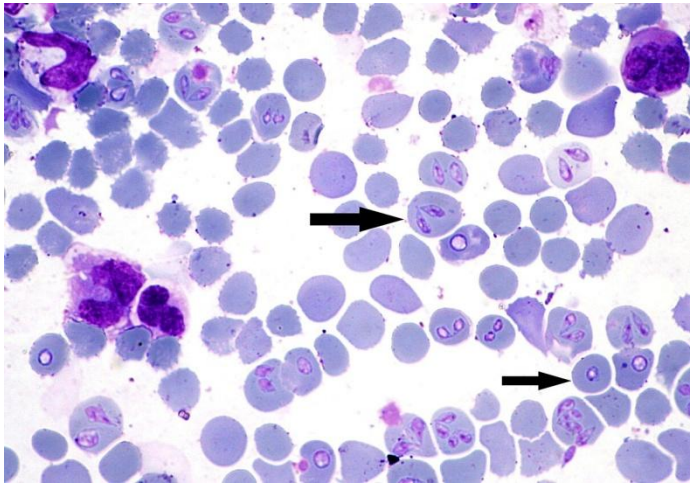
Morphology

- *Babesia* spp. are found single as round, oval or amoeboid trophozoite or in pairs as pyriform (Pear shaped) merozoites inside the R.B.C. Some species may occur in 4 (*Babesia felis*) or 16 (*Babesia canis*).
- Various species divided into 2 groups –
  - Large form (L) - average length more than 3 µm with their narrow ends at an acute angle
  - Small form (S) - average length less than 2.5 µm with an obtuse angle.

Genus: *Babesia*



Large form



Small form

❖ Different species of *Babesia* found in Cattle & Buffalo :-

Species	Definitive host	Vector	Size (Form)
Babesia bigemina	**Cattle and buffalo**	***Boophilus microplus*** (India), ***B. annulatus***	**L**
Babesia bovis or ***Babesia argentina*** or ***Babesia berbera***	**Cattle, and buffalo**	**-do-**	**S**
Babesia divergens	**Cattle**	**- do-**	**S**
Babesia major	**Cattle**	***Haemaphysalis punctata***	**S**

❖ Different species of *Babesia* found in sheep, goat, equine and pig :-

Species	Definitive host	Vector	Size (Form)
Babesia motasi	**Sheep and goat**	***Haemphysalis* sp. , *Rhipicephalus* sp., *Dermacentor* sp.**	**L**
Babesia ovis	**- do-**	**-do-**	**S**
Babesia taylori	**Goat**		**S**
Babesia foliate	**Sheep**		**S**
Babesia caballi	**Horse , donkey & mule**	**R*hipicephalus*, *Hyalomma*, *Demacentor* spp.**	**L**
Babesia trautmanni	**Pig**	***Rhipicephalus* , *Dermacentore* spp.**	**L**
Babesia perroncitoi	**Pig**	**-do-**	**S**

❖ Different species of *Babesia* found in dog & cat :-

Species	Definitive host	Vector	Size (Form)
Babesia canis, Babesia vogeli & B. rossi	Dog	*Rhipicephalus sanguineus*	L
Babesia gibsoni	Dog	*Rhipicephalus sanguineus*	S
Babesia cati	Cat	*Rhipicephalus* , *Dermacentor* etc.	L
Babesia felis	Cat		S

Genus: *Babesia*

Zoonotic Species :-

- *Babesia divergens* (Small form)
- *Babesia bovis* (Small form)
- *Babesia microti* (Small form)

Genus: *Babesia*

Transmission: Transovarian and or stage to stage (transtadial) transmission of *Babesia* species take place in the ticks.

- ✓ When *Babesia* spp. are transmitted through the ovary (egg) for two or more generation of one host female ticks called transovarian transmission. e.g. *Babesia bigemina*.
- ✓ When infection persists from one stage to the next stage in 2 or 3 host ticks feeding on different hosts, transmission is said to be transtadial.

Larva ⟶ Nymph ⟶ Adult

- Adult stages of tick are transmitting infection which they acquired as nymph or larvae.
- Infective stage is sporozoites which inoculated into host during blood sucking of tick.

Life-cycle of *Babesia* spp.

- Sporozoites inoculated in to hosts by the infected tick during blood sucking.
- Sporozoites enter inside RBCs and converted into Trophozoites.
- Trohozoites multiply by binary fission and form merozoites.
- Merozoites form gamonts inside RBCs.
- Gamonts come into gut lumen of ticks during blood sucking of infected hosts.
- Gamonts differentiated into Macrogametocyts and microgametocytes

Genus: *Babesia*

- Macrogametocytes and microgametocyte are fused to form Zygotes.
- Motile zygote is known as Ookinete. Ookinetes forms sporozoites in two ways :

➢ Ookinetes form vermicules in gut cells of tick.

➢ Vermicules migrated into ovary of tick.

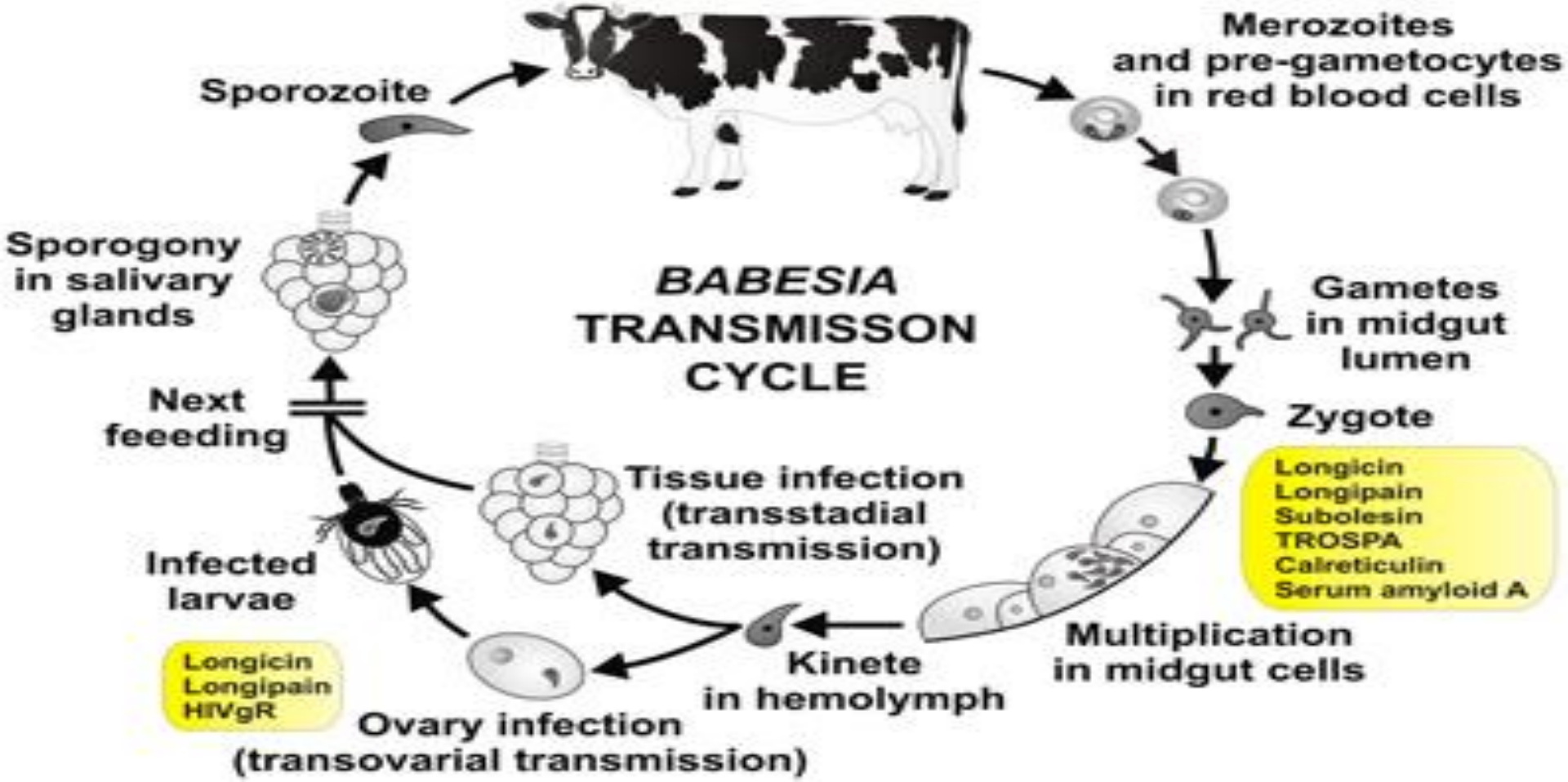
➢ Infected female tick produce eggs infected with vermicules.

➢ Egg hatches into larva infected with vermicules.

➢ Vermicules enter into salivary glands of larva and form infective sporozoites.

✓ In other way, motile Ookinetes directly enter into salivary glands and form sporozoites (Infective stage).

Life-cycle of *Babesia*



Pathogenesis

- Species of the *Babesia* : - *B. bovis*, *B. canis* and *B. motasi* are highly pathogenic than other species of their hosts.
- Age of the host – An **inverse age resistance** is found in *Babesia* infection i.e. older animals are more susceptible to babesiosis in comparison to younger animals.
- Breed of the host, Immune status of host, stress etc.

- Main pathogenesis is intravascular haemolysis which is due to rapid multiplication of *Babesia* inside the RBCs followed by destruction of the RBCs .
- Extravascular haemolysis which mostly occurs in the spleen, due to phagocytosis of infected and non-infected RBCs by the activated macrophage.
- Intra and extravascular haemolysis may cause haemoglobinuria, haemoglobinaemia, bilirubinuria and anaemia with further consequences of tissue hypoxia, metabolic acidosis, hyperkalaemia, hypovolaemic shock and development of multiple organs dysfunction leading to death of the infected host.

Genus: *Babesia*

***Babesia* species caused diseases are known as**

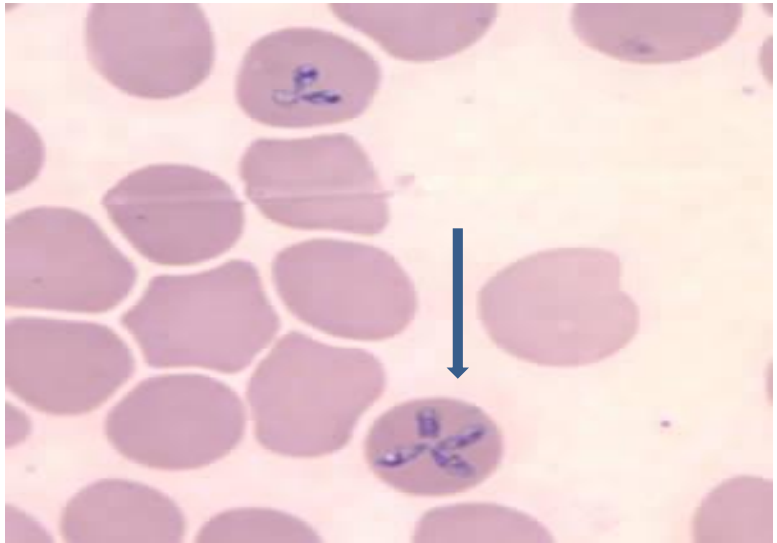
- **Babesiosis**
- **Red water disease**
- **Texas fever**
- **Biliary fever**
- **Piroplasmosis**
- **Spleenic fever**
- **Tick fever**
- **Nantucket fever.**

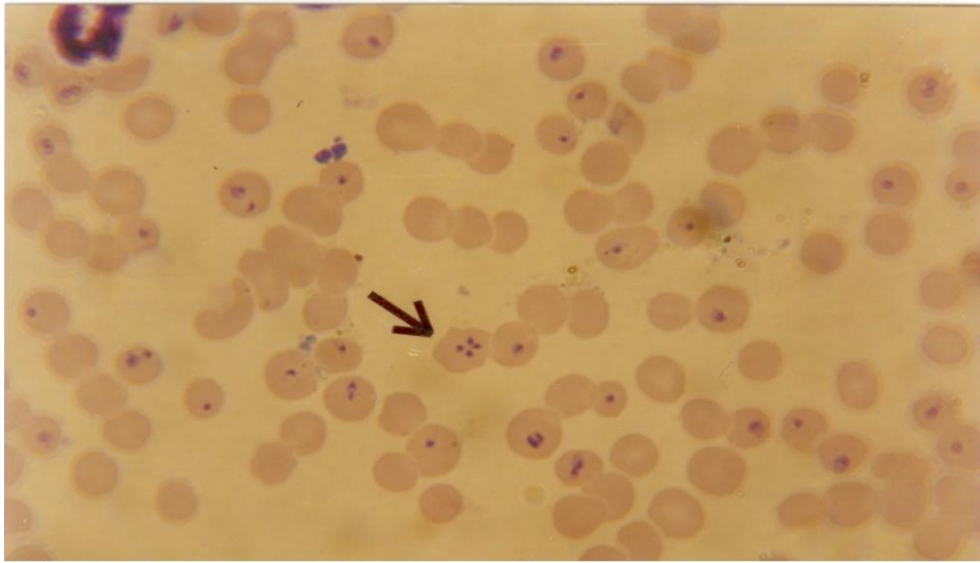
Symptoms

- High fever
  - Urine becomes coffee colour due to haemoglobinurea. Hence the disease called red water disease.
  - Anaemia
  - Pale mucous membrane (Jaundice)
  - Pipe-stem diarrhea: may occur in B. bovis and B. divergens due to spasms of anal spinchter
  - Hepatomegaly and splenomegaly
  - Death in untreated case

Maltese cross

- *Theileria equi (Babesia equi* or *Nuttalia equi)* and *Babesia felis* have a tendency to divide into 4 daughter organisms which appear like a *Maltese cross*.





- Jaundice is more common in equine babesiosis, hence, it is called *biliary fever*. Haemoglobinuria is rare in *Babesia caballi* infection.

- Haemoglobinuria is seen sometimes in peracute case only in *Babesia canis* infection.

- *Rhipicephalus sanguineus* is the principal vector of *Babesia canis* in which transovarian followed by transtadial transmission occur. Both pups and adults are equally susceptible.

- Young calves are generally immune due to maternal antibodies received from the mother through the colostrums.
- Babesiosis mostly occurs in cattle than buffalo.
- **Cerebral babesiosis** occurs in cattle due to *Babesia bovis* infection in which blockage of cerebellum capillaries takes place due to clumping of infected RBCs. The resulting symptoms are ataxia, anoxia, paddling of limbs, convulsion and coma.

- In *Babesia* sp. infection, immunity is premunity i.e. the animals recovered from the clinical infection may continue to harbour organisms and remain immune to reinfection.

Diagnosis of *Babesia*

1. On the basis of cardinal clinical sign (fever, coffee coloured urine etc.)
2. Microscopic examination of blood smear- Peripheral blood sample should be collected from the suspected animals at the of pyrexia. Giemsa/Leishman stained blood smear will show *Babesia* organism mostly in pairs inside the RBCs.



Diagnosis of *Babesia*

3. On the basis of necropsy findings i.e. hepatomegaly, splenomegaly etc.

4. By serological test like CFT, IFA, ELISA etc.

5. Molecular test- Polymerase chain reaction (PCR).

Treatment

I. Diminazene aceturate –@ 3.5 mg/kg body weight S/C or I/M or I/V.

II. Imidocarb is worked as a therapeutic and prophylactic drug against *Babesia bigemina* and *Babesia argentina* (*Babesia bovis*) @ 0.5-1 mg/kg b.wt. given subcutaneously

III. Trypan blue @ 2-3 mg/kg body weight is given intravenously in babesiosis.

IV. Combination therapy of azithromycin and atovaquone used in *Babesia gibsoni* (Asia) infections.

Control

- Chemotherapy- Infected animals should treated with antibabesial drug.
- Chemoimmunoprophylaxis by using Imidocarb dipropionate drug.
- Immunoprophylaxis- *Pirodog* and *Nobivac* commercial vaccines work against *Babesia canis*.
- By Tick control.

- Pre- immunity: When infected animal develop long time immunity against Re-infection with same species of infection.
- Babesia, Theileria and Anaplasma persist infection. (Exception B. canis & B. divergen)

Family – Theileriidae

GENUS - *Theileria*

- *Theileria* named in honor of Arnold Theiler (scientist). Theiler found that East coast fever was not the same as redwater but caused by a different protozoan.
- It is tick transmitted haemoprotozoan parasite of ruminants and captive ungulates.
- Its piroplasm stage found inside RBCs and schizonts stage inside lymphocytes.
- In RBC, the piroplasm stage of *T. annulata* occurs generally annular or ring shaped whereas *T. parva* found as rod shaped. Besides, round, comma and oval shaped may also be found.

- Schizont stage :-
  - Found in cytoplasm of the lymphocytes in the infected lymph nodes and spleen.
  - Two types of schizonts found - macroschizonts and microschizonts.
  - Macoschizonts are 2-16 µm (average 8 µm) in size containing about 8 nuclei.
  - Macroschizonts take stain blue after smear preparation and called Koch's blue bodies.
  - Microschizonts are similar in size but contain 30-120 nuclei.

Genus: *Theileria*

Species	Definitive host	Vector	Disease
Theileria annulata	**Cattle and buffalo**	***Hyalomma anatolicum anatolicum*** **or** ***Hyalomma excavatum*** **(3-host tick)**	**Bovine Tropical theileriosis or Egyptian theileriosis or Mediterranean theileriosis**
Theileria parva	**Cattle and buffalo**	***Rhipicephalus appendiculatus***	**East coast Fever or January fever**
Theileria lawrenci	**Cattle and buffalo**	***Rhipicephalus appendiculatus***	**Corridor disease**

Genus: *Theileria*

Species	Definitive host	Vector	Disease
Theileria lestoquardi **(*T.hirci*)**	**Sheep and goat**	***Rhipicephalus*, *Haemaphysalis*, *Dermacentor* species**	**Malignant theileriosis**
Theileria ovis	**Sheep and goat**	**-do-**	**Benign theileriosis**
Theileria mutans	**Cattle**	**-do-**	**Benign bovine theileriosis**
***Theileria equi* (*Babesi equi*)**	**Equines**	***Rhipicephalus* & *Dermacentor***	**Equine piroplasmosis**

Transmission

- Transtadial or stage to stage transmission found in *Theileria* spp.
- When parasite enter in one stage of tick (larva or nymph) during feeding on an infected animal. Then, the subsequent stage (nymph or adult) of tick transmit the disease during feeding on a susceptible hosts.
- *Theileria* parasites are most commonly transmitted when ticks feed on infected animals as nymphs and then on susceptible cattle as adults.
- Infective stage is sporozoites which inoculated into final host during blood sucking of infected tick.

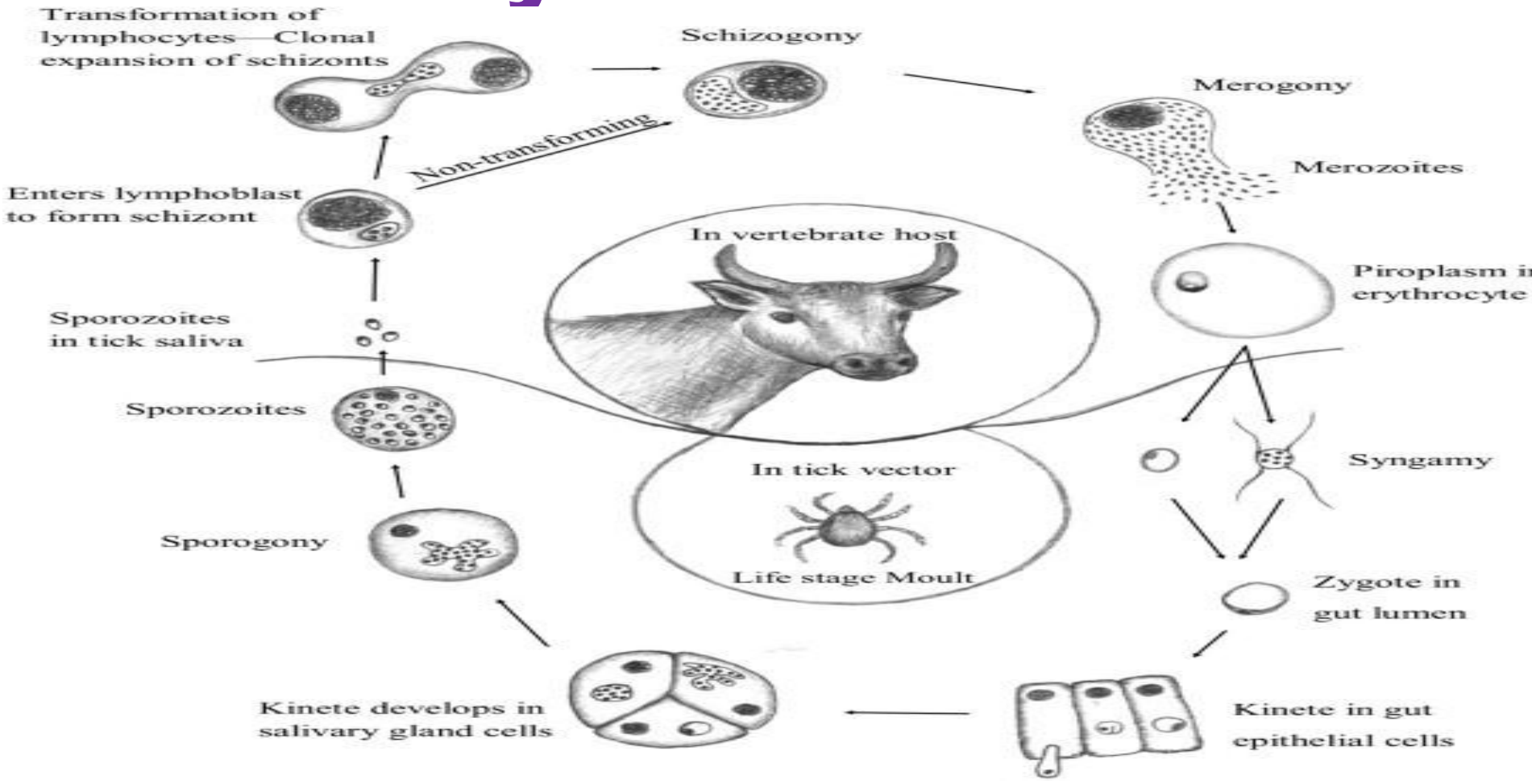
Genus: *Theileria*

Life- Cycle:- **Asexual cycle inside definitive hosts :-**

- **Sporozoites inoculated into hosts by the infected tick during blood sucking.**
- **Sporozites enter into lymphocytes of the peripheral lymph nodes and multiply by schizogony in their cytoplasm and form macroschizonts.**
- **Macroschizonts develop into microschizonts inside cytoplasm of lymphocytes.**
- **Lymphocytes rupture and released microschizonts which invade RBCs and develop into piroplasm stage.**

- Sexual cycle inside the tick
  - When Ixodid ticks suck blood of infected host ,then piroplasm stage are release in the gut of tick and form gamonts which differentiated into macrogametocyts and microgametocytes
  - Macro gametocytes and microgametocyte are fused to form Zygote.
  - Motile zygote is known as Ookinete.
  - Okinete develop into sporozoites in salivary gland of infected ticks

Life-cycle of *Theileria*



- In India, *Theileria annulata* infection mainly occurs during summer and rainy seasons (May to October) due to high incidence of tick vectors during these seasons/months and also due to stress of hot and humid weather.
- *T. annulata* occurs in India and more pathogenic in case of cross-bred and exotic cattle.

Pathogenesis :

- Macroschoizonts (Koch's blue bodies) stage initially lead to increased infected lymphoblast population and later lymphocytosis and leucopenia
- Piroplasmic stage responsible for erythrophagocytosis by macrophages resulting to development of anaemia.

Symptoms

- High fever
  - Enlargement of superficial lymph nodes (prescapular lymph nodes).
  - Unwillingness to feed and drink
  - Cessation of rumination, drop milk production, lacrimation, nasal discharge, anaemia , Corneal opacity etc.
  - Haemorrhagic diarrhoea and death due to dysponea as a result of oedema in the lungs.

Genus: *Theileria*

Symptoms:

Corneal opacity in *Theileria annulata* infected calf.

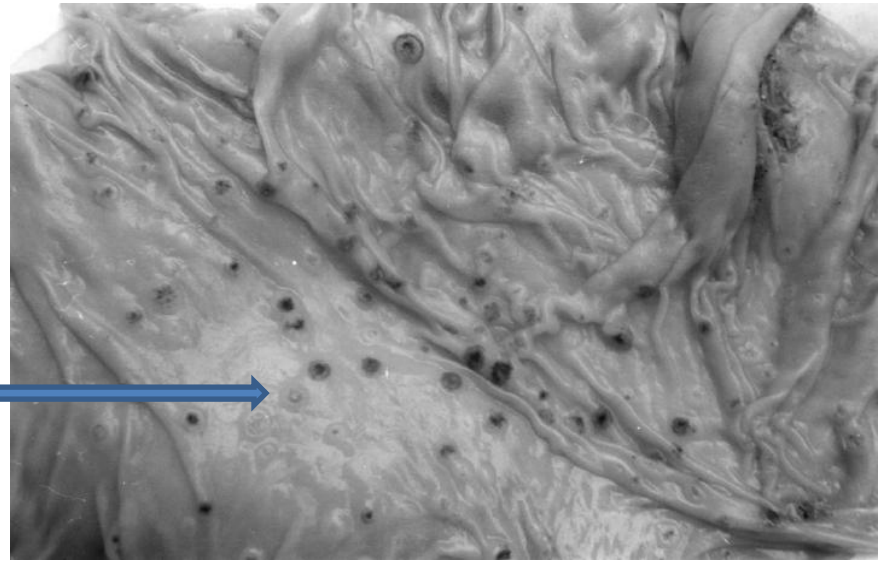


Genus: *Theileria*

Post-mortem lesions :-

- **Necrotic punched ulcers in the abomasums are characteristic post-mortem finding.**
- Generalized enlargement of lymph nodes, hepatomegaly and splenomegaly.

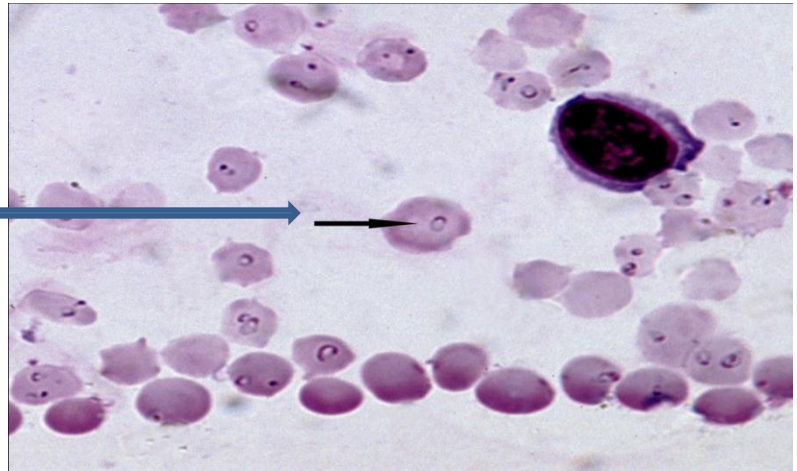
Necrotic punched ulcers



Diagnosis of *Theileria*

- Microscopic examination of blood smear- Peripheral blood sample should be collected from the suspected animals at the of pyrexia. Giemsa/Leishman stained blood smear will show annular (ring shaped) piroplasm stage of *Theileria* organism mostly single inside the RBCs.

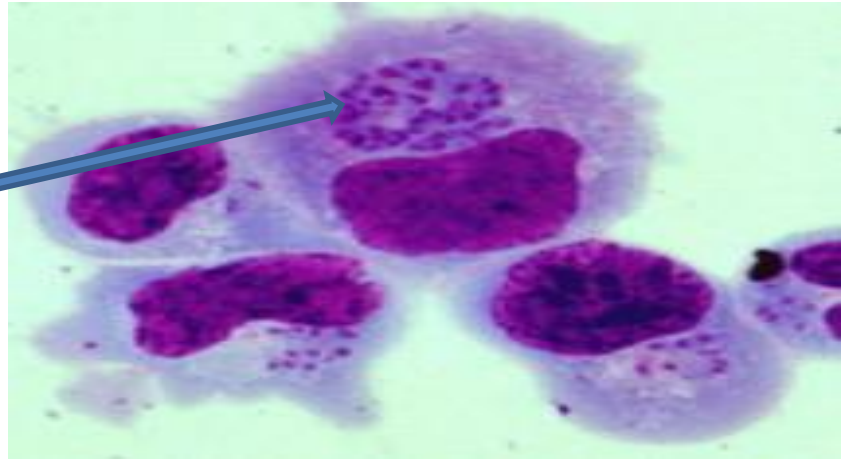
Piroplasm stage of *T. annulata* (Ring shaped)



Diagnosis of *Theileria*

- Lymph gland Biopsy smear – Lymph fluid aspirate from the infected lymph glands, then lymph smear prepared and stained with Giemsa stained revealed macroschizonts stage (Koch's blue bodies) inside the cytoplasm of Lymphocytes.

Koch's blue bodies



Treatment of Theileriosis

Buparvaquone (Butalex) @ 2.5 mg /kg b.wt. i/m is drug of choice.

- 

Treatment of Theileriosis

- Oxytetracycline + Diminazene aceturate are also used in the treatment of theileriosis.

- **Oxytetracycline has effect on schizonts whereas Diminazene aceturate has effect on piroplasms.**

- **Parvaquone, Halofuginone and Menoctone drugs are effective against clinical infections with *Theileria annulata*.**
- Chloroquine sulphate (anti malarial drug) @ 5mg/kg body weight orally.

Control of Theileriosis

I. By chemotherapy with antitheilerial drug.

- By Chemoimmunoprophylaxis- It is a infection-treatment method. Infective sporozoites or viable macroschizonts are inoculated in young susceptible calves and chemoprophylactic agents like Oxytetracycline etc. are used to reduce the virulence of the organisms as well as to immunize the animals. Grounds up tick's suspensions/sporozoites (GUTTS) are used as source of infection

Control of Theileriosis

I. By vaccination:- **Rakshavac – T** is the schizont culture vaccine used in India. The dose of vaccine is 3 ml administered subcutaneous at the age of two months and above in crossbred and exotic cattle. Revaccination - every 3 years.



Theileria equi

- *Theileria equi* was previously known as *Babesia equi* but compelling evolutionary, morphologic, biochemical and genetic evidence supports *Babesia equi* re-classified as *Theileria equi* in 1998.
- In case of *Theileria equi*, sporozoites invade the lymphocytes and after development form Theileria-like schizonts in lymphocytes. The merozoites released from these schizonts invade red blood cells (RBCs) and transform into trophozoites which grow and divide into pear-shaped tetrad (‘*Maltese cross*’) merozoites.

Phylum- Apicomplexa
Class – Sporozoea

- Sub-class :- Coccidia
- Order - Eucoccidiida
- Family - Eimeriidae, Cryptosporididae, Sarcocystidae

- FAMILY -EIMERIIDAE
- History / Discovery: Eimeria was first detected by A. Leeuwenhoek (1674). Dobell gave the name in the year 1922
- Cocccidian parasites are intracellular (few exceptions) apicomplexan protozoa of intestinal epithelial cells chiefly of vertebrates.

Different Genera of Coccidia

Eimeria	*Isospora*	*Neospora*	*Cryptosporidium*	*Tyzzeria*	*Wenyonella*
Sporulated oocyst contains four sporocysts. Each sporocyst contains two sporozoites.	Sporulated oocyst contains two sporocysts. Each sporocyst contains four sporozoites.	Sporulated oocyst contains two sporocysts. Each sporocyst contains four sporozoites.	Sporulated oocyst does not contain sporocysts; only four sporozoites are present in oocysts.	Sporulated oocyst does not contain sporocysts; only eight sporozoites are present in the oocysts.	Sporulated oocyst contains four sporocysts. Each sporocyst contains four sporozoites.

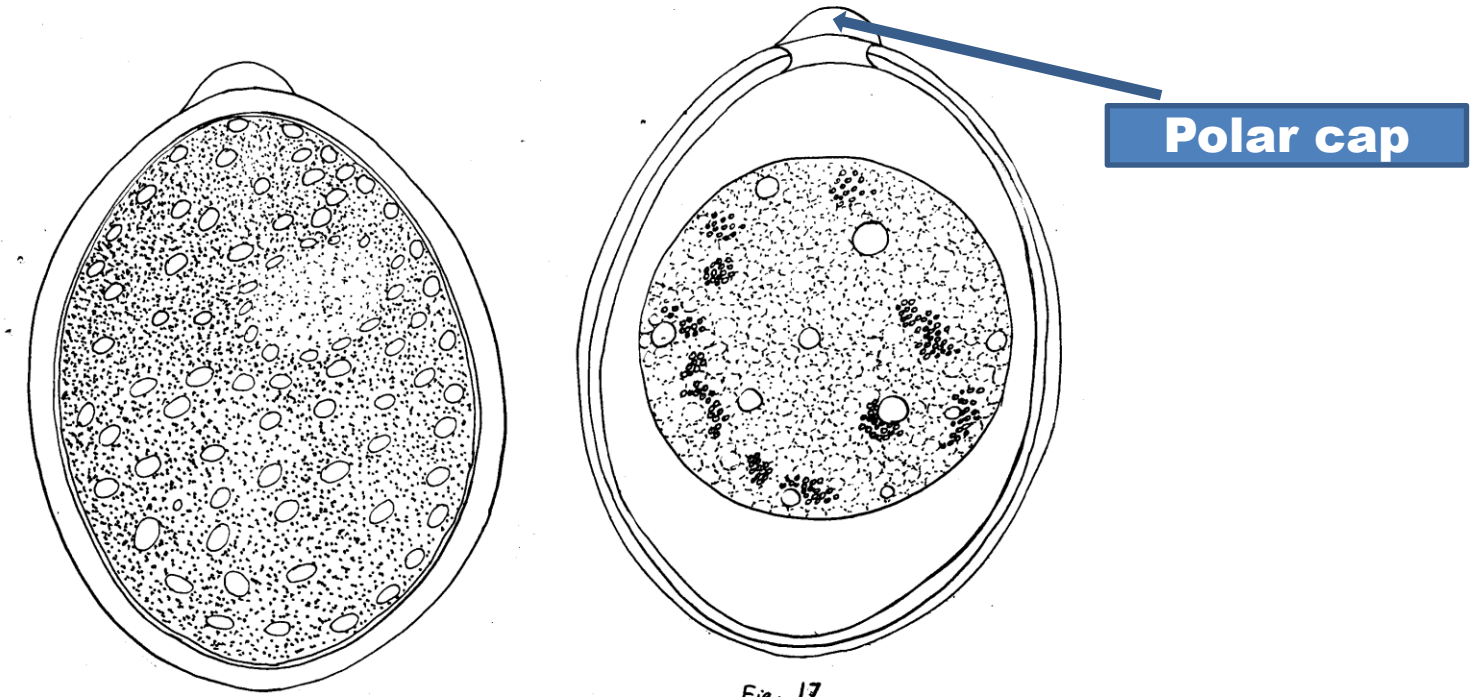
Genus- *Eimeria*

- Organisms commonly called coccidia.
- Intracellular parasite found in the epithelial cells of intestine of vertebrates in which both asexual and sexual reproduction takes place.
- Highly host specific as well as organ/location specific parasite.
- Direct life-cycle.
- Locomotion by gliding.

- Unsporulated oocysts comes out of the infected host through faces .
- Sporulation of unsporulated oocyst occurs outside the host in environment.
- Sporulated oocyst is the infective stage for the host.

Unsporulated oocysts

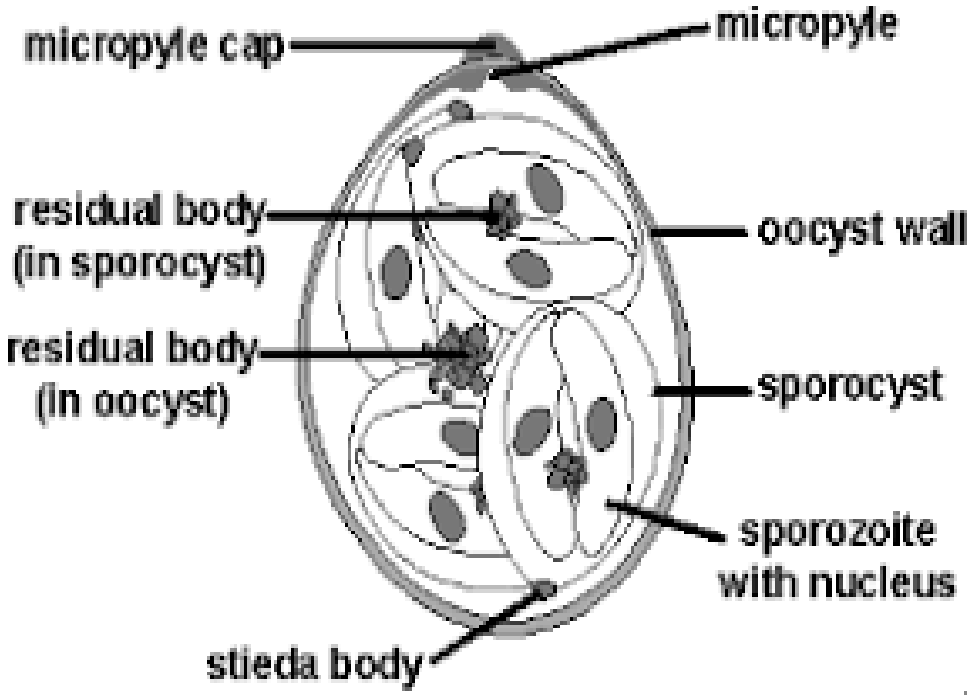
- Usually spherical, sub-spherical, ellipsoidal and oval shaped.
- Usually bilayered, transparent and clearly visible.
- A small pore called micropyle may be present at narrower end which is often covered by a polar cap or micropylar cap.
- A nucleated mass (sporont) is found mostly at the center.


Polar cap

Sporulated oocysts

- **Sporogony occurs outside the host**.
- Sporulated oocysts are the infective stages of the parasites.
- Time taken for sporulation can also helped as an aid to identification of species.
- Sporulated oocyst contains different number of banana–shaped sporozoites, sporocyst residium and stieda body.
- Each sporulated oocyst contains four sporocysts and each sporocyst contains two sporozoites.

Genus- *Eimeria*



Eimeria species found in poultry

Species	Site in host	Disease
Eimeria tenella	**Caecum**	**Caecal coccidiosis**
Eimeria necatrix	**Small intestine**	**Intestinal coccidiosis**
Eimeria brunetti	**Rectum**	**Rectal coccidiosis**
E. acervulina	**Small intestine**	**Intestinal coccidiosis**
E. maxima	**Small intestine**	**Intestinal coccidiosis**
E. mitis	**intestine**	**Intestinal coccidiosis**
E. parecox	**Small intestine**	**Intestinal coccidiosis**

Eimeria species found in Cattle & buffalo

Species	Remarks
E. zuernii	Winter cocidiosis, Most common & pathogenic
Eimeria bovis	most common
E. bareillyi	found in Water buffalo
E. alabamensis	
E. bukidnonensis	Biggest species among *Eimeria* speceis of cattle & buffalo
E. canadensis	

Eimeria species found in sheep

Species	Remarks
E. ovina	**Most common & Pathogenic**
E. Intricata	**Largest coccidian species of sheep.**
E. granulosa	**Egg or urn- shaped oocyst**
E. ahsata	**Dome shaped micropylar cap**
E. crandalis	
E. gilruthi	**Found in abomasum of Sheep & goat**

Eimeria species found in goat

Species	Remarks
E. arloingi	**Most common**
E. caprina	
E. hirci	
E. ninakohlyakimovae	
E. gilruthi	**Found in abomasum of Sheep & goat**

Eimeria species

Species	Final host	Site in host
E. debliecki	**Pig**	**-do-**
E. leuckarti	**Equines**	**-do-**
E. trunctata	**Geese**	**Kidney**
E. Stiedae **(Leeuwenhoek observed first parasitic protozoa i.e. *Eimeria stiedae* from the gall bladder of rabbit)**	**Rabbit**	**Liver causes Hepatic coccidiosis**

Coccidian species of Dog & cat

Species	Final host
Isospora canis	**Dog**
Isospora ohioensis	**-do**
Neosopra caninum	**-do-**
Sarcocystis cruzi	**-do-**
Isospora felis	**Cat**
Isospora rivolata	**-do-**
Toxoplasma gondii	**Dog & cat**

- Location: An intracellular parasite found in the epithelial cells of the intestine .
- Infective stage – Sporulated oocyst
- Transmission:ingestion of sporulated oocyst along with food or water

Life Cycle

- Developmental stages
- Unsporulated oocyst
- Sporulated oocyst
- Sporozoites
- 1st generation schizont
- 1st generation merozoites
- 2nd generation schizont
- 2nd generation merozoites
- Microgamet and Macrogamet
- Zygote

Life-cycle

- inside the host :-

❖ Host gets infection by the ingestion of sporulated oocysts through feed and water.

- Three phases occurs inside the host :-

1. Excystation - Cyst walls rupture and release sporozoites enter in the alimentary canal in the presence of CO_2, bile and trypsin. Sporozoites penetrate the intestinal epithelial cells and form rounded trophozoites.

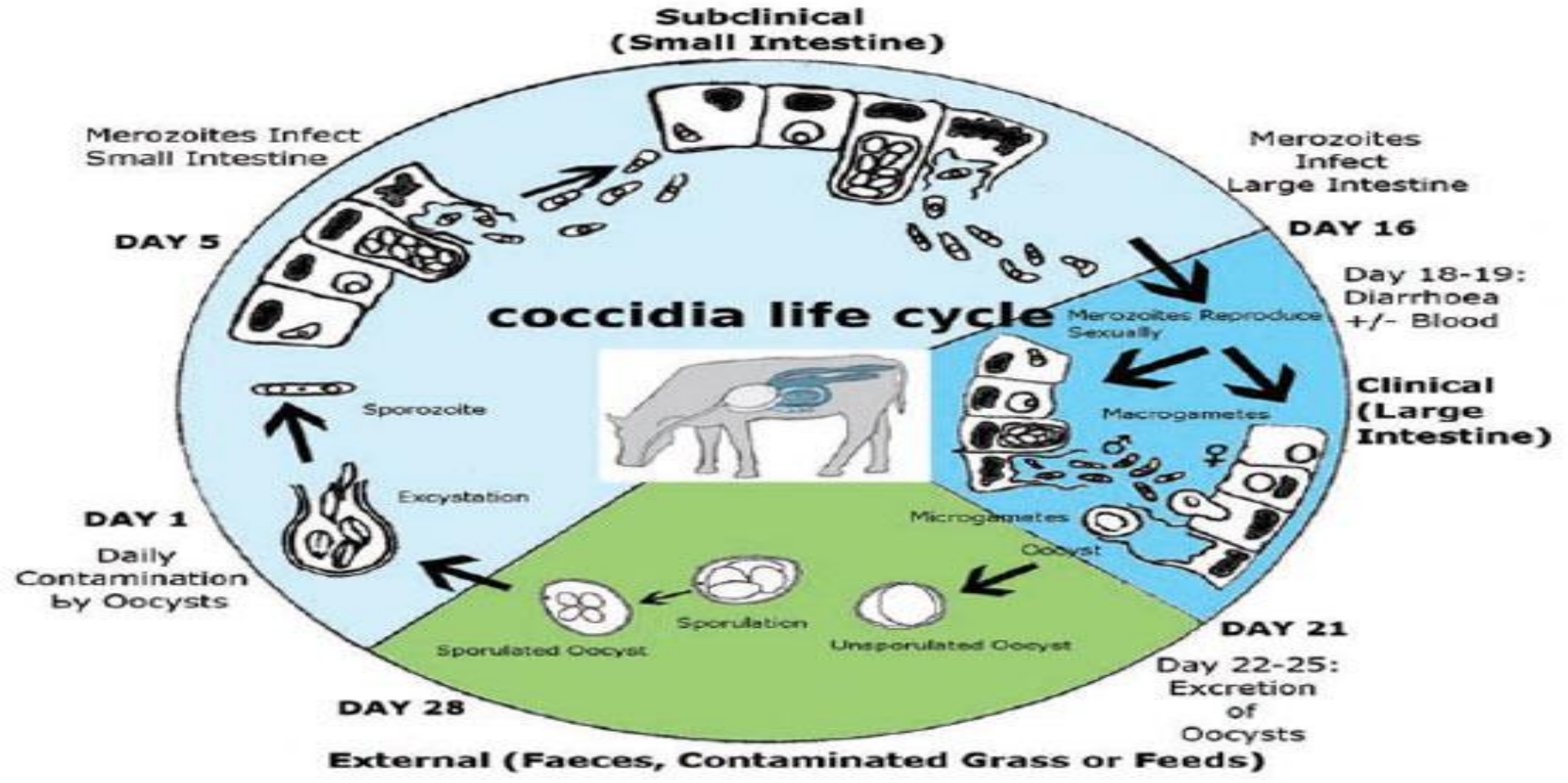
2. Schizogony: Trophozoites multiply by means of schizogony (multiple fission) and form schizonts containing numerous elongated merozoites.

- Schiozonts rupture and released merozoites invade neighbouring cells and continue 2nd generation schizogony.

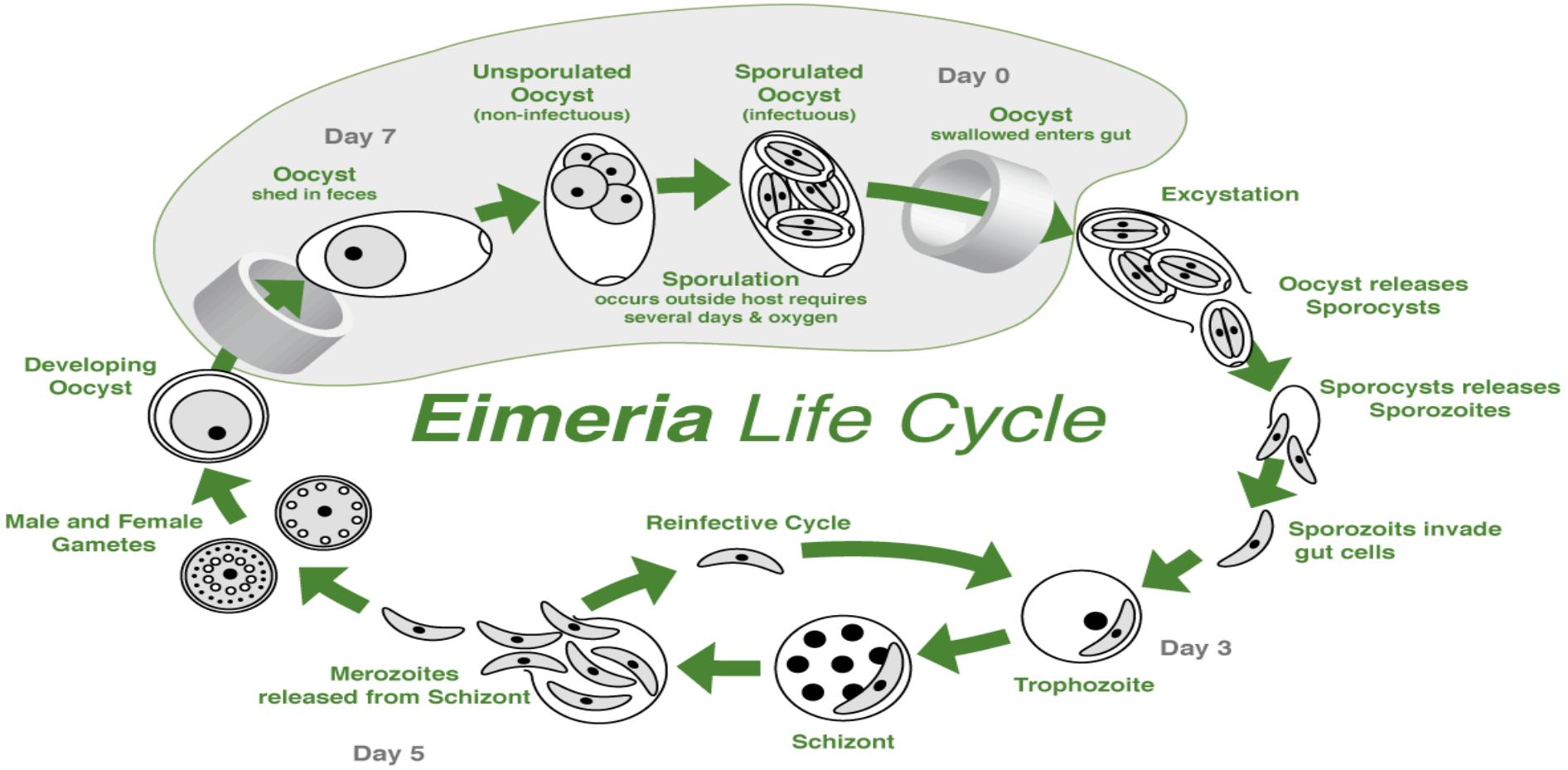
- Syngamy– Merozoites form male (microgametocyte) and female gametocytes (macrogametocytes).
- Microgametocytes and macrogametocytes form microgametes and macrogametes, respectively.
- Flagellated microgamete (motile) are released from the ruptured host cells and fertilized the macrogametes.
- After fertilization zygote is formed which transformed into unsporulated oocysts and passed out through the faces of the infected host.

- Outside the host in the environment :-
  - Unsporulated oocysts became sporulated outside the host in environment in the presence of O2, suitable temperature and moisture.
  - At the temperature of 29-30 degree Celsius with sufficient air and moisture, the sporulation occurs within 1-3 days.

Life-cycle of *Eimeria*



Life-cycle of *Eimeria*



- Coccidiosis is regarded ubiquitous in poultry management.
- It is considered as a man made disease since overcrowding and unhygienic conditions encourage it.
- Young animals /birds are most susceptible and adults act as carrier.
- coccidiosis is a self-limiting disease. It means that once the infection occurs, certain amount of immunity develops in the hosts and the hosts remain resistant to the parasite.

❑ Three types of coccidiosis occurs in poultry-

- Caecal coccidiosis
- Rectal coccidiosis
- Intestinal coccidiosis

Caecal coccidiosis

- **caused by *Eimeria tenella.***
  - **It occurs mostly in young birds of 3-7 weeks of age.**
  - **Petechial haemorrhage found in enlarged caecum on 4^{th} day after infection.**
  - **Lumen of caeca filled with consolidated and dark-brown to blackish caseous mass (caecal core) containing feaces, necrosed cellular debris and blood.**
  - **most pathological feature occurs in caecal coccidiosis only due to second generation schizonts and not by the gamonts.**

Genus: *Eimeria*

Haemorrhages in caecum





Genus: *Eimeria*

- Caecal core is characteristic lesions of caecal coccidiosis.
- Symptoms – dropping, stop feeding but may continue to drink water, bloody diarrhoea (red diarrhoea), anaemia and death.



Rectal Coccidiosis

- caused by *Eimeria brunetti*.
- Affected birds showed white fluidy droppings mixed with blood and mucus casts, severe dehydration, reduced body weight and lack of appetite.

- Intestinal coccidiosis- caused by *E. necatrix*, *E. acervulina*, *E. maxima* and *E. mivati*.
- Generally older birds are affected and chronic form is common.
- In *E. necatrix*, submucosal haemorrhage is found mainly in the middle part of the small intestine.

Genus: *Eimeria*

- Intestinal coccidiosis
  - The small intestine is markedly swollen, haemorrhage and is filled with clotted or unclotted blood.
  - Pin–point to pin-head sized greyish white spots are found in small intestine.

Symptoms-

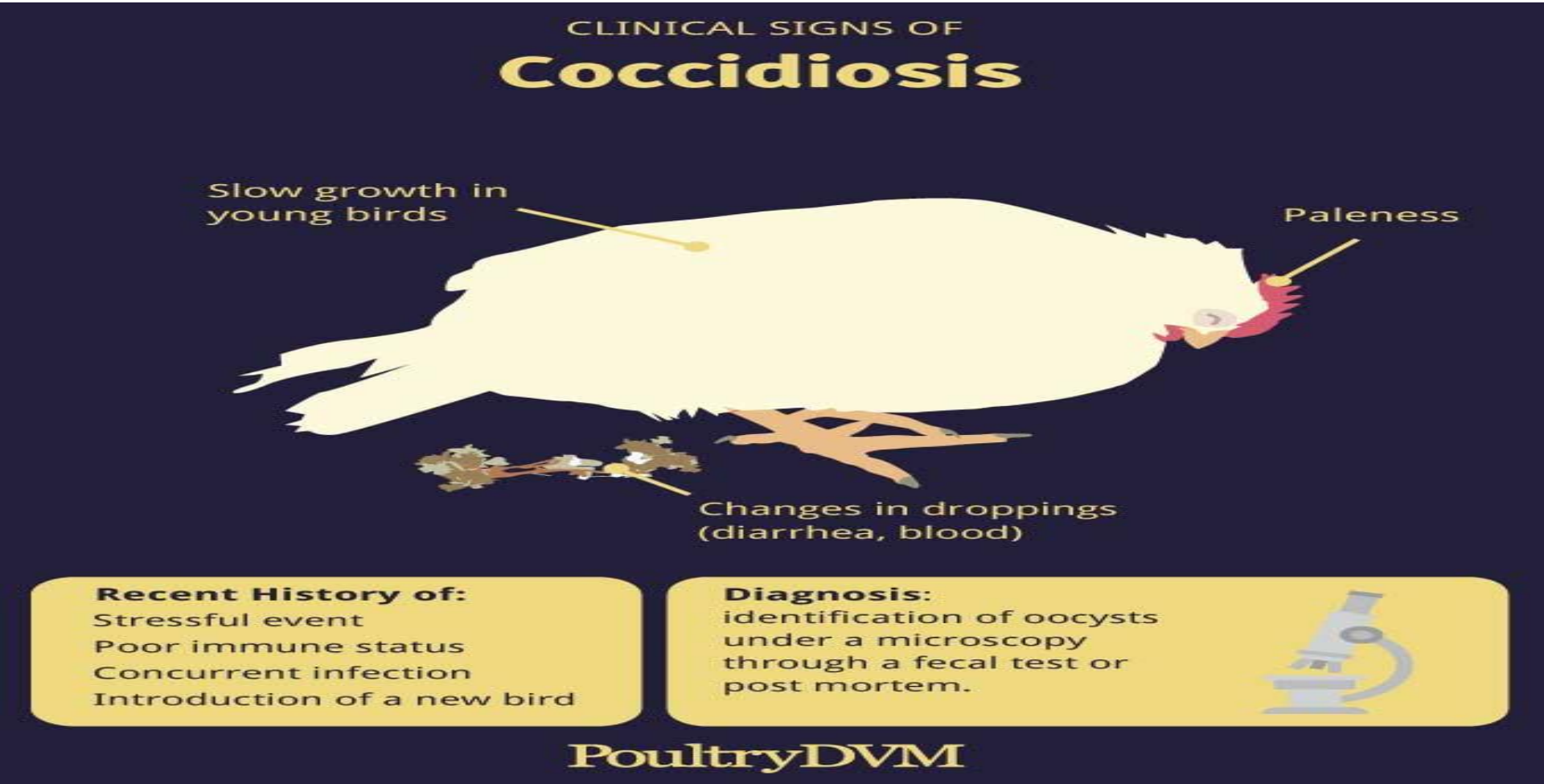
  - Watery diarrhoea with blood (*E. nectarix*), Chronic watery diarrhoea without blood (*E. acervulina*).

Glimpses of difference among *E. tenella, E, necatrix and E. brunetti*

E. tenella	*E. necatrix*	*E. brunetti*
1. Site : Caecum	1. Site : Asexual stages occurs in the small intestine.	1. Site : Small intestine, caecum and colon.
2. Causes caecal coccidiosis.	2. Causes small intestinal coccidiosis.	2. Causes rectal coccidiosis
3. Highly pathogenic .	3. Pathogenic	3. Pathogenic
4. Causes acute disease	4. Causes mostly chronic type of the disease.	4. Not specific
5. Affects mostly young birds.	5. Affects mostly the older birds.	5. Affects the young birds (4-9weeks)
6. It is the second generation schizont which is responsible for pathogenesis.	6. It is the gamont which is responsible for pathogenesis.	It is the gamont which is responsible for pathogenesis.

Species	Site of development	Pathogenicity	Disease type
E. necatrix	Jejunum, ileum, caeca	+++++	Hemorrhagic
E. tenella	Caeca	+++++	Hemorrhagic
E. brunetti	Caeca and rectum	++++	Hemorrhagic
E. maxima	Jejunum, ileum	+++	Malabsorptive
E. mitis	Ileum	++	Malabsorptive
E. acervulina	Duodenum, ileum	++	Malabsorptive
E. praecox	Duodenum, jejunum	+	Malabsorptive

Genus: Eimeria



Bovine Coccidiosis

- Two important organisms are considered to be the most pathogenic in bovines. Those are *E. zuernii and E. bovis*
- Winter coccidiosis - Caused by *Eimeria zuernii*

✓ Occurs in winter season.

✓ affect the caecum and colon

- Symptoms-
  - Foul smelling diarrhoea with or without blood, abdominal pain, soiled hind quarter, anorexia, unable to stand up etc.
  - Infected young calves die due to heavy loss of blood.

- **Diagnosis :**
  - **On the basis of symptoms (Bloody diarrhoea etc.).**
  - **Microscopic examination of faces revealed double walled unsporulated oocysts with nucleated mass.**
  - **P.M.** findings- Diagnosis of coccidiosis in chickens is best accomplished by post-mortem examination of a few affected birds because of major pathogenic effect usually occurs prior to oocysts shed in faeces.

Genus: *Eimeria*

Diagnosis :









Diagnosis

- 2.5 % Potassium dichromate solution are used for sporulation of unsporulated oocysts in Lab.

- $K_2Cr_2O_7$ solution prevents the bacteria from destroying the oocysts and also provides oxygen to the oocysts for their development.

Treatment

- **Sulphadiminine (@120-250 ppm), Amprolium (@ 62.5-125 ppm), Diclazuril (1-5 ppm), Toltazuril (25 ppm) and Semiduramicin are other anticoccidial drugs.**

- **Ionophorus antibiotics i.e. Monensin (@100-125 ppm), Lasalocid 9@100-125ppm) and Salinomycin (@50-70 ppm).**

Treatment	Example	Mechanism of Action
Ionophores	Lasalocid, Monensin, Narasinm Salinomycin, and Semduramicin	Disruption of ion gradient across the parasite cell membrane
Chemicals	Quinolone drugs (Decoquinate and nequinatem buquinolate) Pyridones (Meticlorpindol)	Inhibition of parasite mitochondrial respiration
	Sulphonamides	Inhibition of the folic acid pathway
	Amprolium Diclazuril,	Competitive inhibition of thiamine uptake
	Halofuginone, and Robenidine	Mode of action unknown
	Nicarbazin	Inhibition of the development of the first and second generations of the schizont stage of the parasites

- **Amprolium prevents cocidia from utilizing thiamine by blocking thiamine receptors and effective against first generation trophozoites and schizonts.**
- **Coccidiosis in poultry is man made disease and self limiting disease.**
- **Shuttle and rotation programme adopt in use of anticoccidial drugs in poultry to prevent drug resistance.**

Shuttle programs

- This method has a good chance of eliminating the parasites that demonstrated resistance to a single antimicrobial.
- A variation of the same principle consists on changing coccidiostats between flocks.
- most suitable drug is used for starter, while another drug is used for grower and finisher.

Eimeria species

Vaccination:

- ✓ **Coccivac , immunocox and Nobilis are live unattenuated vaccines.**
- ✓ **Livacox, and paracox are live attenuated vaccines. Attenuation is done by selection for precocious**

Genus: *Cryptosporidium*

- Hosts: Domestic animals and man
- Site / location The organisms are intercellular organism.
- Life cycle - More or less similar to other Eimeria sp.
- Disease - Diarrhoea is caused. In pig the condition becomes aggravated due to concurrent infection of Cryptosporidium and the rota virus.
- Diagnosis - Ziehl- Nielsen staining of the faeces is done.

- It is an intracellular extra cytoplasmic organism located in the notch of microvillus membrane of the digestive epithelium of gut wall. It also found in respiratory epithelium.
- Monoxenous parasite with direct life-cycle
- It has smallest oocyst (5-7.4 µm X 4.5 -5.6µm) among all coccidian.
- Ocysts are spherical to ovoid in shape and ocyst wall is bilayered, smooth and colourless.
- Sporogony occurs inside the host. Sporulated oocysts excreted though the faeces of the infected host. Each sporulated oocyst contains four naked sporozoites without sporocyst.

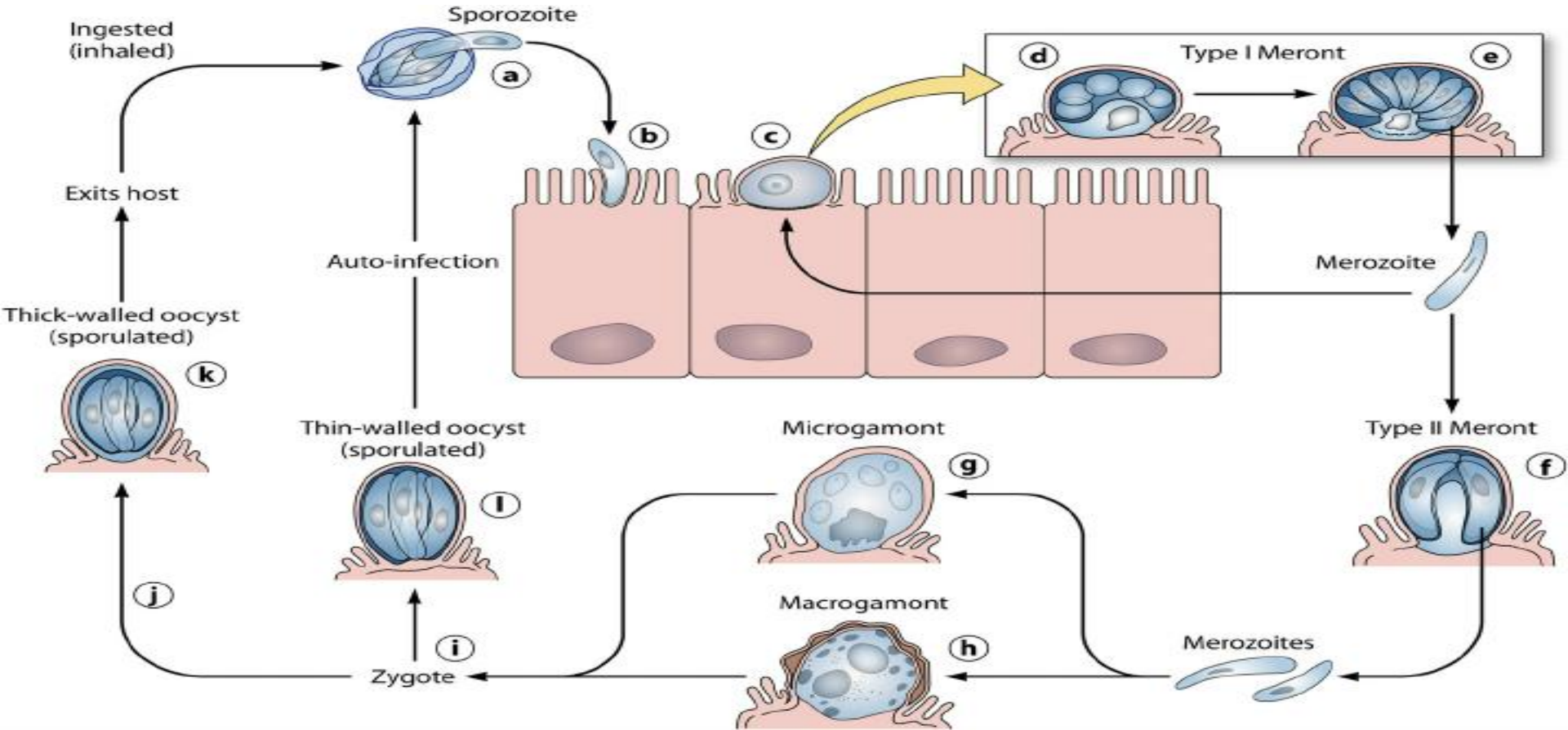
Cryptosporidium species

Species	Host
Cryptosporidium parvum	**Ruminants**
C. hominis	**man and monkey**
C. bovis	**cattle**
C. canis	**Dog**
C. suis	**Pig**
C. baileyi	**Birds**

- **Life- cycle : Direct**
- **Infective stage : thick walled sporulated oocysts.**
- **Transmission: Host gets infection through ingestion of sporulated oocysts through contaminated feed and water or** through inhalation (aerosol).
- Auto-infection occurs in *Cryptosporidium* because thin walled oocysts do not leave the host's intestine and initiate a new developmental cycle.

- Two types of oocysts are formed i.e. **thin walled and thick walled oocysts**.
- Thick walled oocysts pass out in the faeces of infected hosts whereas thin walled oocysts excyst in the gut and released sporozoites cause auto-infection.

Life- cycle of Cryptosporidium



- Generally young hosts like calves, kid, lamb, children etc. are most affected.
- It causes villus atrophy, degeneration, sloughing of enterocytes, crypt hypertrophy, inflammation of epithelial cells etc.
- Watery cholera like diarrhoea is the cardinal sign.
- Other symptoms are weight loss, abdominal discomfort, dehydration etc.
- Cryptosporidia is also regarded as potential cause of traveler's diarrhoea.

Diagnosis :

- **On the basis of symptoms like Watery cholera like diarrhoea in young hosts.**
- Diagnosis is made by observing very small sporulated oocysts in **Ziehl- Neelsen stained (Acid Fast Staining or Kinyoun acid fast** stain) faecal smears.

Phylum- Apicomplexa
Class – Sporozoea

- Sub-class :- Coccidia
- Order - Eucoccidiida
- Family - Eimeriidae, Cryptosporididae, Sarcocystidae

- FAMILY -EIMERIIDAE
- History / Discovery: Eimeria was first detected by A. Leeuwenhoek (1674). Dobell gave the name in the year 1922
- Cocccidian parasites are intracellular (few exceptions) apicomplexan protozoa of intestinal epithelial cells chiefly of vertebrates.

Different Genera of Coccidia

Eimeria	*Isospora*	*Neospora*	*Cryptosporidium*	*Tyzzeria*	*Wenyonella*
Sporulated oocyst contains four sporocysts. Each sporocyst contains two sporozoites.	Sporulated oocyst contains two sporocysts. Each sporocyst contains four sporozoites.	Sporulated oocyst contains two sporocysts. Each sporocyst contains four sporozoites.	Sporulated oocyst does not contain sporocysts; only four sporozoites are present in oocysts.	Sporulated oocyst does not contain sporocysts; only eight sporozoites are present in the oocysts.	Sporulated oocyst contains four sporocysts. Each sporocyst contains four sporozoites.

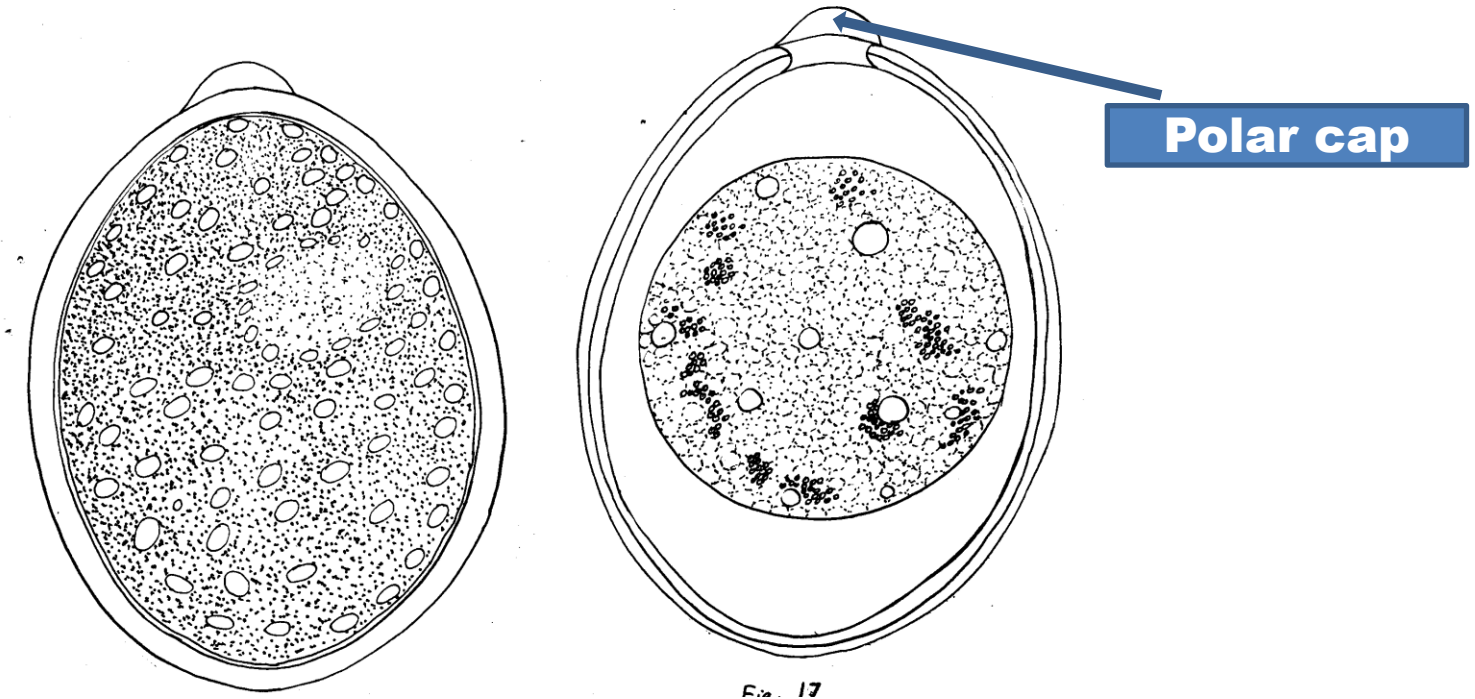
Genus- *Eimeria*

- Organisms commonly called coccidia.
- Intracellular parasite found in the epithelial cells of intestine of vertebrates in which both asexual and sexual reproduction takes place.
- Highly host specific as well as organ/location specific parasite.
- Direct life-cycle.
- Locomotion by gliding.

- Unsporulated oocysts comes out of the infected host through faces .
- Sporulation of unsporulated oocyst occurs outside the host in environment.
- Sporulated oocyst is the infective stage for the host.

Unsporulated oocysts

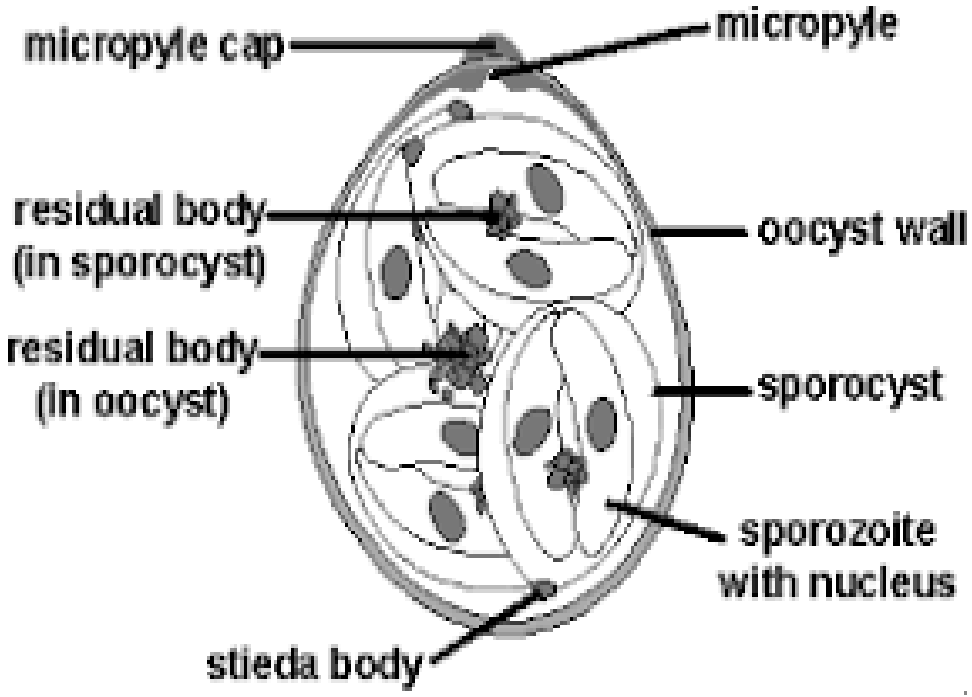
- Usually spherical, sub-spherical, ellipsoidal and oval shaped.
- Usually bilayered, transparent and clearly visible.
- A small pore called micropyle may be present at narrower end which is often covered by a polar cap or micropylar cap.
- A nucleated mass (sporont) is found mostly at the center.


Polar cap

Sporulated oocysts

- **Sporogony occurs outside the host**.
- Sporulated oocysts are the infective stages of the parasites.
- Time taken for sporulation can also helped as an aid to identification of species.
- Sporulated oocyst contains different number of banana–shaped sporozoites, sporocyst residium and stieda body.
- Each sporulated oocyst contains four sporocysts and each sporocyst contains two sporozoites.

Genus- *Eimeria*



Eimeria species found in poultry

Species	Site in host	Disease
Eimeria tenella	**Caecum**	**Caecal coccidiosis**
Eimeria necatrix	**Small intestine**	**Intestinal coccidiosis**
Eimeria brunetti	**Rectum**	**Rectal coccidiosis**
E. acervulina	**Small intestine**	**Intestinal coccidiosis**
E. maxima	**Small intestine**	**Intestinal coccidiosis**
E. mitis	**intestine**	**Intestinal coccidiosis**
E. parecox	**Small intestine**	**Intestinal coccidiosis**

Eimeria species found in Cattle & buffalo

Species	Remarks
E. zuernii	Winter cocidiosis, Most common & pathogenic
Eimeria bovis	most common
E. bareillyi	found in Water buffalo
E. alabamensis	
E. bukidnonensis	Biggest species among *Eimeria* speceis of cattle & buffalo
E. canadensis	

Eimeria species found in sheep

Species	Remarks
E. ovina	**Most common & Pathogenic**
E. Intricata	**Largest coccidian species of sheep.**
E. granulosa	**Egg or urn- shaped oocyst**
E. ahsata	**Dome shaped micropylar cap**
E. crandalis	
E. gilruthi	**Found in abomasum of Sheep & goat**

Eimeria species found in goat

Species	Remarks
E. arloingi	**Most common**
E. caprina	
E. hirci	
E. ninakohlyakimovae	
E. gilruthi	**Found in abomasum of Sheep & goat**

Eimeria species

Species	Final host	Site in host
E. debliecki	**Pig**	**-do-**
E. leuckarti	**Equines**	**-do-**
E. trunctata	**Geese**	**Kidney**
E. Stiedae **(Leeuwenhoek observed first parasitic protozoa i.e. *Eimeria stiedae* from the gall bladder of rabbit)**	**Rabbit**	**Liver causes Hepatic coccidiosis**

Coccidian species of Dog & cat

Species	Final host
Isospora canis	**Dog**
Isospora ohioensis	**-do**
Neosopra caninum	**-do-**
Sarcocystis cruzi	**-do-**
Isospora felis	**Cat**
Isospora rivolata	**-do-**
Toxoplasma gondii	**Dog & cat**

- Location: An intracellular parasite found in the epithelial cells of the intestine .
- Infective stage – Sporulated oocyst
- Transmission:ingestion of sporulated oocyst along with food or water

Life Cycle

- Developmental stages
- Unsporulated oocyst
- Sporulated oocyst
- Sporozoites
- 1st generation schizont
- 1st generation merozoites
- 2nd generation schizont
- 2nd generation merozoites
- Microgamete and Macrogamete
- Zygote

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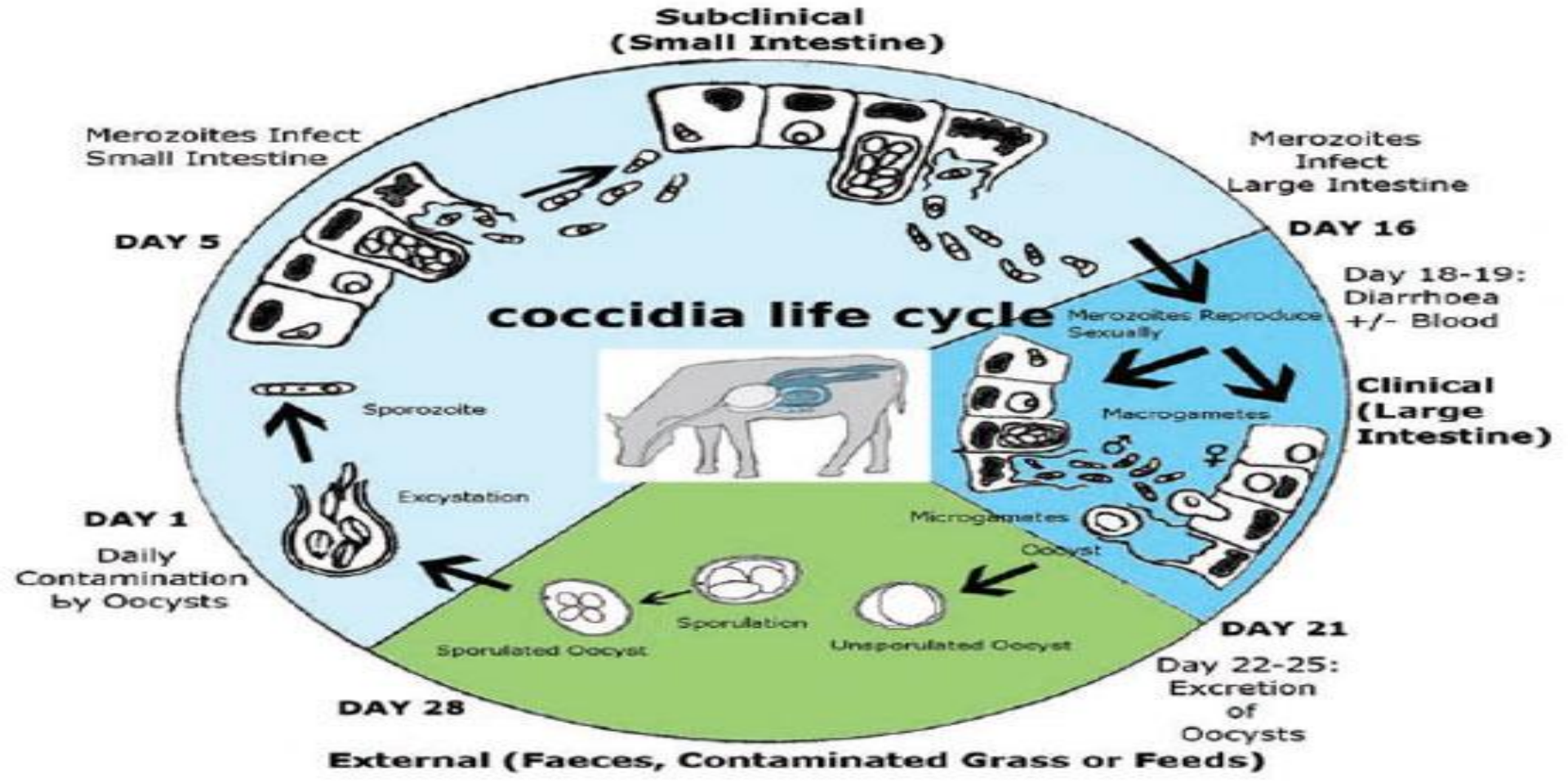
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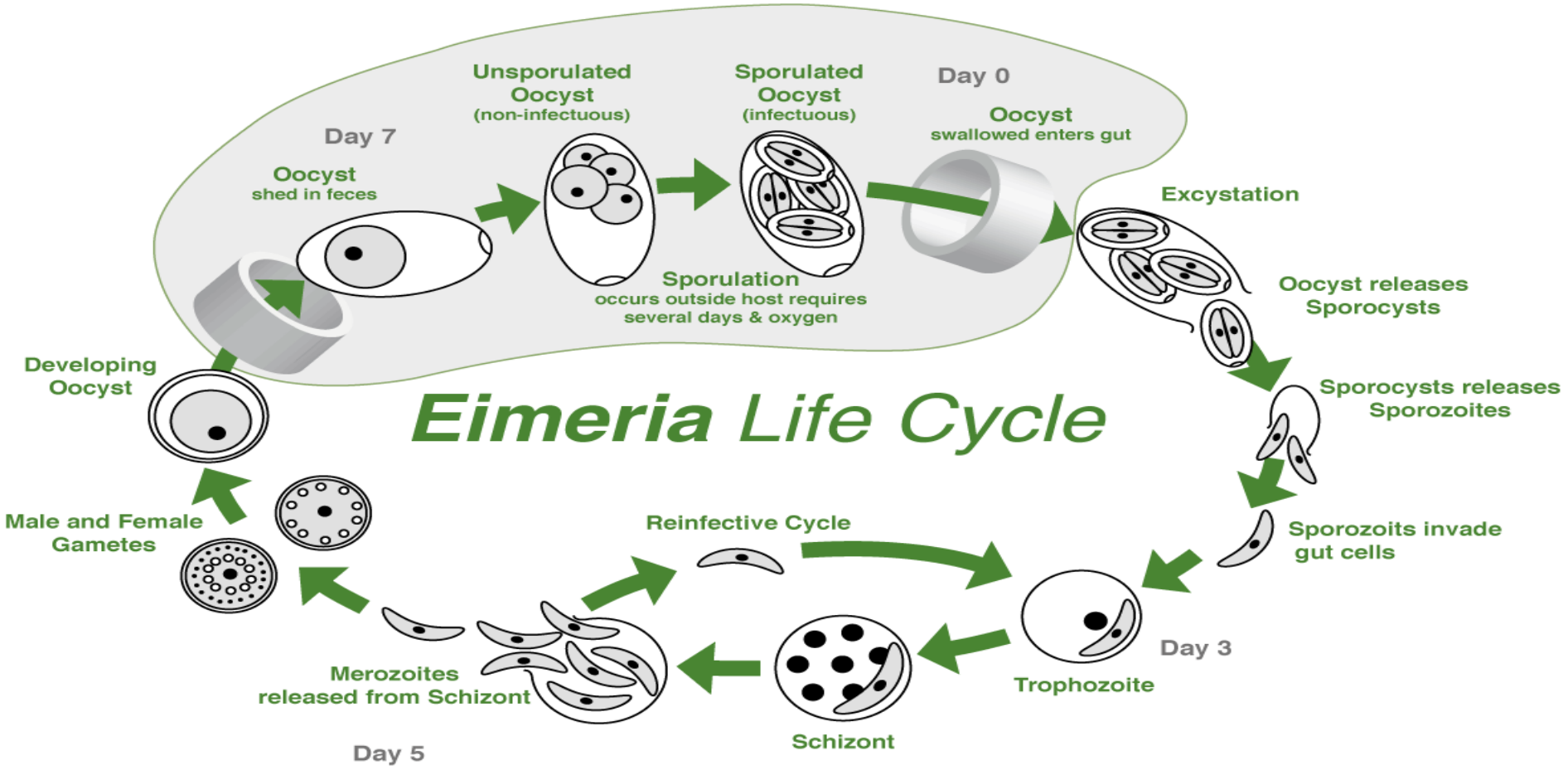
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- Rectal coccidiosis
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Caecal coccidiosis

- **caused by *Eimeria tenella.***
  - **It occurs mostly in young birds of 3-7 weeks of age.**
  - **Petechial haemorrhage found in enlarged caecum on 4^{th} day after infection.**
  - **Lumen of caeca filled with consolidated and dark-brown to blackish caseous mass (caecal core) containing feaces, necrosed cellular debris and blood.**
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Genus: *Eimeria*

Haemorrhages in caecum





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- Caecal core is characteristic lesions of caecal coccidiosis.
- Symptoms – dropping, stop feeding but may continue to drink water, bloody diarrhoea (red diarrhoea), anaemia and death.



Rectal Coccidiosis

- caused by *Eimeria brunetti*.
- Affected birds showed white fluidy droppings mixed with blood and mucus casts, severe dehydration, reduced body weight and lack of appetite.

- Intestinal coccidiosis- caused by *E. necatrix*, *E. acervulina*, *E. maxima* and *E. mivati*.
- Generally older birds are affected and chronic form is common.
- In *E. necatrix*, submucosal haemorrhage is found mainly in the middle part of the small intestine.

Genus: *Eimeria*

- Intestinal coccidiosis
  - The small intestine is markedly swollen, haemorrhage and is filled with clotted or unclotted blood.
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Symptoms-

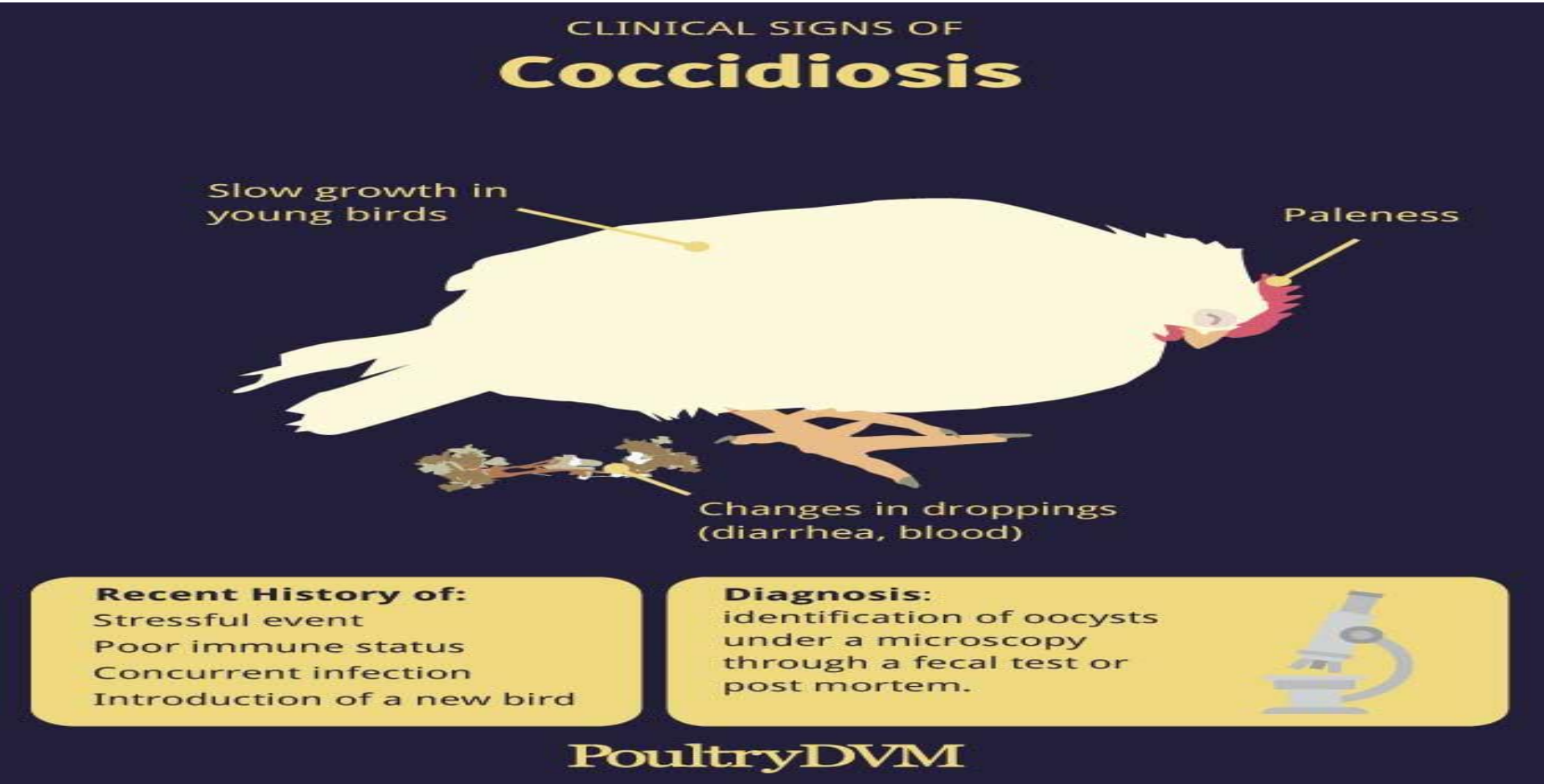
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Genus: Eimeria



Bovine Coccidiosis

- Two important organisms are considered to be the most pathogenic in bovines. Those are *E. zuernii and E. bovis*
- Winter coccidiosis - Caused by *Eimeria zuernii*

✓ Occurs in winter season.

✓ affect the caecum and colon

- Symptoms-
  - Foul smelling diarrhoea with or without blood, abdominal pain, soiled hind quarter, anorexia, unable to stand up etc.
  - Infected young calves die due to heavy loss of blood.

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- Life cycle - More or less similar to other Eimeria sp.
- Disease - Diarrhoea is caused. In pig the condition becomes aggravated due to concurrent infection of Cryptosporidium and the rota virus.
- Diagnosis - Ziehl- Nielsen staining of the faeces is done.

- It is an intracellular extra cytoplasmic organism located in the notch of microvillus membrane of the digestive epithelium of gut wall. It also found in respiratory epithelium.
- Monoxenous parasite with direct life-cycle
- It has smallest oocyst (5-7.4 µm X 4.5 -5.6µm) among all coccidian.
- Ocysts are spherical to ovoid in shape and ocyst wall is bilayered, smooth and colourless.
- Sporogony occurs inside the host. Sporulated oocysts excreted though the faeces of the infected host. Each sporulated oocyst contains four naked sporozoites without sporocyst.

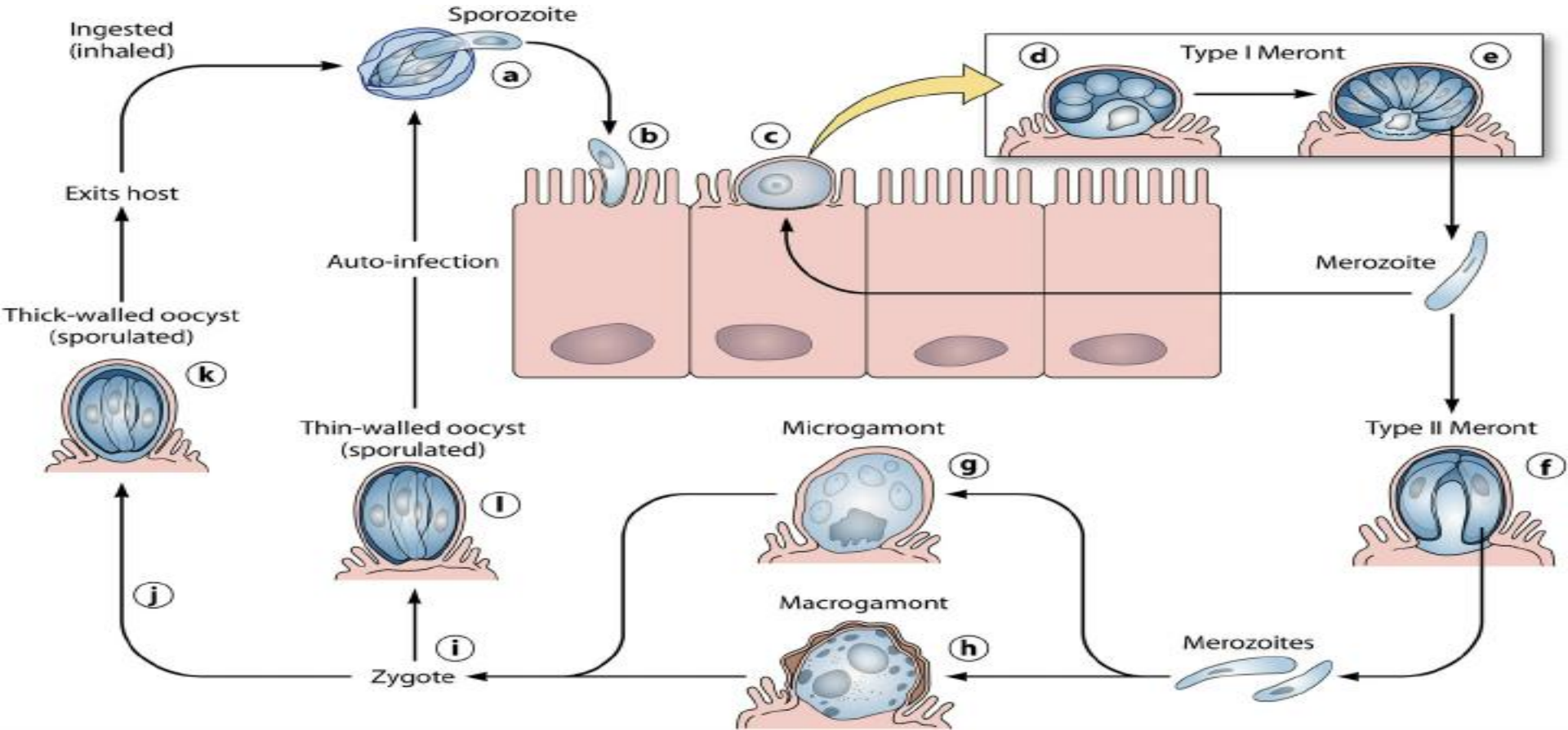
Cryptosporidium species

Species	Host
Cryptosporidium parvum	**Ruminants**
C. hominis	**man and monkey**
C. bovis	**cattle**
C. canis	**Dog**
C. suis	**Pig**
C. baileyi	**Birds**

- **Life- cycle : Direct**
- **Infective stage : thick walled sporulated oocysts.**
- **Transmission: Host gets infection through ingestion of sporulated oocysts through contaminated feed and water or** through inhalation (aerosol).
- Auto-infection occurs in *Cryptosporidium* because thin walled oocysts do not leave the host's intestine and initiate a new developmental cycle.

- Two types of oocysts are formed i.e. **thin walled and thick walled oocysts**.
- Thick walled oocysts pass out in the faeces of infected hosts whereas thin walled oocysts excyst in the gut and released sporozoites cause auto-infection.

Life- cycle of Cryptosporidium



- Generally young hosts like calves, kid, lamb, children etc. are most affected.
- It causes villus atrophy, degeneration, sloughing of enterocytes, crypt hypertrophy, inflammation of epithelial cells etc.
- Watery cholera like diarrhoea is the cardinal sign.
- Other symptoms are weight loss, abdominal discomfort, dehydration etc.
- Cryptosporidia is also regarded as potential cause of traveler's diarrhoea.

Diagnosis :

- **On the basis of symptoms like Watery cholera like diarrhoea in young hosts.**
- Diagnosis is made by observing very small sporulated oocysts in **Ziehl- Neelsen stained (Acid Fast Staining or Kinyoun acid fast** stain) faecal smears.

Family: Sarcocystidae

- Members are tissue cyst forming coccidia.
- Heterogeneous parasites.
- Sexual stage found in final host and asexual stage is found in intermediate hosts.
- Genus: *Toxoplasma*, *Sarcocystis*, *Neospora*, *Besnoitia* and *Hamondia*.

- Family - Sarcocystidae
- Genus - Toxoplasma
- GENUS - Toxoplasma
- Species - *Toxoplasma gondii*
- These coccidian parasites are intracellular apicomplexan protozoa of intestinal epithelial cells of vertebrates.
- It has zoonotic importance and it has been considered as one of the most important parasites in human beings and in animals as well.

- Morphology:-
  - It is an obligate intracellular intestinal zoonotic coccidian parasite.
  - *Toxoplasma* (Toxon = arc; plasma = form) organisms are arc-shaped.
  - Nicolle and Manceaux discovered *Toxoplasma gondii* from a North African rodent (*Ctenodactylus gondi*).
  - Hence, the organism named as *Toxoplasma gondii*

- **Definitive hosts :** Felines (Domestic cat is most important) in which enteroepithelial cycle occur.

- **Intermediate hosts: -** Any mammal (Sheep, goat, cattle, pig & dog), birds and man act as intermediate host in which extraintestinal (muscle, liver, lung , brain etc.) cycle found.

- Unsporulated oocyst: Excreted though the faeces of the infected final host (cat).
- Sporogony occurs outside the host and form sporulated oocyst in environment.

- Three infective stages of Toxoplasma gondii -
  - Sporulated oocyst
  - Tachyzoites
  - Bradyzoites.

Sporulated oocyst

- Each sporulated oocyst contains two sporocysts and each sporocyst contains four sporozoites.





Tachyzoites

- Found in extraintestinal tissues (muscle, liver, lung, brain etc.) of intermediate host.

- Tachyzoites are rapidly dividing form and formed in acute stage of infection.

- It is crescent shaped, centrally placed nucleus with Pseudocyst i.e. no definite parasitic membrane surrounding the group of tachyzoites.

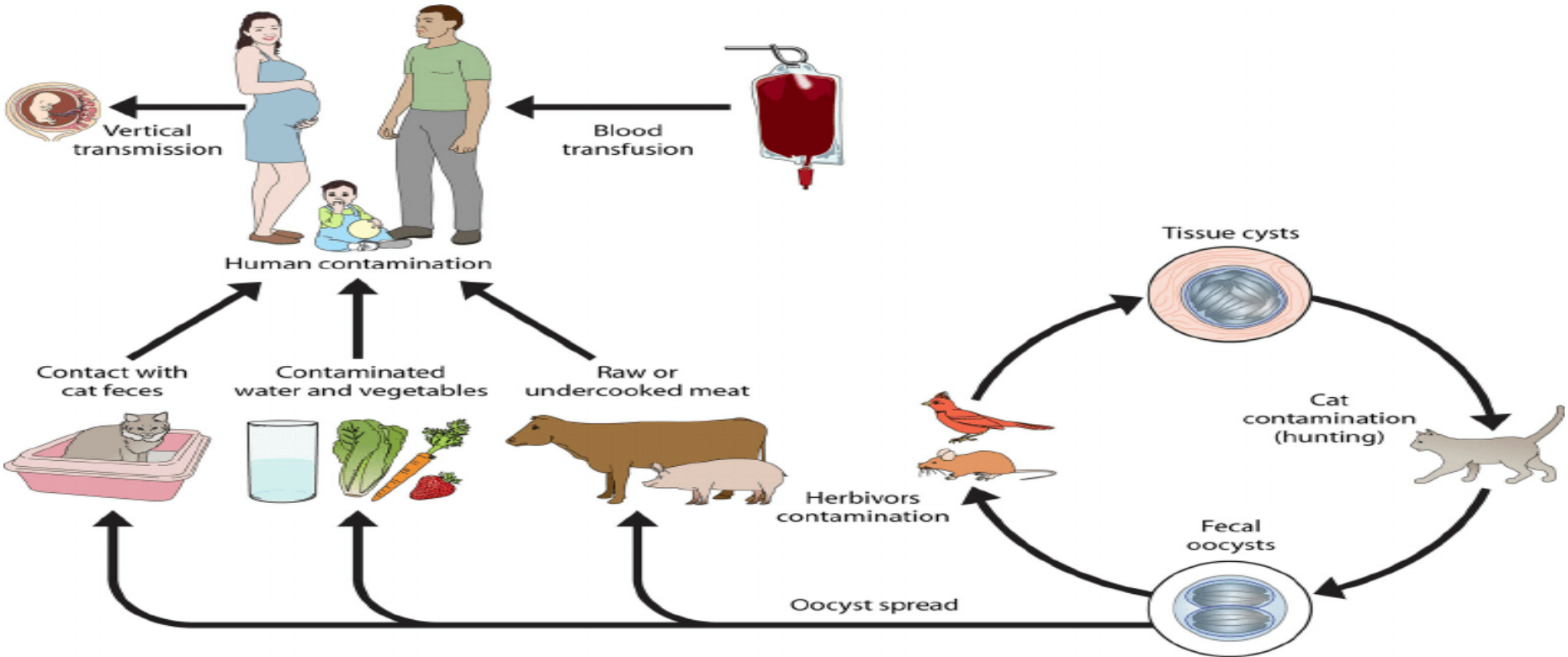
Bradyzoites

- **Bradyzoites** are slow dividing form and found in chronic phase of disease.
- Lancet shaped bradyzoites packed in a cyst and usually consists of thousands of bradyzoites per cyst.
- **Schizonts (contain 32 merozoites) and gamonts stages occur in the small intestine of intermediate host.**

Mode of transmission -

- Ingestion of sporulated oocysts along with feed and water.
- Ingestion of tissues/meat containing tachyzoites and bradyzoites.
- Congenital transmission.

Transmission of *T. gondii*



Development inside final host

I. Entero-epithelial cycle occurs.

II. Final host get infection by the ingestion of any of the three infective stages (Tachyzoites, bradyzoites or sporulated oocysts).

III. Enodyogeny and endoploygeny types asexual reproduction found.

Development inside final host

- After ingestion of tissue cysts by the final host (cat), cyst wall is dissolved by proteolytic enzymes in the stomach and small intestine and released bradyzoites.
- Bradyzoites penetrate epithelial cells of intestine and by the endodyogeny and endopolygeny reproduction form schizonts.
- Schizonts rupture and release merozoites which form gametes.
- Microgametes and macrogametes fused to form zygote which develop into unsporulated oocyst.
- Unsporulated oocysts passed with the faces of infected final host.

Development inside the intermediate hosts

- Intermediate hosts get infection by the ingestion of sporulated oocysts.
- Ingestion of infected meat containing tachyzoites or bradyzoites or congenitally through placenta.
- After infection of sporulated oocyst, oocyst wall ruptures in the intestinal and released sporozoites.
- Sporozoites penetrate the intestinal epithelial and associated lymph nodes and multiply to form tachyzoites.
- Tachyzoite through lymph and blood spread in body organs and encysted in the brain, skeletal and cardiac muscles and liver and form bradyzoites.

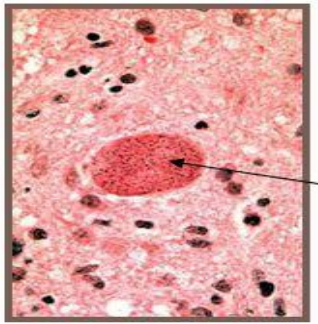
- Brdayzoites are microscopic and survive in tissues as long as the host lives.
- After ingestion of meat containing bradyzoites, cyst wall of bradyzoites ruptured by the action of proteolytic enzymes and released bradyzoites.
- Bradyzoites transforms into tachyzoites in the host cells. Tachyzoites multiply repeatedly and ultimately encyst in tissue.
- Cycle completed when tissue cysts are ingested by cat.

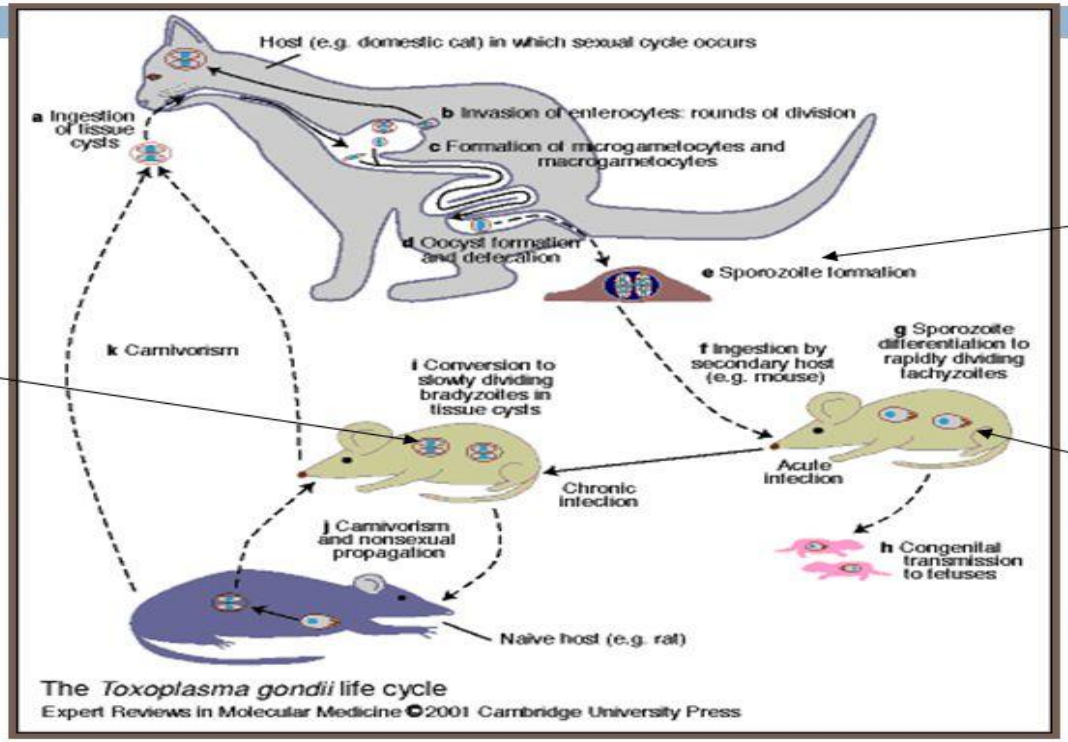
- Congenital or transplacental transmission inside the intermediate hosts –
  - Occurs when a previously non-infected host becomes infected during pregnancy.
  - It occurs at any stage of gestation but foetus is severely affected when dams becomes infected during first half of gestation.

Life-cycle of T. gondii

Toxoplasma gondii – Life cycle

Bradyzoite

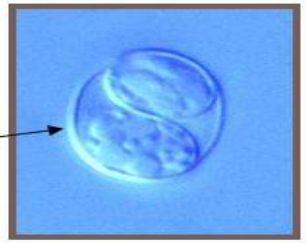




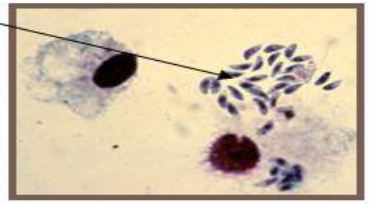
The *Toxoplasma gondii* life cycle

Expert Reviews in Molecular Medicine ©2001 Cambridge University Press

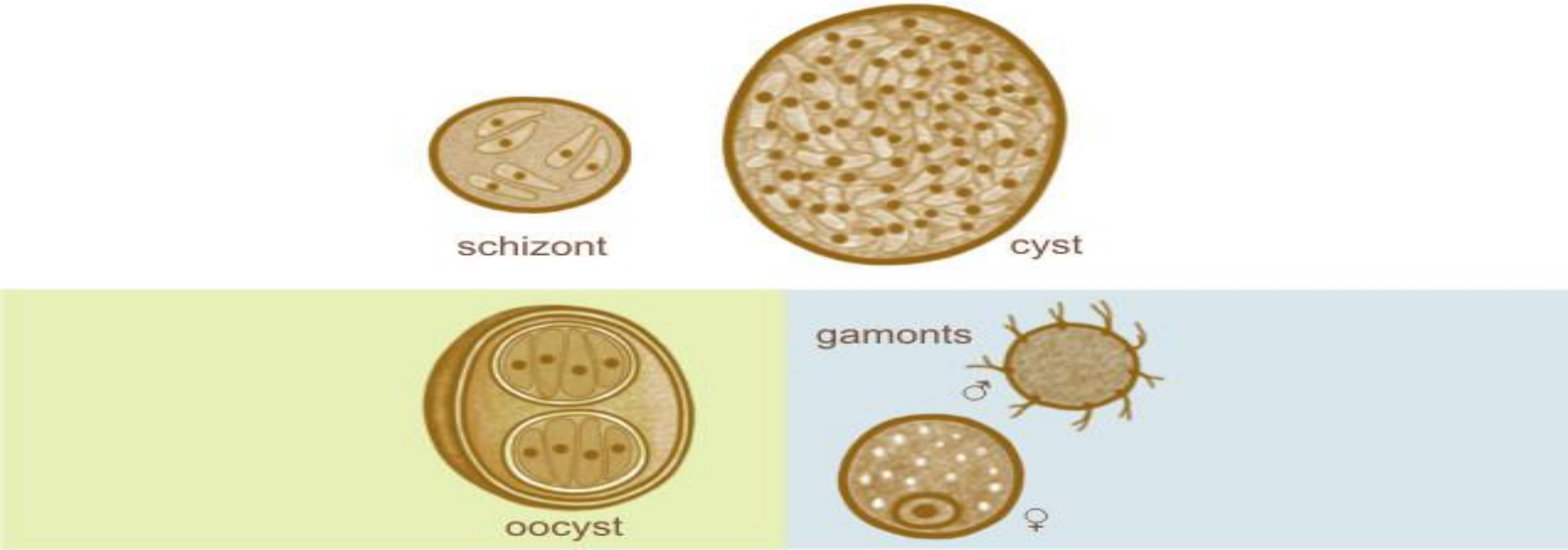
Oocyst



Tachyzoite



Different stages of *T. gondii*



- Majority of infection is asymptomatic both in definitive and intermediate hosts.
- Sheep and goat – Abortion, still birth and mummification occurs due to encephalomyelitis and placental necrosis.
- Pig - Weakness, cough, nasal discharge, stillbirth, abortion, pneumonia, ascites, lymphadenitis , enteritis etc.
- Dog- Intermittent fever, respiratory distress, diarrhoea, vomition and nervous disorder.
- Cattle- most resistant.
- Cat- Anorexia, pneumonia, icterus, fever, diarrhoea etc.

Pathogenesis and Symptoms

- **Man- Infection is usually asymptomatic in immunocompetent adult but cause disease and death in immunocompromised patients and in congenitally infected children. Congenital** infection occurs only when a woman is exposing to infection for the first time during pregnancy.

- Tachyzoites crossing the placenta and may cause abortion, still birth and severely affected infants show retinochorditis, cerebral necrosis, hepatosplenomegaly, convulsion and hydrocephalus.

Diagnosis

- In final host:- Microscopic examination of faces revealed double walled unsporulated oocysts with nucleated mass.

- In intermediate host:- On the basis of symptoms (abortion, still births , mummified foetus etc.).

- Animal inoculation test- Cerebral spinal fluid, secretion, tissue fluids etc. are of suspected animals inoculated intraperitoneally in mice. Tachyzoites will be found in the peritoneal fluids or impression smear of mesenteric lymph nodes, liver, spleen etc. 7-14 days after infection.

- **Sabin Feldman dye test (Dye test)**: detect specific antibodies in the serum of toxoplasma infection (living) suspected animals or man. Alkaline methylene blue, a complement–like serum factor (probably properdin) and antibody are used in this test.
- **TORCH test** (TORCH panel) is also used to detect congenital Toxoplasmosis.
- Other serological test like CFT, IFAT, ELISA etc.
- Molecular test like PCR

- **Treatment:**
  - **Drugs used in treatment are Sulphadiazine, Pyrimethamine and Clindamycin.**

- **Control-**
  - **Proper washing of hands before meal.**
  - **Reduction of stray cat population raw offals should not be consumed by the cats.**
  - **Pregnant woman should not come in contact with cat.**
  - **Toxovac** and **Ovillis Toxovac** are live vaccine contains tachyzoites from an incomplete strain S-48 of *Toxoplasma gondii* has been developed to protect ewes.

Sarcocystis spp.

- Name derived from the Greek words Sarkos means flesh and Kystis means cyst. It is a tissue cyst forming coccidia.
- Sexual stages found only in definitive hosts which is carnivores and asexual stages occur only in the intermediate host.
- Definitive (Final) host:- Usually Dog, cat and Man
- Intermediate host :- Cattle, buffalo, sheep, goat, pig, horse
- Location – Found in small intestine of final host and muscle of intermediate hosts

Sarcocytsis species

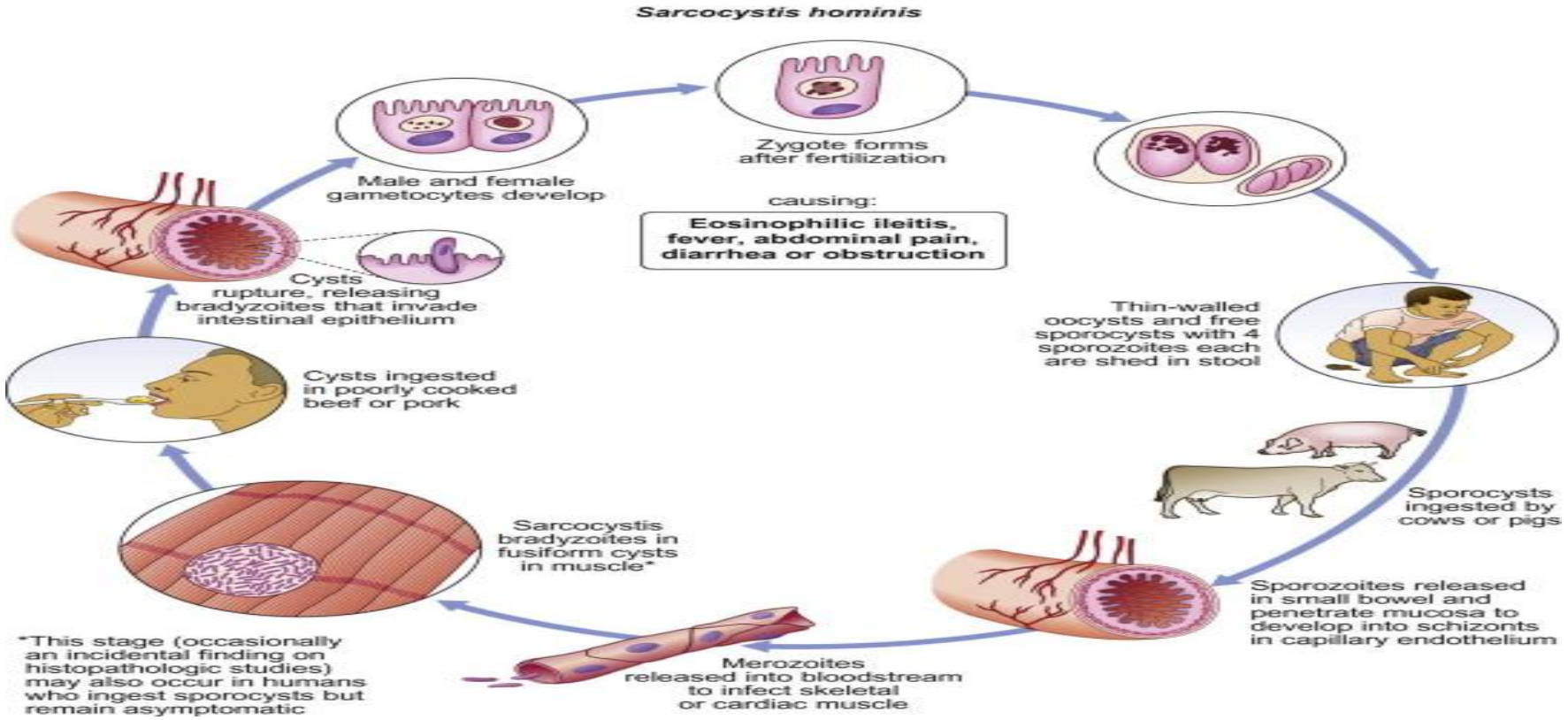
Species	Definitive host	Final host
Sarcocystis cruzi	cattle	Dog
S. hominis	cattle	man
S. tenella	Sheep	Dog
S. gigantiea	Sheep	Dog
S. capracanis	Goat	Dog
S. hircicanis	Goat	Dog
S. fusiformis	Water buffalo	Dog
S. miescheriana	Pig	Dog

Sarcocytsis species

Species	Definitive host	Final host
S. suihominis	**Pig**	**Man**
S. porcifelis	**Pig**	**Cat**
S. neurona	**Horse**	**Opposum**
S. gigantiea	**Sheep**	**Dog**
S. capracanis	**Goat**	**Dog**
S. fusiformis	**Water buffalo**	**Dog**
S. miescheriana	**Pig**	**Dog**

- Each sporulated oocyst contains two sporocysts and each sporocyst contains four sporozoites.
- Sporulation occurs inside the host.
- Different stages of Development:-
  - Sarcocyst- Terminal asexual stages found encysted primarily in the striated muscles of intermediate hosts.
  - Metrocysts (mother cells)- Immature sarcocysts contain globular parasites called metrocysts.
  - Bradyzoites (zoites)- Metrocysts form banana- shaped bradyzoites by endodyogeny type of asexual repooroducxtion.

Life-cycle of *Sarcoystis* sp.



Infective stages of *Sarcocystis* spp.

Infective stage for definitive hosts –

Cyst containing bradyzoites.

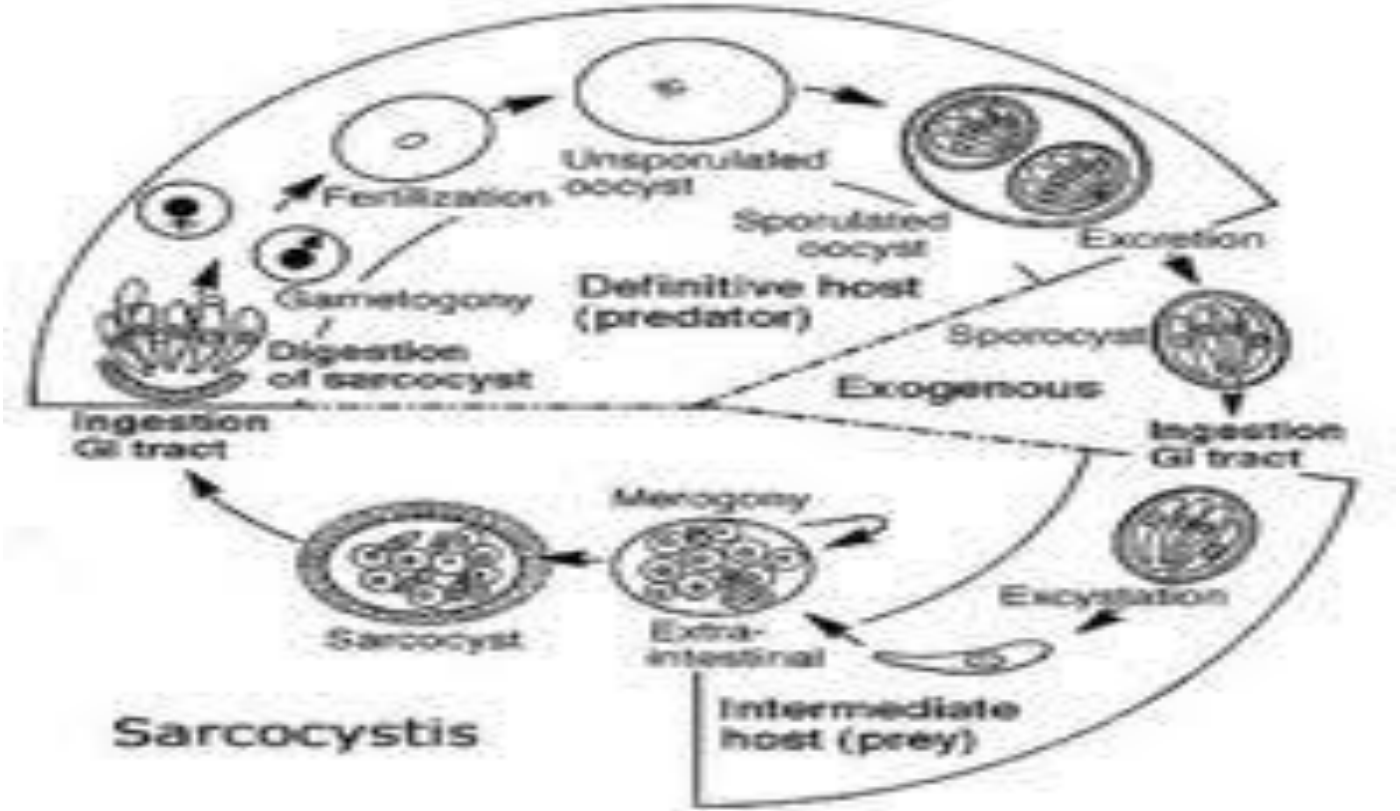
Infective stage for Intermediate host-

Sporulated oocysts.

Transmission & Life cycle

- Final hosts get infection by the ingestion of sarcocysts or bradyzoites containing meat.
- Intermediate hosts get infection by the ingestion of sporulated oocysts containing feed and water.
- Final hosts get infection by the ingestion of sracocyst or bradyzoityes containing meat. of infected intermediate host.
- Bradyzoites are liberated from the sarcocysts after digestion by the G.I. juices.
- Bradyzoites enter lamina propia of villi and small intestine and form micro - and macrogamonts.

Life-cycle of *Sarcocystis* spp.



- Fusion of micro and macrogamets results formation of oocyst which sporulated in the intestine and free sporocyst are passed with faces of the infected hosts.
- Intermediate host get infection by the ingestion of sporulated oocysts containing feed and water.
- **After excystation, sporozoites are released and enter capillaries of the different organs.**
- **Sporozoites after schizogony process form merozoites which transform into sarcocysts in the muscles cells of tongue, heart, diaphgram etc.**

Pathogenesis & Symptoms

- *Sarcocystis cruzi* is the **most pathogenic species** in cattle.
- anorexia, fever, marked loss of hair at the end of the tail often in cattle, submandibular oedema, exophthalmia, haemorrhages on the serous surface of viscera, neurolical signs, Lymphadenopathy enlargement of lymph nodes, cysts in myocardium, oesophagus, tongue and masseter muscles and abortion in breeding stock.
  - It caused disease in cattle **is known as Dalmeny disease in Canada, USA and UK.**

- **Sarcocystis tenella is most pathogenic species of sheep which caused abortion, myositis, encephalomyelitis and dog sitting posture in lamb.**
- **Sarcocystis neurona causes a serious neurological disease of horses called Equine Protozoal Myeloencephalitis (EPM) which leads ataxia, muscular weakness etc.**

Family: Plasmodiidae

- **Heteroxenous parasites.**
- **Schizogony occurs in vertebrates and gametogony and sporogony in invertebrates.**
- **Pigment (haemozoin) is usually formed in the host cell except *Leucocytozoon* spp.**
- **Genus : *Haemoproteus*, *Leucocytozoon* and *Plasmodium***

Plasmodium

- Members are commonly called malarial organism of birds, mammals and man.
- Culicine mosquitoes act as vector of bird malaria whereas Anopheline mosquitoes act as vector of mammalian and human malaria

Plasmodium species found in birds & animal

Species	Definitive host	Vector
Plasmodium gallinaceum	**Chicken**	***Culex, Aedes*** **spp.**
Plasmodium relictum	**pigeon**	***Culex, Aedes*** **spp.**
P. bubalis	**Buffalo**	**Unknown**

Zoonotic species of *Plasmodium*

Species	Definitive host	Vector
P. cynomolgi	Monkey and man	*Anopheles* spp.
P. knowlesi	Monkey and man	*Anopheles* spp.
P. simium	Monkey and man	*Anopheles* spp.

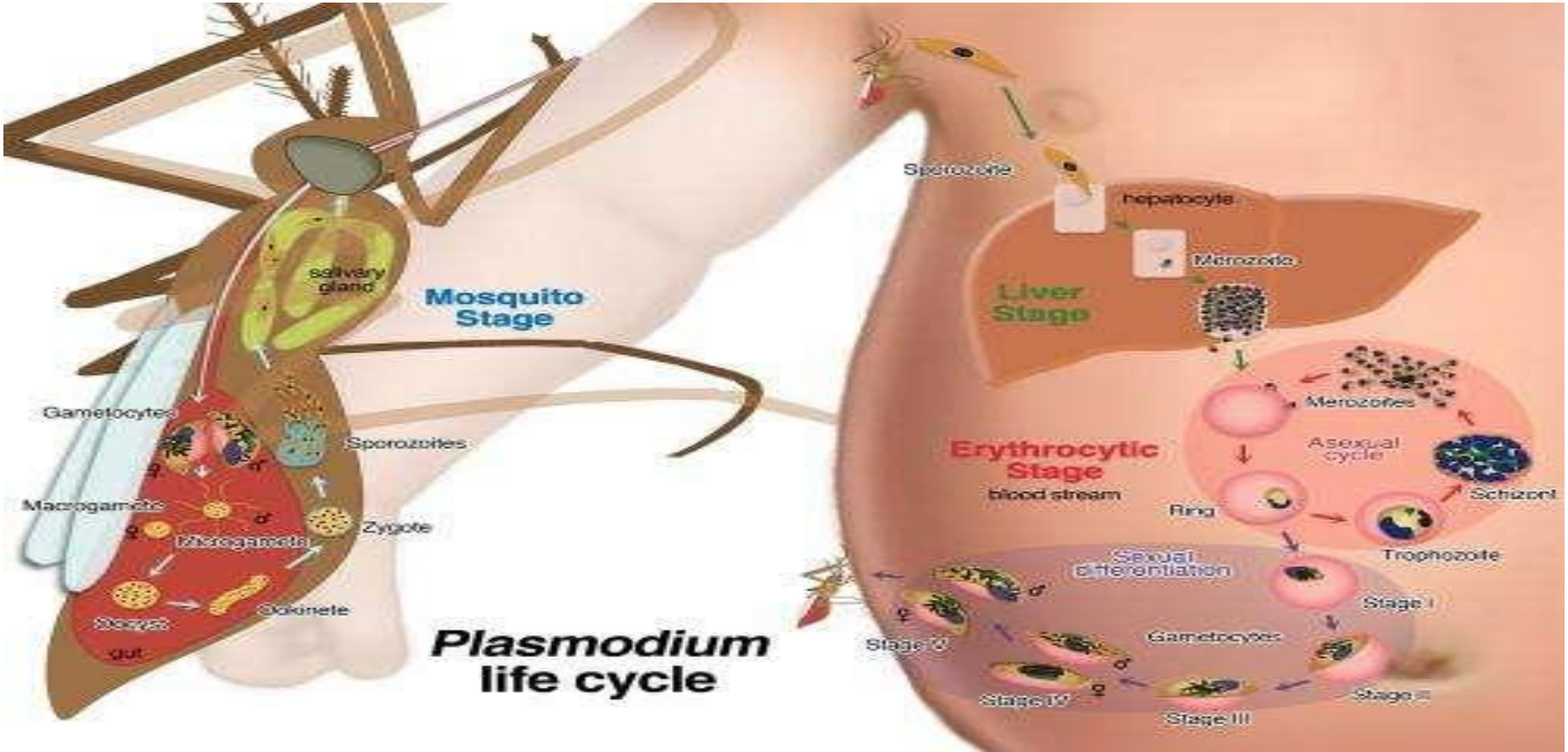
Species of *Plasmodium* found in man

Species	Vector	Disease
P. falciparum	*Anopheles* spp.	Malignant tertian malaria or falciparum malaria or Subtertian malaria
P. vivax	*Anopheles* spp.	Benign tertian malaria or vivax malaria
P. malariae	*Anopheles* spp.	Quartan malaria
P. ovale	*Anopheles* spp.	mild tertian malaria

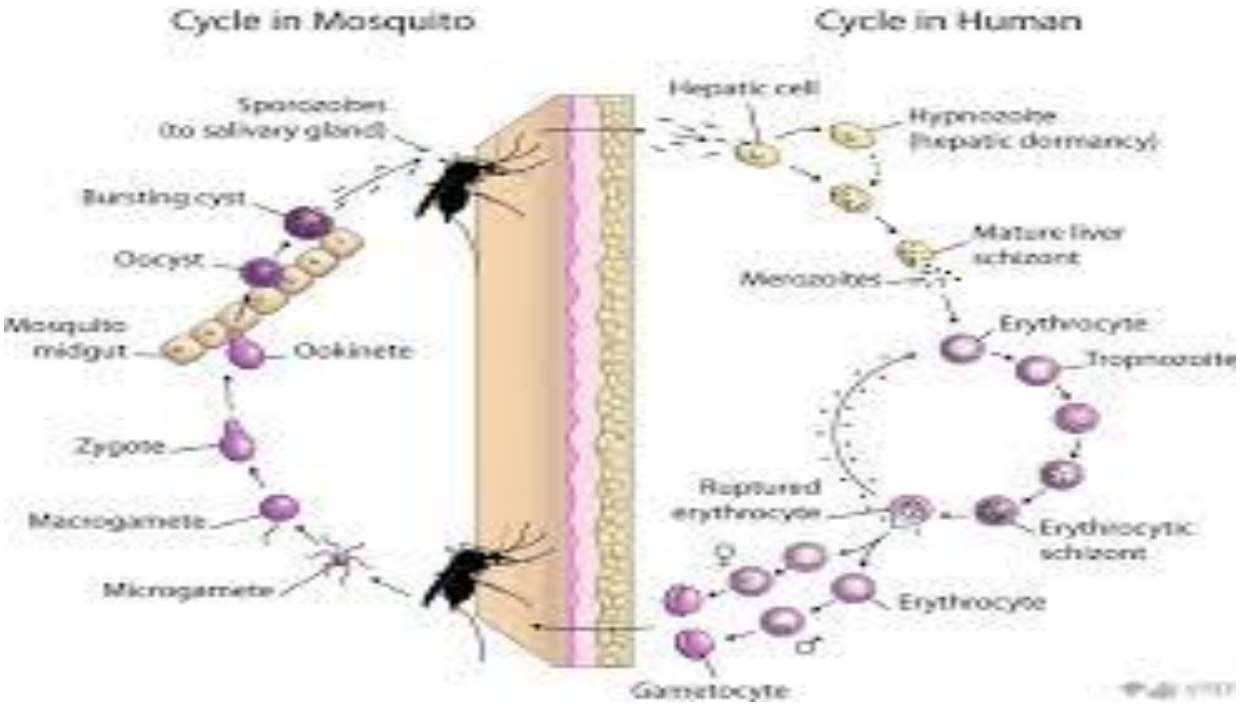
- Sporozoite is the **infective stage.**
- Cryptozoite is called first generation pre-erythrocytic schizonts.
- Second generation pre-erythrocytic schizonts are metacrytozoites whereas phaenerozoites are called exoerythrocytic schizonts.
- By exflagellation process 6-8 flagella like microgamete occur from macrogametocyte in the mosquito gut.

- A mosquito once infected remains infected for its life span, transmitting malarial parasites every time if it takes a blood meal.
- Release of merozoite from RBCs is associated with fever in case of human malaria.
- Fever does not appear to be a characteristic syndrome in avian hosts.
- On entering the RBC of vertebrate hosts, the merozoite rounds up to form a trophozoite then signet ring form developed inside the R.B.C.

Life- cycle of *Plasmodium*



Life- cycle of Plasmodium



Pathogenesis and clinical signs: Chickens are more susceptible than adult birds. Symptoms consists of progressive emaciation, anemia, paralysis, cerebral stroke etc.

Diagnosis:- On the basis of clinical signs or By demonstration of trohozoites inside the RBCs.

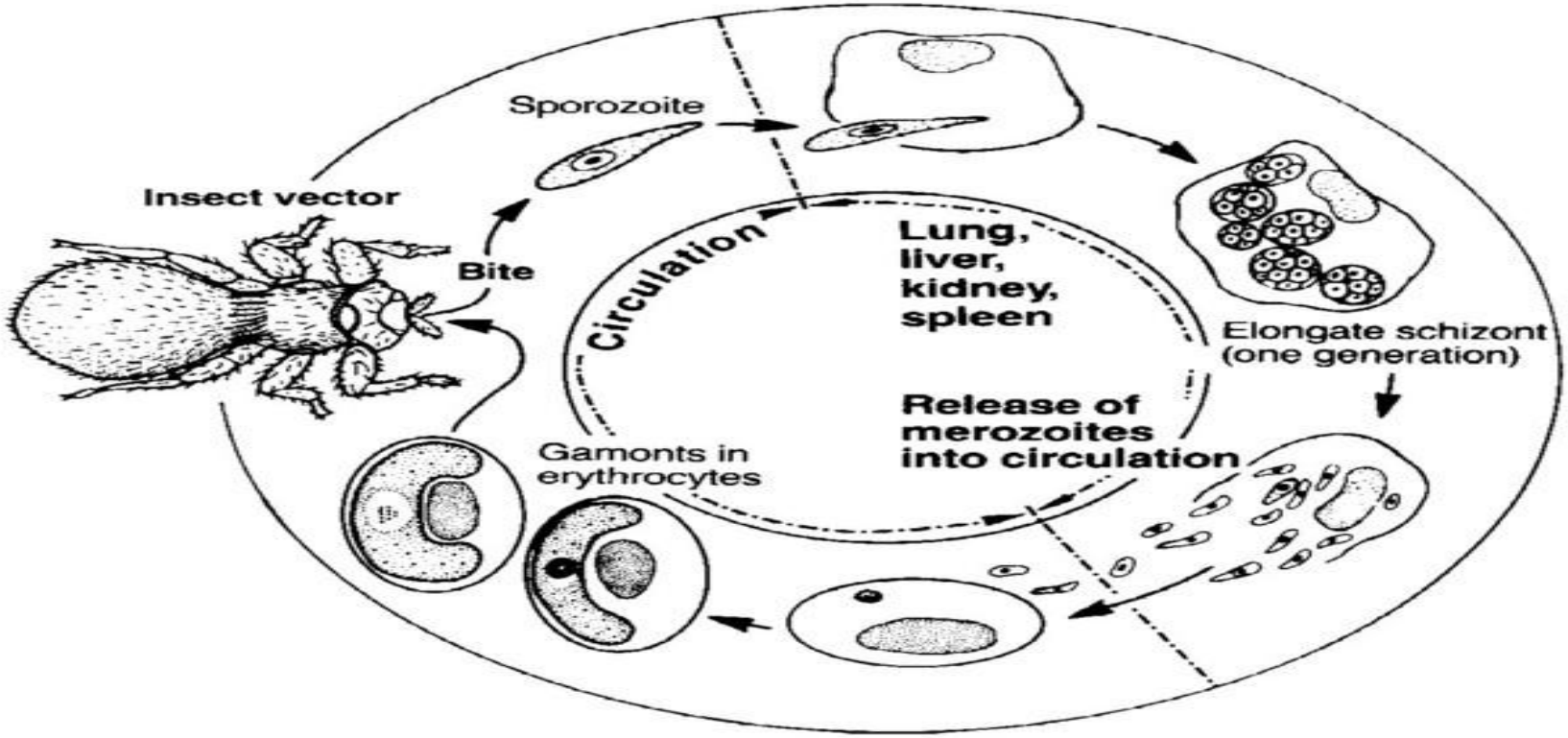
Treatment:

- Primaquine, Chloroquine, Pyrimethamine etc.

Haemoproteus

- Definitive hosts: *Haemoproteuscolumba* affects pigeon and dove whereas *Haemoproteus meleagridis* found in turkeys.
- Vector : Hippoboscid fly i.e. Pseudolynchia canariensis or Pseudolynchia maura.
- Gaemetocyte : Gametocyte is elongate, crescent shaped found inside the RBC which partially encircle the nucleus of RBC in the form of halter.
- Infective stage : sporozoites which form schizonts containing 15 or more unpigmented uninucleated cytomeres.

Life-cycle of *Haemoproteus*



Haemoproteus

Genus: *Leucocytozoon*

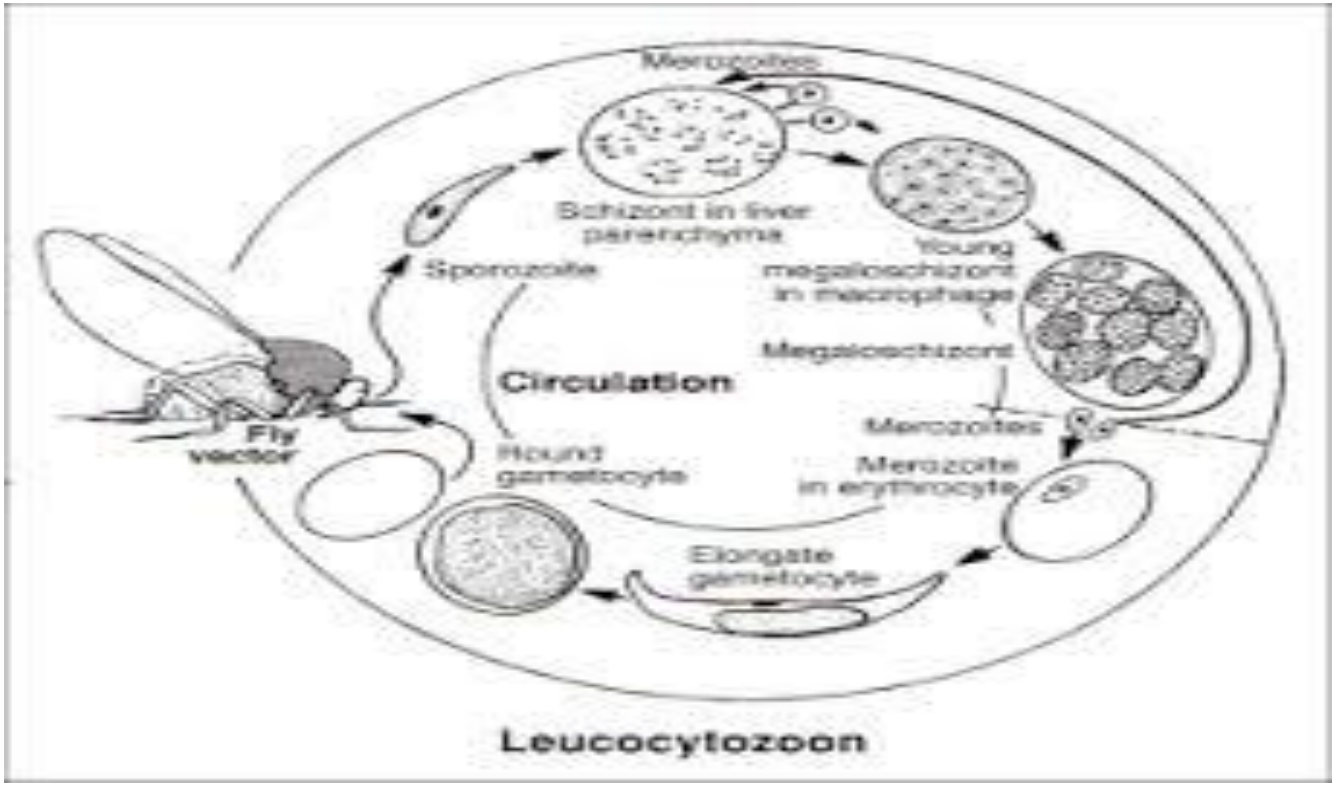
- ***Leucocytozoon*** **is the largest haemoparasite encountered in birds.**
- **Heteroxenous parasite.**
- **Schizogony occurs in vertebrates and gametogony and sporogony in invertebrates.**
- ***Leucocytozoon*** **gametocyte does not contain retractile pigment.**
- **Gametocytes stage of *Leucocytozoon* species found in lymphocytes and /or may be in erythrocytes of infected birds.**

Leucocytozoon

Species	Definitive host	Vector
Leucocytozoon simondi	**Domestic duck**	***Simulium* spp.**
Leucocytozoon smithi	**Turkey**	***Simulium* spp.**
Leucocytozoon caulleryi	**Chicken, turkey etc.**	***Culicoides* spp.**

- Gaemetocyte : Mature gametocyte of *Leucocytozoon* is elongate, oval bodies found inside the lymphocyte and erythrocyte.
- Host cell nucleus is compressed to side of cell and form a narrow dark bands.
- Schizogony occurs in the endothelial and parenchymatous cells of liver, kidney, Lung, brain etc.
- Megaloschizonts more numerous than hepatic schizonts found in endothelial cells of lungs, kidney, brain etc.
- Infective stage : sporozoites are inoculated into definitive host by the infected fly.

Life-cycle of *Leucocytozoon*



Pathogenesis and clinical signs

- Young birds suffer more than the adult birds. Clinical signs include anorexia, anaemia, listlessness, greenish diarrhoea etc.

- White spots found on the heart muscle in *Leucocytozoon* infection.

Diagnosis:

- By demonstration of gamonts found inside the lymphocyte and erythrocyte in stained blood smear and the megaloschizonts in impression smear of lung.

Treatment :

- Pyrimethamine plus sulfonamides as prophylaxis whereas in clinical cases, furazolidon or pyrimethamin is effective.
- Sulphamonomethoxine sodium drug is also used in treatment.

- Subphylum -Sarcodina
- Order - Amoebida
- Family -Endamoebidae
- Genus Entamoeba
- GENUS -ENTAMOEBA

- Family members are called parasitic amoebae which occur in the digestive tract of vertebrates and invertebrates.
- Movement by Pseudopodia.
- Holozoic type of nutrition.
- Binary fission type of asexual reproduction.
- Encystment is common feature.

Genus: *Entamoeba*

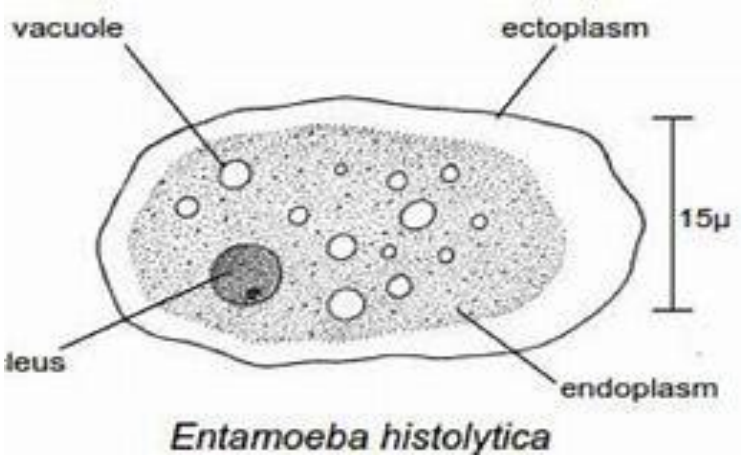
Species	Host	No. of nucleus present inside cyst
Entamoeba histolytica	Man, dog, cat, monkey, pig etc.	Quadrinucleated cyst
Entamoeba coli	Man, dog, monkey, pig etc.	8-nucleated cyst
Entamoeba bovis	Cattle	Uninucleated cyst

Entamoeba histolytica

It is a zoonotic protozoan parasite.

Mainly two developmental stages are found :- Trophozoite and Cyst.

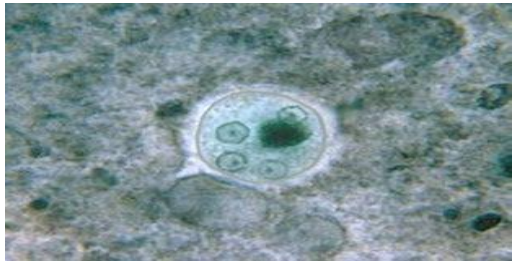
Trophozoite :- Size about 10-60 µm. It has clear ectoplasm and granular endoplasm.



Entamoeba histolytica

Cyst :

- ✓ Trophozoite discharges undigested food and condenses into a spherical mass called cyst.
- ✓ Usually Round in shape and 5-15 µm in size.



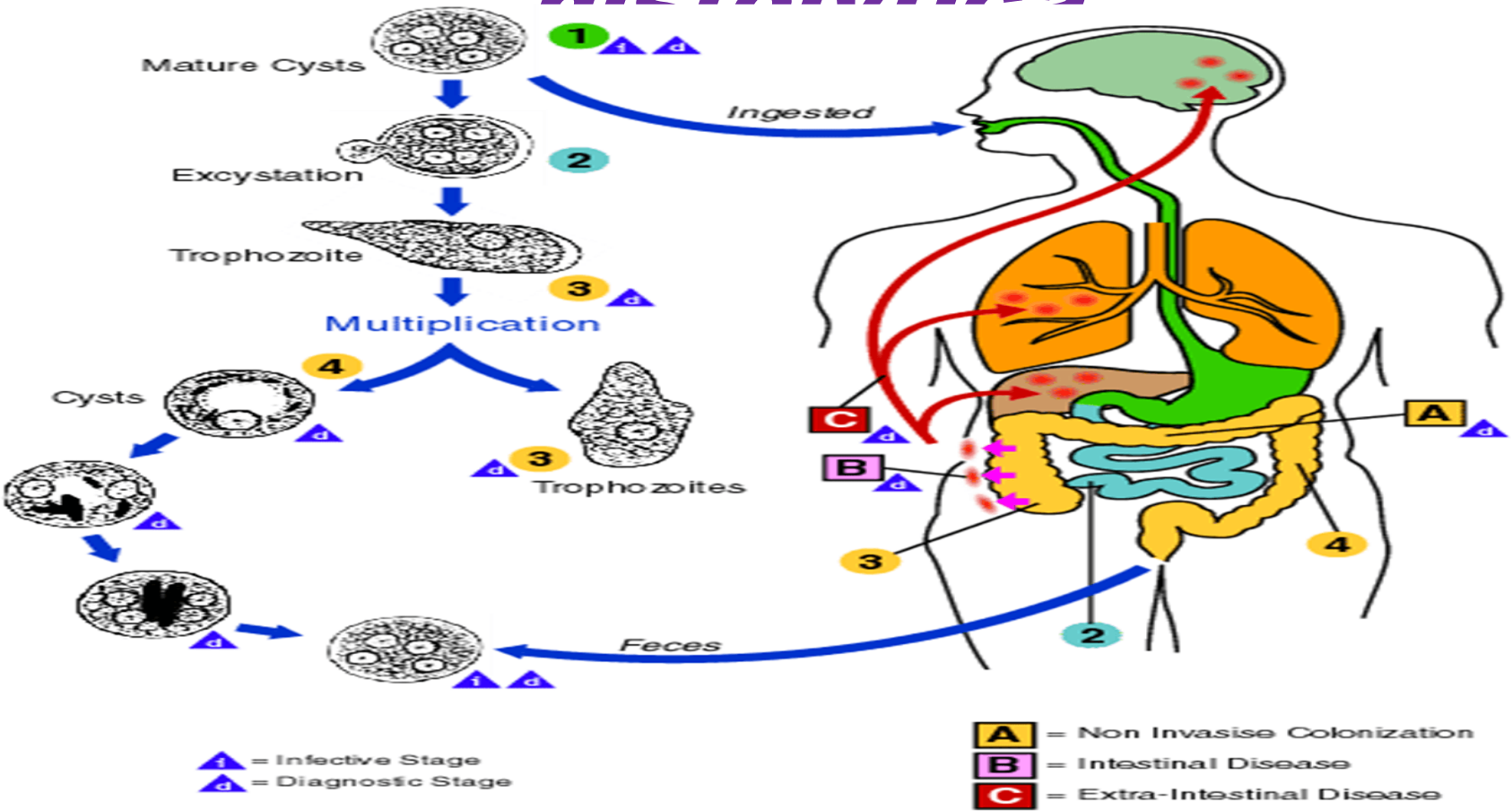
Transmission

- through cysts contaminated food or water , as trophozoites do not survive more than 30 minutes after passing with stools.
- Eating of raw and uncleaned vegetable usually in the form of salad.
- Eating of food contaminated by flies, use of night soil polluted water etc.

Life- cycle

- Hosts get infection by the ingestion of cysts.
- Excystment occurs in the intestine in the presence of trypsin enzyme and released metacystic form.
- Meatcystic form undergo nuclear and cytoplasmic division and form eight nucleated daughter trophozoites which migrate to the large intestine and grow into full size and invade the bowel mucosa.

Life-cycle of *Entamoeba histolytica*



Pathogenesis

Pathogenesis depends on various factors like strain variation, presence of *Escherichia coli* or *Aerobactor aerogenes* , nutritional status of hosts, concurrent disease, immunity etc.

- Parasites penetrates the intestinal wall by the lysis of the epithelium by the action of phosphohydrloae release by liposomes.
- Amoebae multiply and invade mucosa to produce **inverted flask shaped ulcers.**
- Amoebae may reach other body parts like liver where it may produce inflammation and abscesses.

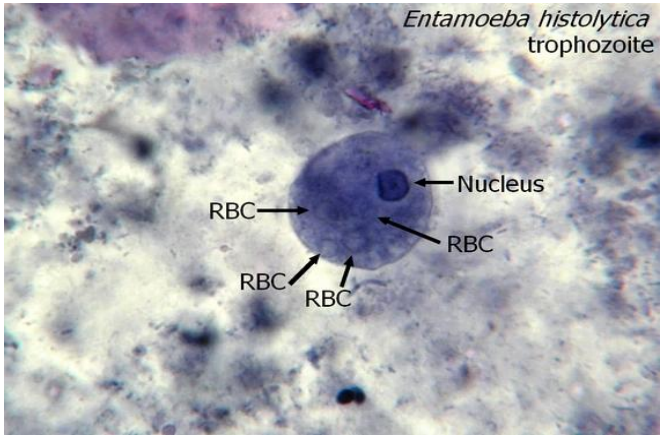
Symptoms

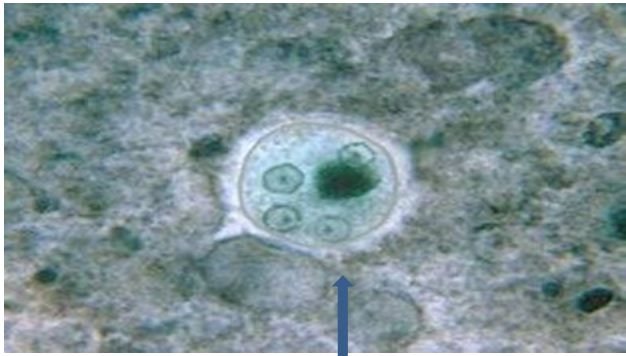
- Acute amoebic dysentery- faces consists of almost entirely blood and mucus with amoebae, abdominal pain, with straining.
- Chronic dysentery – recurrent dysentery, occasional abdominal pain, nausea, irregular bowels, headache, flatulence etc.

Entamoeba histolytica

Diagnosis :-

- **On the basis of symptoms like faeces with blood and mucus, abdominal pain etc.**
- **Microscopic examination of faeces reveals for the presence trophozoites (in diarrhoeic faeces) or quadrinucleated cysts (*Entamoeba histolytica*) or eight nucleated cysts (*Entamoeba coli*).**
- **2 % iodine is also used for clearly detection of cysts.**





Four nucleated cyst

Treatment : Metronidazole , Tinidazole etc.

Control : Adoption of proper sanitation, personal hygiene, proper disposal of sewage and night soil, avoidance of faecal contamination of food and water, supply of clean drinking water etc.

- Phylum - Ciliophora
- Class - Kinetofragminophorea
- Family - Balantidiidae
- Genus - Balantidium

Balantidium coli

- Highly organized protozoan having two dissimilar nuclei.
- A large macronucleus responsible for cytoplasmic activities of the organisms and a small vesicular micronucleus concerned with reproductive process

- Locomotion: by cilia.
- Reproduction: Asexual reproduction by transverse binary fission and sexual reprocess by conjugation.
- Host: Pig, dog, cattle, monkey and man.
- Location: large intestine (caecum and colon).
- Two developmental stages: Trophozoite and cyst

Balantidium coli

Trophozoite

- Active motile stage and 50-60µm in length.
- At the anterior end funnel shaped peristome which leads to cytopharynx or mouth.
- Two dissimilar nuclei i.e. macronucleus kidney shaped and micronucleus lies in the notch of macronucleus.

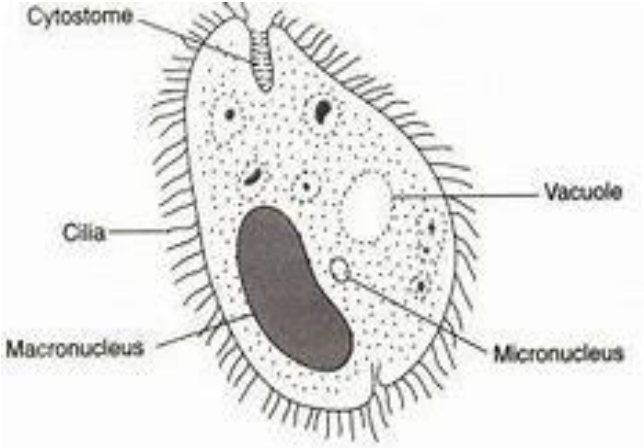


FIG 6–15 *Balantidium coli* trophozoite

Balantidium coli

Trophozoite

- Two contractile vacuoles one at each end.
- An excretory organelle i.e. cytopyge present at the posterior end of the organism.

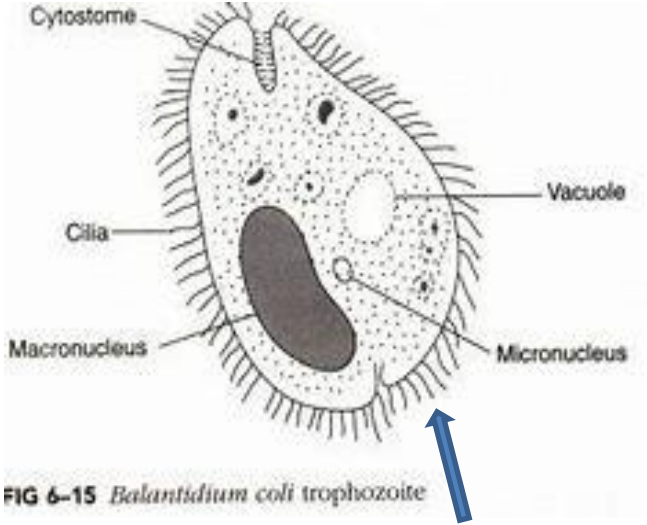


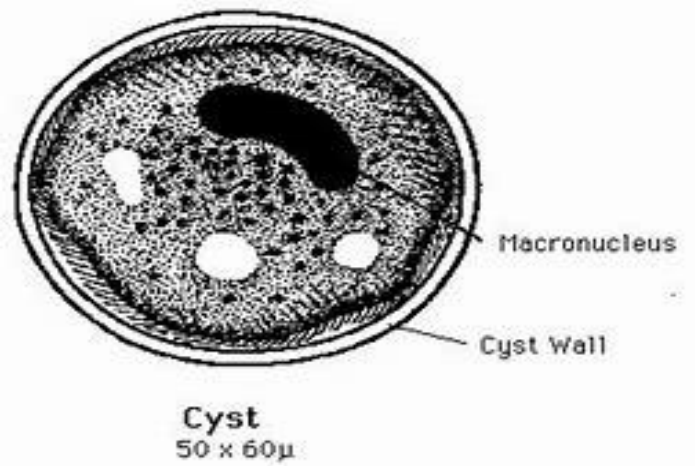
FIG 6–15 *Balantidium coli* trophozoite

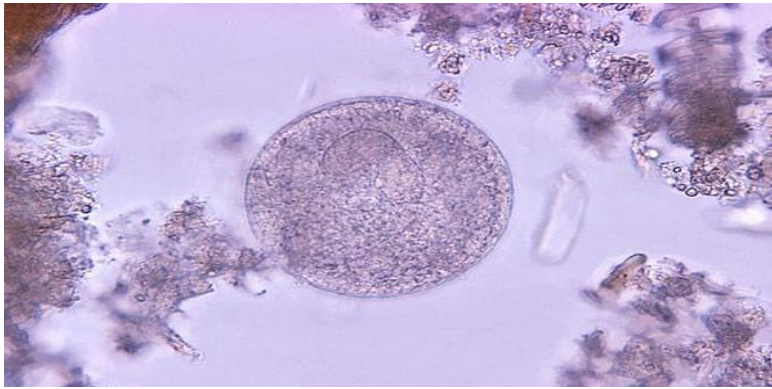
Balantidium coli

Cyst:

- Ovoid to spherical in shape, double walled, yellowish in colour and 40-60 µm in diameter.

- Cysts are formed both inside and outside the host body.

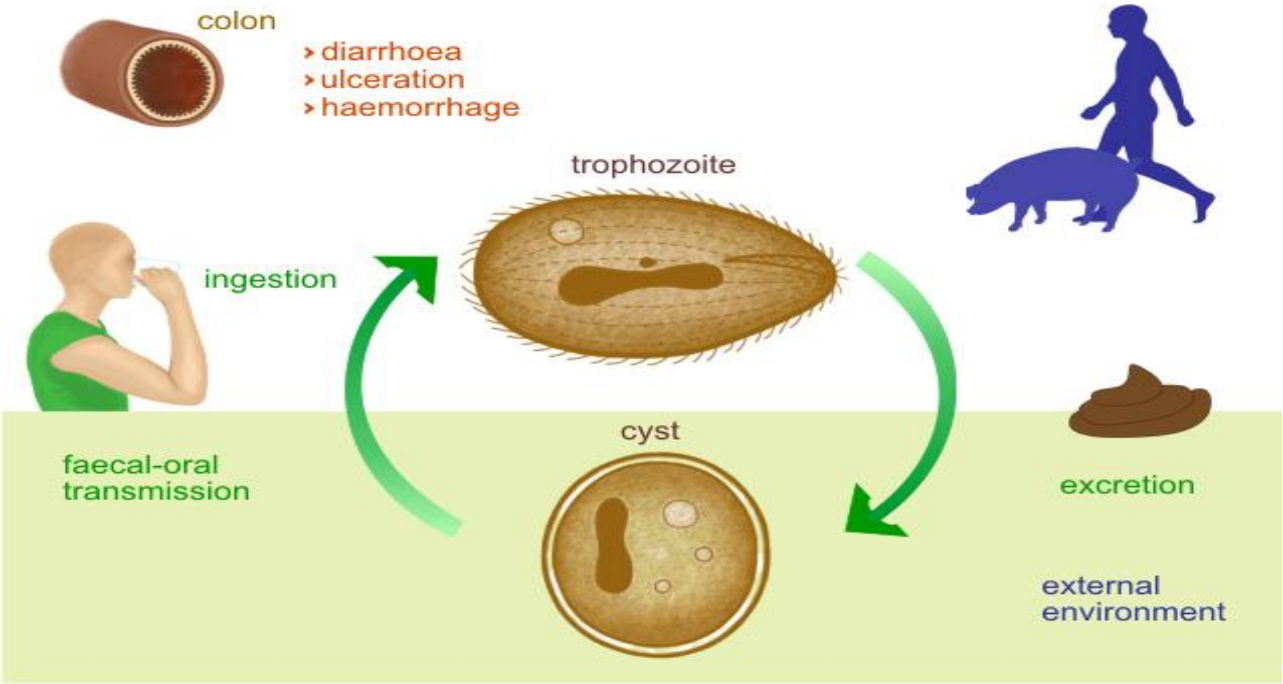




Transmission

- Pig is considered as primary hot and in it *B. coli* exists as commensal in the large intestine of most pigs.
- Pig is probable the persistent source of infection for man, cattle etc.
- Hosts get infection through the ingestion of contaminated food and water with cyst of *B. coli*.

Life-cycle of *Balantidium coli*



Pathogenesis and symptoms

- In pigs normally it is non-pathogenic but occasionally invade the mucosa and producing superficial to deep ulcer with enteritis. It produces diarrhoea and dysentery with hemorrhages
- In man, *B. co*li produce superficial to deep ulcer associated with enteritis. The initial lesions may resemble those produce by *Entamoeba histolytica* but do not show the similar tendency to enlarge or spread.

Neospora caninum

- *Neospora caninum* is a newly recognized fatal apicomplexan protozoal infection of dogs and other animals.
- It is a heteroxenous parasite.
- Definitive (Final) host:- Dog
- Intermediate host :-Ruminates, horse and dog.
- Each sporulated oocyst contains two sporocysts and each sporocyst contains four sporozoites.
- Sporulation occurs outside the host.

Life Cycle

- Tachyzoites are found in neural cells, fibroblast, macrophages and other cells of body whereas bradyzoite (tissue cyst) are found only in neural tissues (brain, spinal cord and retina).
- Bradyzoites are the infective stage for definitive host (dog).
- Tissue cysts (bradyzoits) infected dogs shed unsporulated oocysts which become sporulate in environment.

- Each sporulated oocyst of *Neospora caninum* contains two sporocysts and each sporocyst with four sporozoites.

- Intermediate hosts may get infection by ingestion of food and water contaminated with *Neospora caninum* sporulated oocysts.

- Tachyzoites of *Neospora caninum* has been transmitted from infected mother to foetus in cattle, sheep and goat.
- Neonatal calves may also get infection through the ingestion of tachyzoites containing milk and colostrum.
- Transplacental transmission is the only proven route of transmission in dogs.

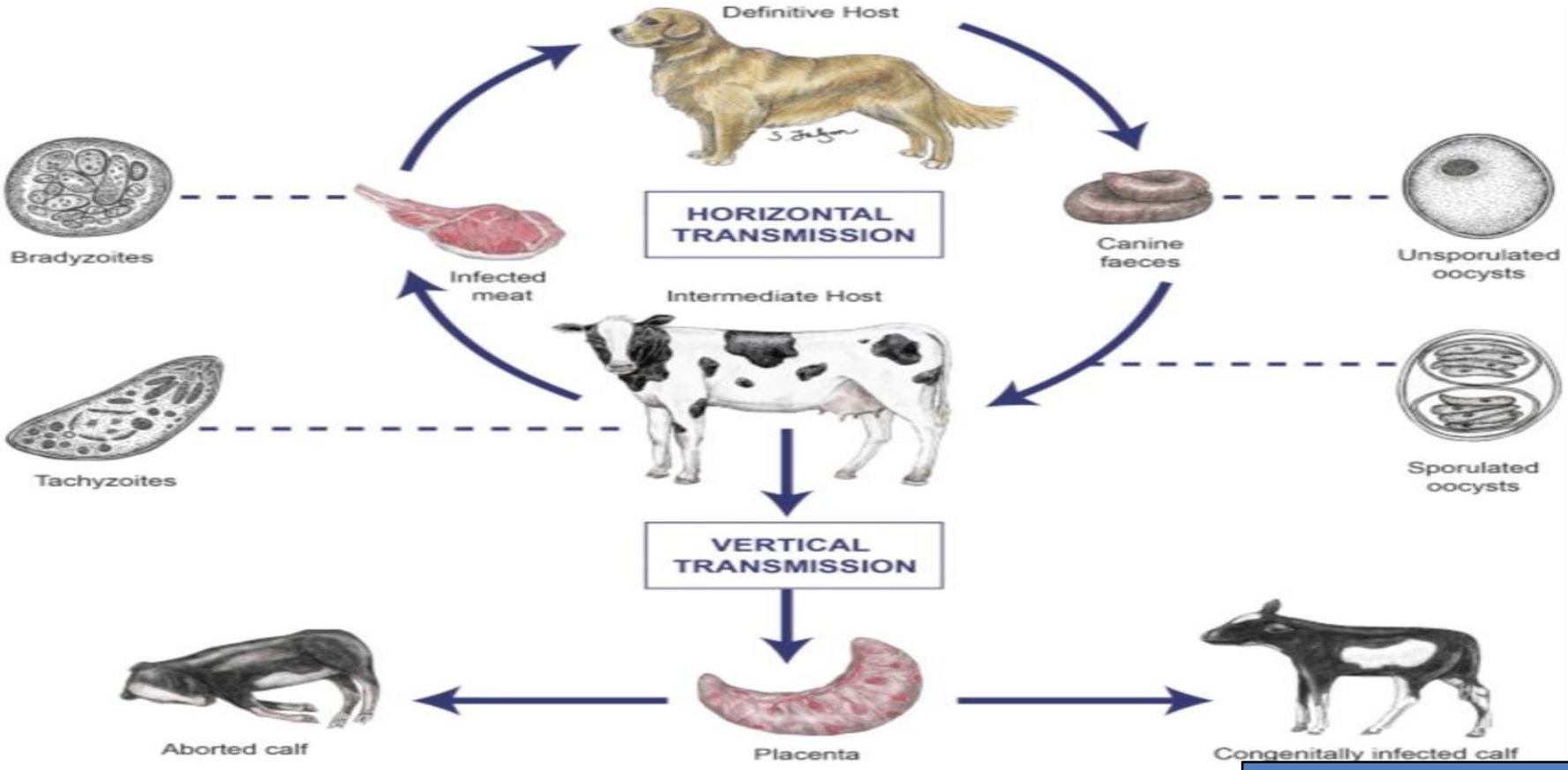


Image source: Google image

Symptoms:

- Clinical symptoms include **ascending paralysis of hind limbs**, difficulty in swallowing and paralysis of jaw, retinitis, encephalomyelitis, myositis etc.
- Transplacentally infected pups develop severe neuromuscular disease.

Treatment: Drugs used in the treatment of Neosporosis are Clindamycin, Trimethoprim + Sulfadiazine, Pyrimethamine etc.

Vaccination: Bovilis and Neoguard are the commercially available vaccines containing killed tachyzoites which reduce abortion in pregnant hosts.

Types of oocysts

Genus	Types of oocysts	Sporogony
***Eimeria* spp.**	**Tetrasporocystic bisporozoic (four sporocysts and each sporocyst contains two sporozoites)**	**Out side the host**
***Isospora*, *Toxoplasma*, *Sarcocystis* and *Neospora* spp.**	**Bisporocystic tetrasporozoic (two sporocysts and each sporocyst contains four sporozoites)**	**Outside the host except *Sarcocystis spp.***
***Cryptosporidium* spp.**	**Asporocystic tetrasporozoic (four naked sporozoites)**	**Inside the host**

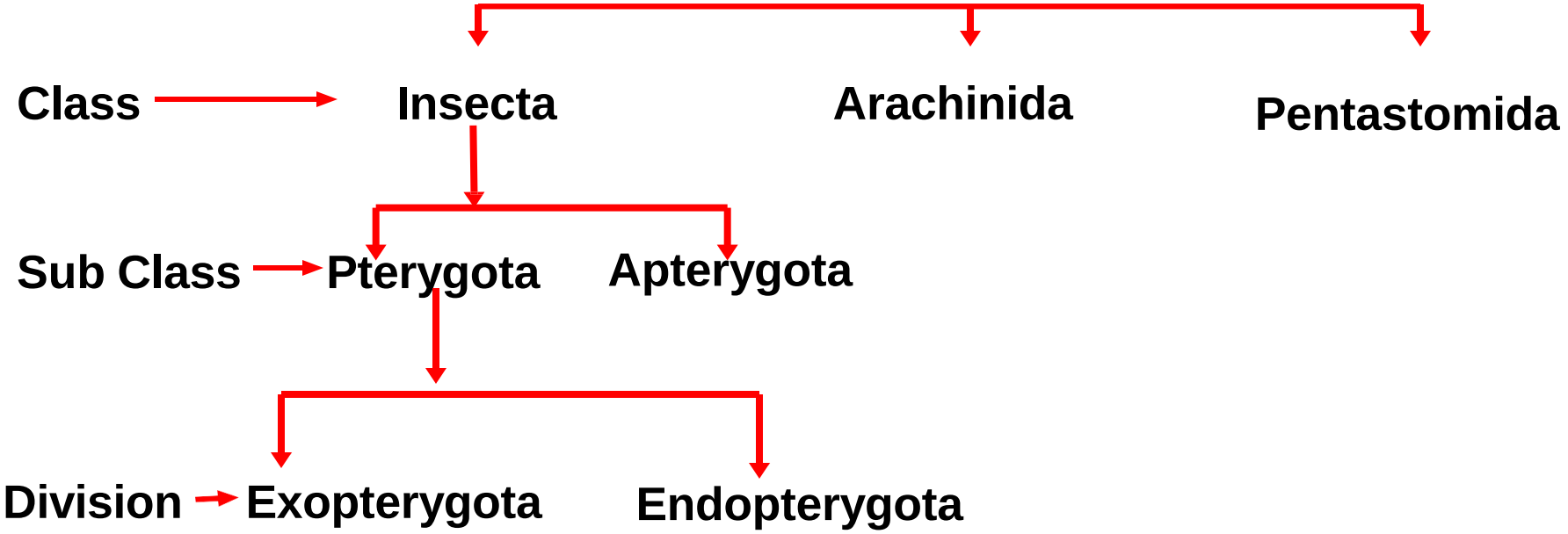
Entomology: Study of Insects

- Phylum - Arthropoda
- Class - Insecta, Arachnida, Alyriapoda, Pentastomida, Crustacea
- Arthros = Jointed Podos = Foot
- Main characteristics of Arthropoda :-

1. A hard chitinous exoskeleton .
2. A segmented body.
3. A jointed limb

* All arthropods are unisexual having males and females separately.

PHYLUM- ARTHROPODA



Aterygota	Pterygota
1. The members coming under this subclass are wingless. The name itself is self explanatory of absence of wings.	1. The members under this subclass are winged insects.
2. Pregenital abdominal appendages are present in the adult.	2. Pregenital abdominal appendages are absent in adult except genitalia and cerei.

EXOPTERYGOTA

Order →

- Mallophaga – biting lice
- Siphunculata – Sucking lice
- Hemiptera- Bugs
- Odonta- Dragon Flies
- Orthoptera – Grasshopperss & cochroaches

ENDOPTERYGOTA

Order →

- Diptera – (true flies)
- Siphonoptera- (fleas)
- Coleoptera – beetles
- Hymenoptera – bees, wasps

- The subclass (Pterygota) has been further grouped into two basic divisions basing mainly on development of the wings.
- The divisions are as following:
- Endopterygota - wings develop internally
- This subdivision includes the following orders:

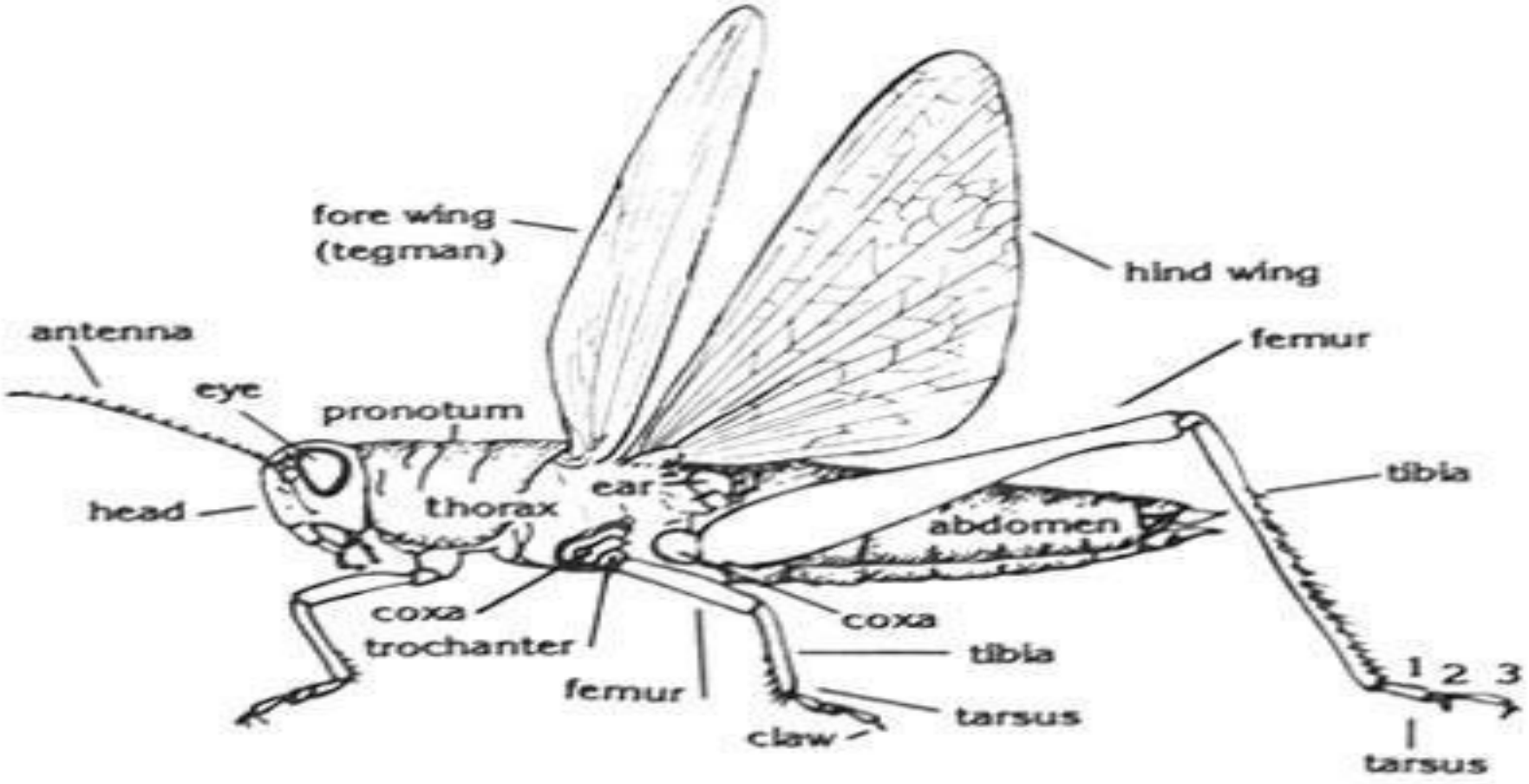
  1. Siphonaptera (fleas)
  2. Diptera (Ideal flies)
  3. Hymenoptera (bees)
  4. Coleoptera (beetle)

- Exopterygota - wings of the members of the division develop externally.
- This division includes the following orders:

1 . Mallophaga (biting lice)
2. Siphunculata (sucking lice)
3. Orthoptera (cockroach and grass hopper)
4. Hemiptera (bugs)
5. Odonata (dragon fly)

- MOULTING : Moulting is formation of new exoskeleton periodically after casting off the old chitinous covering during the growth of an arthropod , Each casting of the exoskeleton is called ‘ Moulting or Ecdysis,

- Arthropods developed an outer covering of chitin forming an exoskeleton which encloses the whole body.
- It not only covers the external surface of the body, but also passes through the mouth into the anterior part of the alimentary canal called the stomodaeum and also through the anus into the posterior part of the alimentary canal called the proctodaeum.
- The exoskeleton is usually present in the form of chitinous plates called sclerites.
- Each sclerite is a typical segment of the body having a dorsal sclerite called tergum, a ventral sclerite called sternum, and a lateral plate between the tergum and sternum, called a pleuron.
- Arthropods are metamerically segmented animals. Anterior group of segments form the head, the middle group the thorax and the posterior group the abdomen


fore wing
(tegman)
hind wing
antenna
eye
pronotum
femur
head
thorax
ear
tibia
abdomen
coxa
coxa
trochanter
tibia
femur
tarsus
claw
1 2 3
tarsus

Internal Organs

- Circulatory system consists of enlarged dorsal blood vessels , which is enclosed in a compartment of the haemocoele full of blood called ‘Pericardium’. ‘Ostia’ is opening in its wall .
- Respiratory system is small circular opening in the exoskeleton called ‘Spiracles’ Which allow air into the body
- Digestive system divided into three parts :- (1)Fore gut or Stomodaeum. (2) Mid gut or Mesenteron . (3) Hind gut or Proctodaeum.
- Excretory system: At the junction of mid gut and hind gut there are variable number of exretory tubules called as Malpigian tubules
- Reproductive system: Sexes are separate .

Circulatory system

- general body cavity full of blood, which is called haemocoele.
- All the organs of the body bathe in the blood.
- The heart is an enlarged dorsal blood vessel, which is enclosed in a compartment of the haemocoele full of blood called pericardium.
- The heart sucks blood from the pericardium through openings in its wall called ostia.

Respiratory system

The respiratory organs of arthropods are:

(1) gills (bronchiae) of various kinds found in larvae, nymphs and adults of aquatic species

(2) Tracheae: fine, elastic tubes with a thin chitinous lining which are held open by rings or spiral thickenings of the chitinous lining. Tracheae branch and rainify among the internal organs which take air entering through their external openings called stigmata

(3) lung-books and gill-books occur in spiders and crabs

(4) respiration occurs through the cuticle e.g. parasitic mites.

Alimentary canal

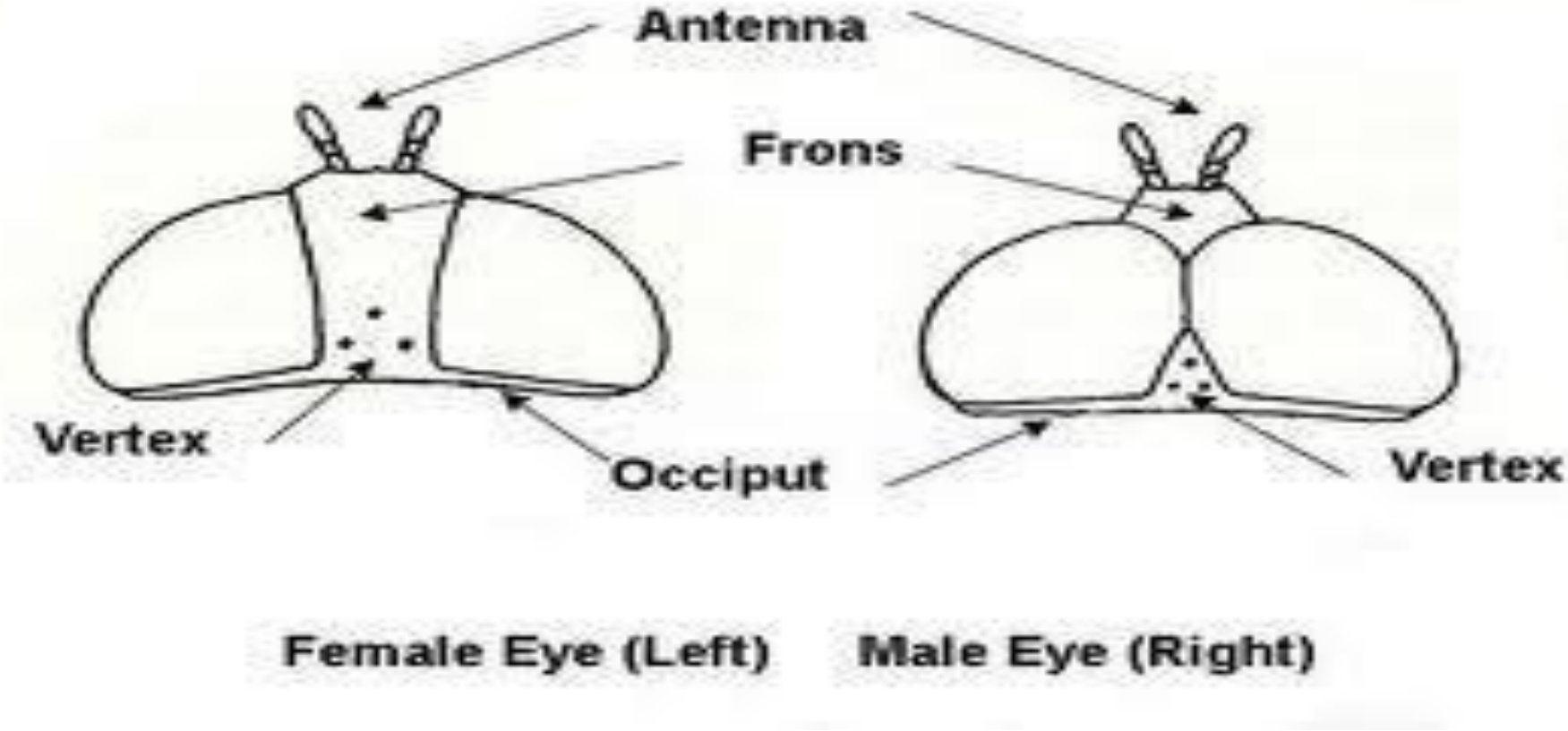
- Stomodaeum, lined by chitin, may be divided into a sucking pharynx, a provenritriculus (crop) and a gizzard
- Proctodaeum is also lined by chitin
- Mid-gut called mesenteron which connects the proctodaeum with the stomodaeum.

Excretory system

- Insects have tubules called Malpighian tubules; which are arranged in a ring round the alimentary canal. They usually open into the anterior end of the proctodaeum.
- Arachnida also have Malpighian tubules but they also have coxal glands which open on the coxae of the legs.

Nervous System

- The nervous system of arthropods consists of cerebral ganglia in the head, united by circumoesophageal ,commissures to a ventral double nerve cord.
- It runs along the ventral side of the body and has nerve ganglia on it.
- There is one ganglion in each segment.
- Eyes, sensory setae and other sense organs are also associated with nervous system.
- Eyes can be compound or simple (Ocelli)



DICOPTIC & HOLOPTIC EYES



HOLOPTIC & DICOPTIC EYES

I. Subphylum :. Mandibulata - Lacks chelicerae; mandibles present; one or two antennae present; contains insects, crustacea, myriapods (centipedes, millipedes).

II. Subphylum : Chelkerata - Lacks antennae; possesses a pair -of chelicerae as the first pair of their appendages; contains arachnids (ticks and mites)

III. Subphylum : Pentastomida

- SUB-PHYLUM : MANDIBULATA
- CLASS : INSECTA
- Head : It is ovoid or globular capsule, composed of a number of plates or sclerites, at the anterior end of the body.
  - Eyes are usually present and are placed laterally, above the cheeks or genae.
  - They have compound eyes, which may meet one another in the midline (holoptic) or may be wide apart (dichoptic).

- Thorax : It consists of three segments-a large anterior, prothorax; a middle, mesothorax; and a posterior, metathorax.
  - Typically, each segment bears a pair of jointed legs and, in majority of insects, both meso and metathorax carry one pair of wings each.
- The exoskeleton of each segment consists of chitinised sclerites, a dorsal tergum, two lateral pleuron and a single ventral sternum.

Legs

- Each leg is composed of a linear series of segments and articulate with the ventral side of each thoracic segment

(1) the first leg segment is basal joint that articulates with the body (pleuron) is called coxa

(2) the second segment is a small trochanter

(3) the third segment is the largest and short piece of the leg called femur

(4) the fourth segment is a slender spining called tibia

(5) the fifth segment is called tarsus which is usually consisted of five pieces.

At its apex, the tarsus bears a group of structures forming pretarsus which is prolonged mostly into a pair of claws

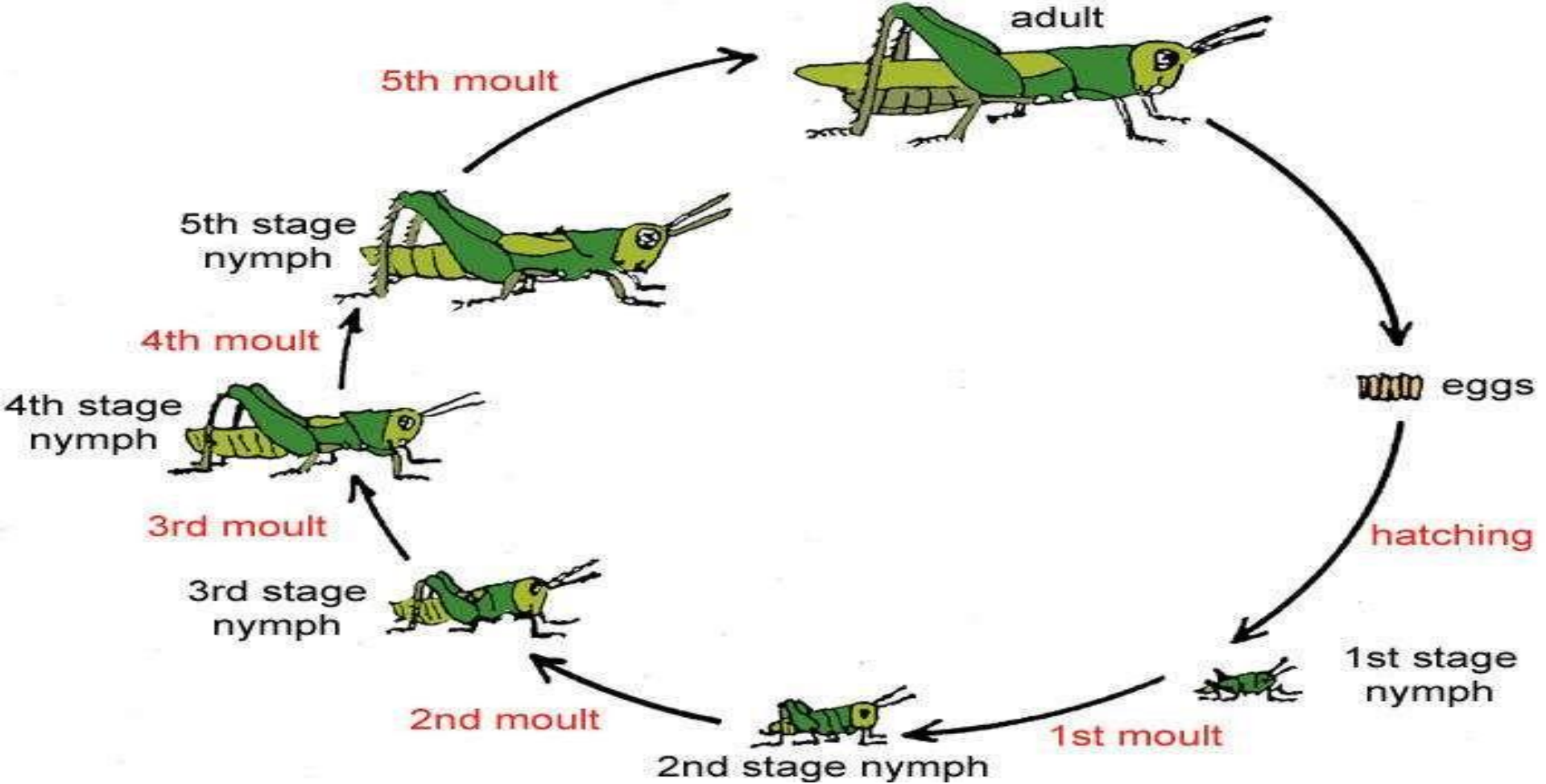
Wings

- Usually two pairs of wings occur which are outgrowths of the integument of the thorax articulated along the edges of the terga of meso- and metathorax and supported by hollow chitinous tube-veins (breathing tubes).
- The narrow fore-wing or tegmina are parchment like and the hindwings are broad and membranous with many veins.
- Each species of insects has its constant and characteristic wing venation which is valuable in identification and classification.
- In coleopteran insects the anterior pair of wings are thickened and serve only as protective covering for the second pair and are called elytra.
- In dipteran insects, the second pair of wings is reduced to small rounded structures on stalk, called halters or balancers.

Metamorphosis

- biological process of development of an organism from hatching into an adult stage
- **Holometabolism**/Complete metamorphosis: includes four life stages: egg, larva, pupa and imago. It is commonly seen in insects of order Endopterygota that includes butterflies, bees, ants, flies and beetles.
- The pupae are of three kinds:
- Obtect: compact, legs and other appendages are closed
- Exarate: legs and other appendages are free and extended
- Coarctate: these pupae develop inside the larval skin
- **Imago:** Imago, or adult, is the final stage of holometabolous development.

- **Hemimetabolism/Incomplete metamorphosis**: is a type where insects show only three developmental stages: egg, nymph and imago.
- Organisms undergo gradual changes and there is no pupal stage involved.
- Nymph, the second developmental stage, has a thin exoskeleton and largely resembles imago but does not have wings or reproductive organs.



HEMIMETABOLUS LIFE CYCLE



HOLOMETABOLUS LYFE CYCLE

ORDER -SIPHONAPTERA

- members coming under this order are called fleas.
- The flea itself causes damage to the hosts. In addition to the flea bite, the animals become restless which results in indirect loss of production.
- The stick-tight flea, *Echidnophaga gallinaecea* are very important as they cause great constraint in the poultry industry.
- Common name of the members - Flea

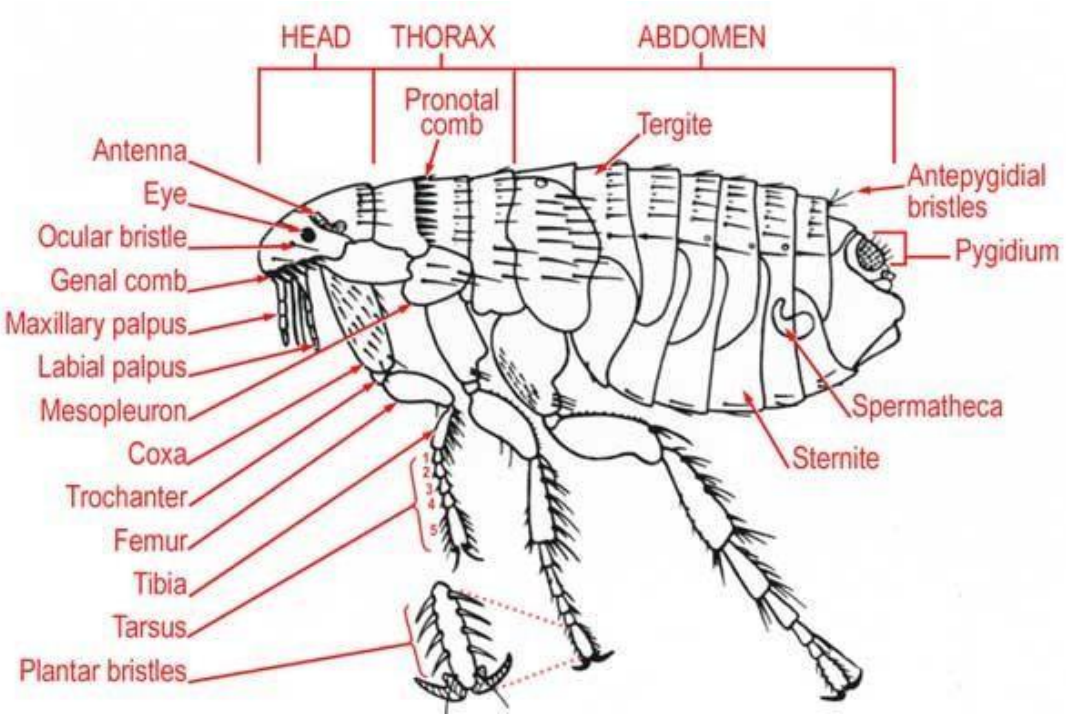
Flea

- body of the flea is very characteristic because the body is laterally compressed which is contrasting to the lice which are dorsoventrally compressed.
- In general, the antennae are three segmented.
- Eyes are present or absent. When present, these are simple types. Compound eyes are never found.
- Three pairs of legs are present, of which third pair of legs are remarkably well developed.
- Body is divided into three parts- head, thorax and abdomen.
- Wings are absent.
- The abdomen is segmented. There are 10 segments in the abdomen of which ninth segment bears a specific structure called sensilium or pygidium.
- There is presence of setae anterior to this segment which are called as antisensilial or antipygidial bristle.

Order: Siphonaptera

The name siphonaptera is derived from the Greek words siphon+ apteron which means the sucking wingless insects i.e. fleas




HEAD
THORAX
ABDOMEN
Pronotal comb
Tergite
Antenna
Eye
Ocular bristle
Genal comb
Maxillary palpus
Labial palpus
Mesopleuron
Coxa
Trochanter
Femur
Tibia
Tarsus
Plantar bristles
Antepygidial bristles
Pygidium
Spermatheca
Sternite
1
2
3
4
5

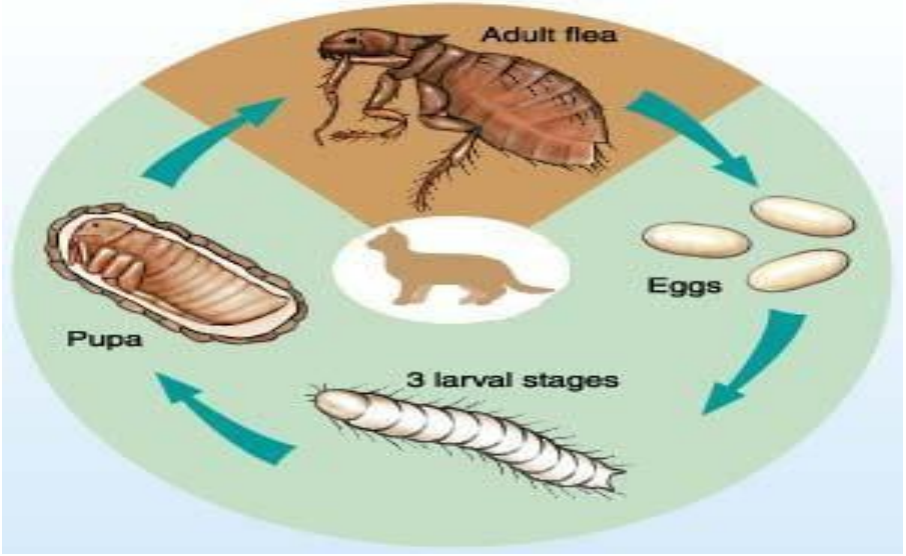
- Male flea has chitinous and coiled penis (aedeagus).
- Last segment of ten segmented abdomen has two hooked processes called the anal struts which are used for holding on to substrata or for locomotion.
- Both sexes are blood sucker but only the adult fleas are parasitic.

Morphological characters:

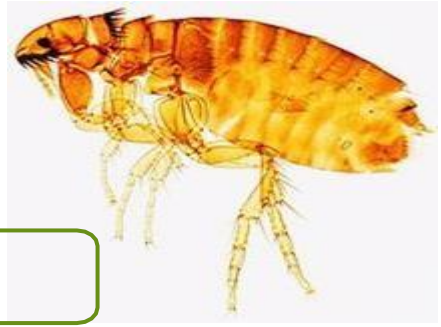
- Wingless insects with laterally compressed bodies .
- Eyes present or absent and three-segmented antennae. Compound eye absent.
- 3- pairs legs. Third pair of legs much larger than the others
- Head and thorax bears a numbers of prominent spines called combs/ Ctenidium
- Genal combs present on the head whereas pronotal combs are present on the posterior border of first thoracic segment.
- Abdomen has ten segments. The 9^{th} abdominal segment of both male and female flea bears a dorsal plate called sensilium or pygidium.

Life-cycle:

- Holometabolus (complete metamorphosis).
- Life-cycle comprises as egg, larva, pupa and adult.

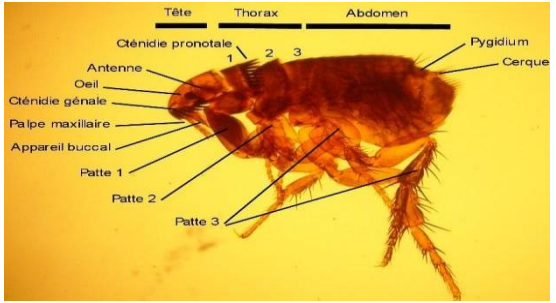


Flea	Host	Salient morphological characters
Ctenocephalides canis (**common dog flea**)	Dog	Both genal and pronotal ctenidium present in which genal ctenidium is horizontal.
Ctenocephalides felis (**common cat flea**)	Cat	Both genal and pronotal ctenidium present in which genal ctenidium horizontal.



Ctenocephalides canis

Ctenocephalides felis



Flea	Host	Salient morphological characters
Spilopsyllus cuniculi	Rabbit	Both genal and pronotal ctenidium present in which genal ctenidium is oblique.
Ceratophyllus gallinae (common flea of chicken)	Poultry	Only pronotal ctenidium is present.
Echidnophaga gallinacea (Stick-tight flea)	Poultry	Ctenidium absent and forehead angled anteriorly



Spilopsyllus cuniculi



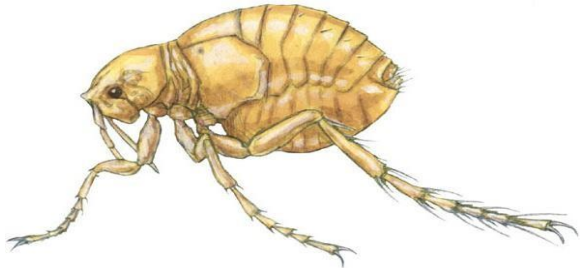
Ceratophyllus gallinae



Flea	Host	Salient morphological characters
Pulex irritans (common human flea)	Man, also in pig, dog, cat	Ctenidium absent and Frons (frontal part of head) rounded anteriorly. It may also occur on the pig, dog, cat & rat.
*Tunga penetrans (C*higger or chigoe flea or sand flea)	Man & Pig	Only pronotal ctenidium is present.
Xenopsylla cheopis (Black rat flea or oriental flea)	Rat	-



Pulex irritans



Tunga penetrans



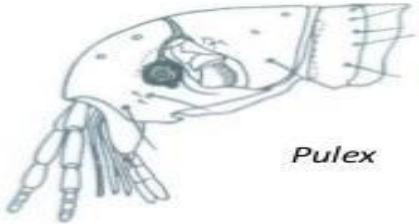
Xenopsylla cheopis

Laboratory Confirmation/ Species Identification

No comb/ctenidia



Echidnophaga

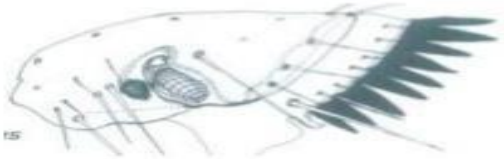


Pulex



Xenopsylla

With Pronatal comb only

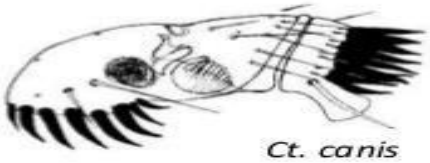


Ceratophyllus



Nosopsyllus fasciatus

with Genal and Pronatal comb



Ct. canis



Ct. felis

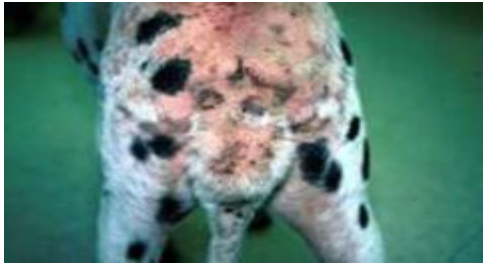


Spinopsyllus

Pathological significance & Disease transmission:



- Cause annoyance and irritation to the hosts during biting for sucking of blood.
- Infested host become restless, loose body condition etc.
- Animals exposed to 1st times flea bites results formation of erythema followed by pin point elevation.
- Acute itching leads to formation of papules and pustules and causing a condition called “flea bite dermatitis”.



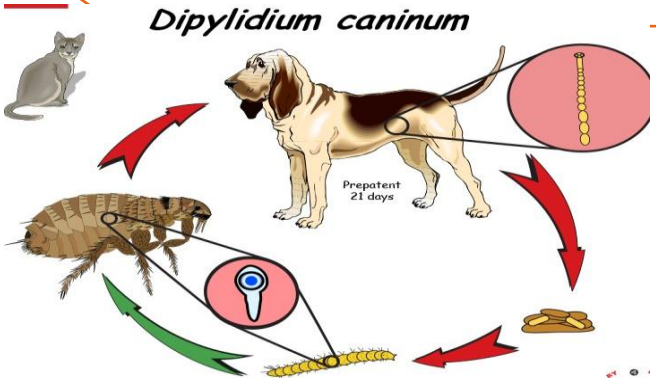
Pathological significance & Disease transmission:

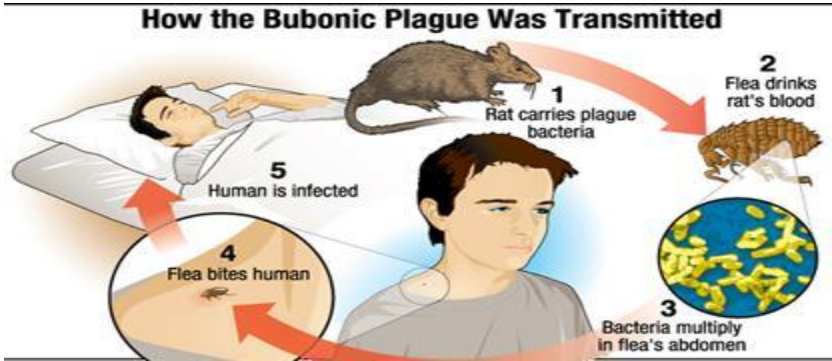
- Flea-bite allergy is a hypersensitivity reaction to the flea saliva released into the skin during feeding.

- Flea's saliva contains a hapten (an incomplete antigen) which combines with the host's skin collagen to form a complete allergen. The resulting allergy is most commonly a combination of immediate and delayed type by hypresentivity.



Fleas	vector/ Disease transmission
Ctenocephalides canis, Ctenocephalides felis & Pulex irritans	Act as intermediate host for *Dipylidium caninum* (Dog tapeworm), *Dipetalonema reconditum* (dog filarial worm)
Xenopsylla cheopis	vector of *Yersinia pestis* and Rickettsia typhi, the causative agent of Murine typhus, Endemic typhus, Mexican typhus.
Spilopsyllus cuniculi	found on the ears of rabbits and vector of myxomatosis





Treatment

- **Treatment of the infested animals with suitable insecticides like deltamethrin, malathion,, lindane etc. by spraying on the body as well as in and around shed of animals.**
- **Ivermectin @ 1ml/50 kg b.wt S/C .**
- **Fleas collars impregnated with insecticide like Methoprene are usually used in controlling of fleas of dog & cats.**

Important genus, species and importance

Genus	Species	Hosts affected/ common name	Importance
Xenopsylla	*Xenopsylla cheopis*	Rats are affected	*Yersinia pestis*, causative agent of **bubonic plague** are carried by *Xenopsylla cheopis*.
Pulex	*Pulex irritans*	Human and pig	Acts as the intermediate host of *Dipylidium caninum*

Genus	Species	Hosts affected/ common name	Importance
Echidnophaga	*Echidnoplaga gallinacea*	These fleas are called as **Stick- tight flea**	These fleas affect poultry, dogs, cats, rabbits etc.
Ctenocephalides	*Ctenocephalides felis* *Ctenocephalides canis*	Common cat flea Common dog flea	Act as the intermediate hosts of *Dipylidium caninum* and *Dipetalonema recoditum*
Tunga	*Tunga penetrans*	Man, pig, (Jigger, **Chigoe or Sand flea**)	Cause the disease Tugiasis
Ceratophyllus	*Ceratophyllus fasciatus*	Rat	-
Spilopsyllus	*Spilopsyllus cuniculi*	Rabbit flea	Affects the rabbits and transmit myxomatosis
Vermipsylla	*Vermipsylla alakurt*	**Alakurt flea**	

ORDER-DIPTERA

- All the members coming under this order are called as true flies.
- The body is commonly divided into three parts - head, thorax and abdomen.
- The thorax has three parts like prothorax, mesothorax and metathorax
- pro and metathorax are fused with mesothorax.

- A pair of thin, membranous wings are present in the mesothorax.
- Hind pair of wings are modified into halteres or balancers.
- A pair of antennae is present.
- In these flies of the order, complete metamorphosis is found.
- Larvae are apodous and head is not developed.
- Pupa is coarctate or obtectate type.

- Diptera is divided into three suborders;
- Brachycera
- Nematocera
- Cyclorrhapha

- Brachycera
- Family –Tabanidae
- Genera
  - Tabanus
  - Haematopota
  - Chrysops
  - Pangonia

Tabanus	*Haematopota*	*Chrysops*	*Pangonia*
1. Presence of vestigeal ocilli.	1. Presence of functional ocilli.	1. Presence of functional ocilli.	1. Presence of functional ocilli.
2. Probosis is shorter than head and hangs down.	2. Short probosis hangs down.	2. Probosis is not longer than head.	2. Probosis is very long and it may even extend beyond the length of the fly and project forward.
3. Wings are usually clear	3. Wings are mottled.	3. A broad transverse dark band is present on the wings of the fly.	3. In general the wings are clear.
4. Third segment of antenna has four annulations.	4. Third segment of antenna has three annulation.	4. Third segment of antenna has four annulations.	4. The third segment of antenna has 6-7 annulations.

Tabanus

- Common name : Horse fly .
- Host : Large domesticated & wild animals and birds also.
- Species :*Tabanus rubidus*, *Tabanus striatus* .
- Morphology :
- They are dark coloured robust flies.
- The eyes are large and holoptic in male dicoptic in female
- The proboscis (long appendage coming out of head) is shorter than head.
- The mouth parts is adopted for blood sucking and lapping
- The antennae is 3 segmented.

Life Cycle

- The female flies require blood meal for development of eggs
- The cigar shaped eggs hatch larva expelled out.
- The larva of Tabanus identified by presence of ‘Graber’s organ in the terminal end .
- The larva acts as predator and greyish white in colour .
- The larva come very close to the ground surface and enter about 1-2 inch then prepare a pupal cell.
- The pupa is obtectate type .
- The adult fly come out from pupa.

- The affected animals become restless at the time of bite . The bites painful and irritating , the bite area become swollen.

- They are actively involved in transmission of causative agent of various viral, bacterial and protozoan diseases like Equine infectious anaemia , Bovine leukemia, Hog cholera, Anthrax , Anaplasma, Nagana disease, Ma-de- cadras, Tryanosomiasis

- Suborder - Nematocera
- Under the suborder Nematocera there are following four families:
  - Culicidae
  - Ceratopoganidae
  - Simuliidae
  - Psychodidae

FAMILY -CERATOPOGONIDAE

- Genus - Culicoides & Austroconops
- They are commonly called as biting midges, no - see - ums and punkies etc.
- Punkies: The name has been derived from the word, punkwa which means 'ash' like because of burning sensation of biting of Culicoides spp.
- No - see –ums: The name has been given so because the flies are hardly visible because of their small size and very often go unnoticed.
- The main significance of these flies is the transmission of the important filarial worms.

Culicoides

- Common name : Biting midge, No-see-ums, Punkies
- Host : All domesticated animals and man also
- Species : Culicoides puncticolis

Morphology

- The flies are very small 0-2. 5 cm).
- The thorax is characteristically humped on where there is presence of humeral pit.
- The members have the wings with dark and light combination.
- The thoracic and abdominal segments are similar in size.
- The body of the adult fly is without hairs.
- Brown coloured pupa bears respiratory horns.

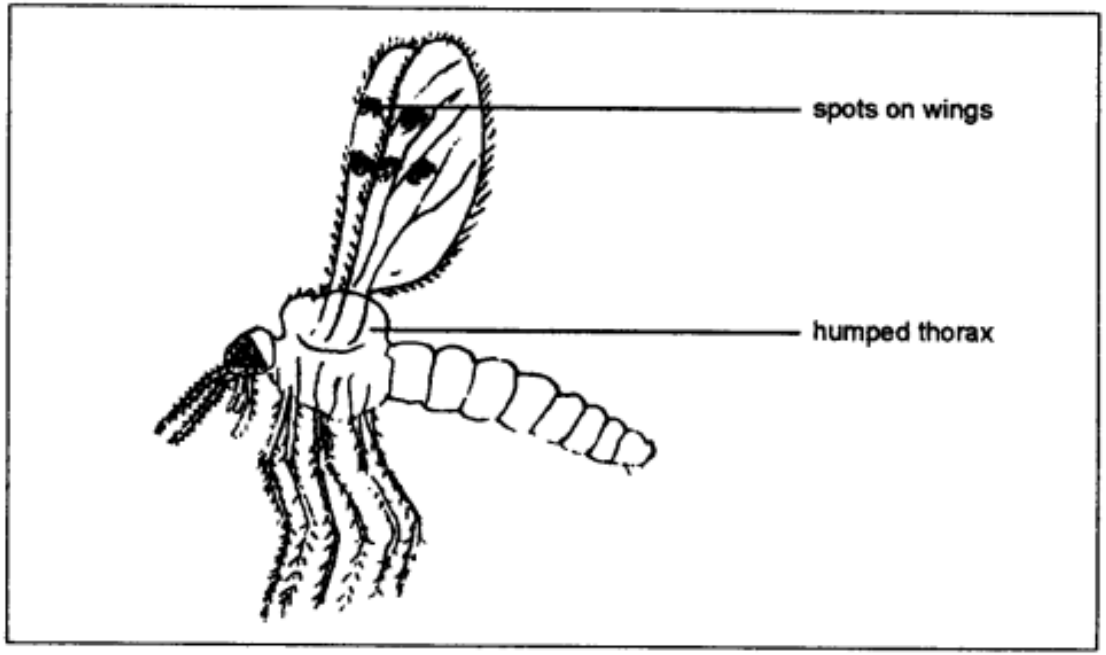


Fig. 102. Culicoides spp.

Life Cycle

- The eggs are characteristically banana- shaped.
- The larva which emerges out of the eggs is typical nematoceran type having sclerotised head, 11 body segments and no appendages and they swim by ossilatory movements.
- The larvae feed on nematodes and other predators.
- Four ecdysis occur during the larval stage and eventually gives rise to pupa. Pupa has prothoracic horns.
- They are brown in colour and obtectate type.
- From the pupa the imago comes out.

- Vector of *Dipetalonema perstans*, *Onchocerca gibsoni*, *Haemoproteus meleagridis*
- They are also responsible for causation of kind of allergic dermatitis or seasonally occurring intense pruritus in skin caused by Culicoides robertsi in horse , called ‘Sweet itch’ Sweat itch’ or ‘ Queensland itch in Australia.

FAMILY - SIMULIIDAE

- Common name : Black flies ,Turkey gnats , Buffalo gnats.
- Vector of Leucocytozoonosis, EEE, Vesicular Stomatits, Oncocerca
- Species :
  - Simulium indicum
  - Simulium ornatum .

- The flies are small, dark well built and stout bodied.
- Size of the fly is larger than the members of Ceratopogonidae.
- The eyes of the female are dichoptic which are well separated.
- Segments of the antenna are very characteristic which are globular in appearance and 11 segmented.
- Wings are short but broad and have neither scales nor hairs. However few bristles are present.
- Characteristic golden and silver coloured hairs are present on the body.
- Larvae have prolegs.
- The pupae are boot shaped, slipper shaped and bear paired gills.

Life Cycle

1. Egg laying habit is very characteristic. The eggs are laid by the female fly on the objects which are placed in or near the running water.
2. After hatching of the eggs the larvae come out. The larva is hour-glass shaped. Other characteristic identifying features are present in the larva-like eye spot, anal gills and posterior sucker.
3. Presence of proleg is an important identifying feature of the larva of this fly. The proleg is surrounded by a circlet of hooks. A pair hairy brush-like structure is present at the anterior part of the larvae.
4. The larvae turn to pupae spinning a cocoon surrounding the body of the larva.
5. The pupa may broadly be divided into two parts like cephalothorax and abdomen.

- FAMILY -PSYCHODIDAE
- Genus Phlebotomus
- Species *Phlebotomus papatasii*, *P. argentipes P sergenti*, *P. major*, *P. logipalpalis P. orientalis*
- Common name -Sand flies and owl midges
- Phlebotomus spp are the vectors of important protozoan parasite like Leishmania

- These are small-sized brownish fly. The shape is elongated and look shiny.
- Body is narrow.
- Antennae and legs are noticeably long (16 segmented)
- Lanceolate wings remain erected on the body.
- Body and wings, both are covered with numerous hairs.
- Like the other two families these flies are also strongly humped.
- Several knife-like sylets are present in the mouth parts.

- Female flies lay the eggs in moist places of cracks and crevices.
- The flies may either be autogenous (no requirement of blood meal for first gonotrophic cycle) or anautogenous (requirement of blood meal for their all gonotropic cycles).
- From the egg the larva comes out.
- The larva is grayish white with dark head. They are elongated apodous. The larvae pass four larval stages.
- The pupa is exarate type

- Order: Nematocera (Nemato means long, cera means antenna).
- Family : Culicidae, Psychodidae , Simuliidae , Ceratopogonidae
- Family: Culicidae

- **MOSQUITOES**
- Species: *Anophles quadrimaculatus, A.Stephensi*
- *Culex tarsalis, Culex fatigans*
- *Aedes dorsalis, Aedes aegypti*

Anopheles	*Culex*	*Aedes*
1. Grossly these mosquitoes can be identified by the sitting behaviour. The mosquitoes sit on the surface forming an acute angle.	1. They always remain parallel to the surface while sitting.	1. These mosquitoes sit parallel to the surfaces.
2. In female the palps are as long as proboscis. Male palps are clubbed and as long as proboscis	2. In female the palps are less than half of proboscis. Male palps are not clubbed but as long as proboscis.	2. The palps are less than the proboscis. Male palps are not clubbed but as long as proboscis.
3. In the larva siphon tube is absent. Characteristic palmate hairs are present on the abdomen.	3. In the larva siphon tube is present. Palmate hairs are absent.	3. Siphon tube is present. Palmate hairs are absent.
4. In the pupa broad type of breathing trumpet is present.	4. In the pupa narrow (Lateral view) breathing trumpet is present.	4. In the pupa narrow (Lateral view) breathing trumpet is present.

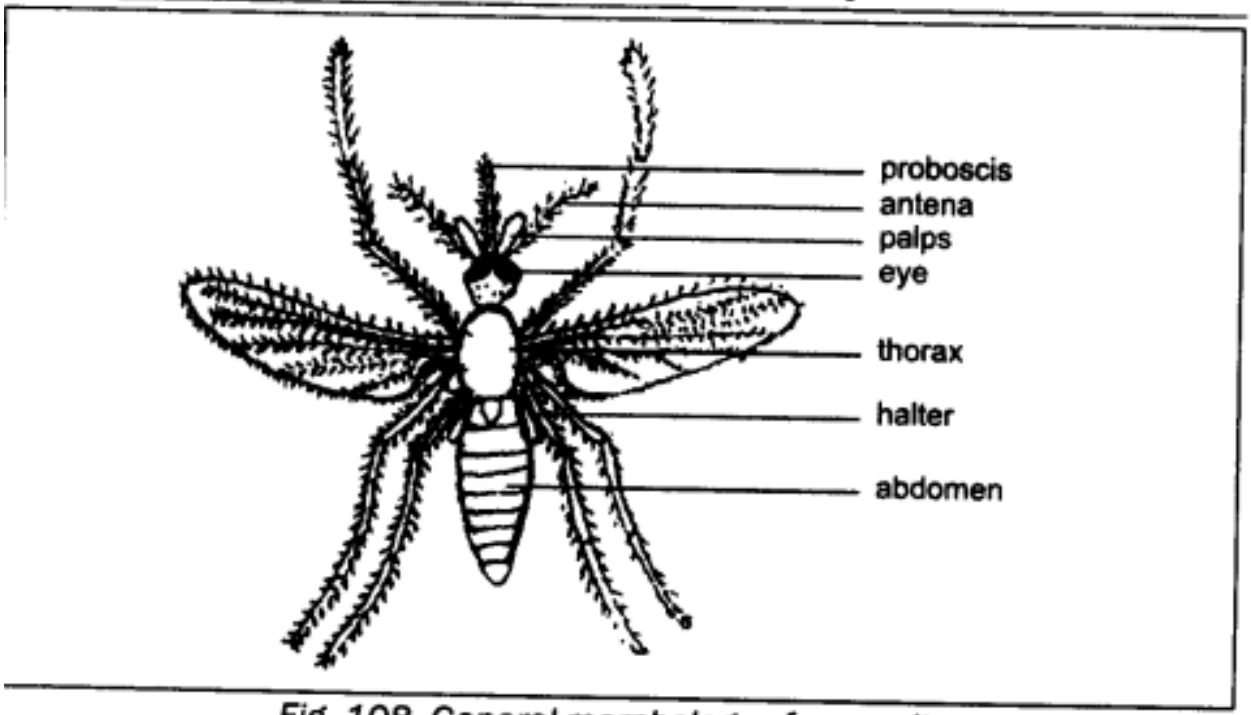


Fig. 108. General morphology of mosquito

- Eyes: Large compound eyes, holoptic in males and dichoptic in females , Ocelli absent
- Antenna: Long and slender antenna, 14-15 segmented, plumose in males and pilose in females
- Mouthparts: Mouthparts are piercing and sucking type - type of feeding is called solenophage (feeds on blood by piercing capillaries and sucking blood directly from a host.) - pipe feeding
- Only females feed on blood

Life Cycle

- All mosquito species go through four distinct stages during their life cycle:
- Egg - Hatches when exposed to water.
- Larva –Termed as "wriggler" lives in water; molts several times; most species surface to breathe air.
- Pupa –Termed as "tumbler" does not feed; stage just before emerging as adult.
- Adult -Flies short time after emerging and after its body parts have hardened.
- The first three stages occur in water, but the adult is an active flying insect. Only the female mosquito bites and feeds on the blood of humans or animals.

- *Aedes* is called the tiger mosquito due to the presence of white bands at the leg joints
- *Anopheles* is referred to as the dappled mosquito due to the presence of dappling (round spots) on the wings
- Palmate hairs are the most important characteristic feature for the identification of the larvae of Anopheles.

Vectors

- Anopheles - *Plasmodium vivax, Dirofilaria immitis*
- Culex - *Plasmodium gallinaceum*, *Dirofilaria immitis*, Eastern and western equine encephalitis, Japanese B encephalitis
- Aedes - *Plasmodium gallinaceum*, *Dirofilaria immitis*, Virus of Dengu fever of man, Virus of Yellow fever of man, Eastern and Western equine encephalitis, Japanese B encephalitis

Control

- Use of insecticide
- Application of paris green mixed with kerosene oil on the surface of the water is a common and easy practice. The larvae present in the water die due to lack of oxygen as the surface is covered by the layer of the mixture.
- Biolgical control by Gambusia (larvivorous) fish is another practice.

- Suborder - Psyclorrhapha
- FAMILY - MUSCIDAE
- Family – Muscidae - Under this family there are seven subfamilies. Of these families medical and veterinary importance are as following :
  - Muscinae
  - Stomoxinae
  - Faniinae

- MUSCA
- Common name: House fly .
- Host : Large domesticated & wild animals and birds also.
- Species : Musca domestica , Musca autumnalis, M. vomitoria, M. larvipara
- *Musca domestica*- Non -biting filth fly
- *Muscina stabulans*- False stable fly
- *Fannia canicularis* -LittIe house fly.

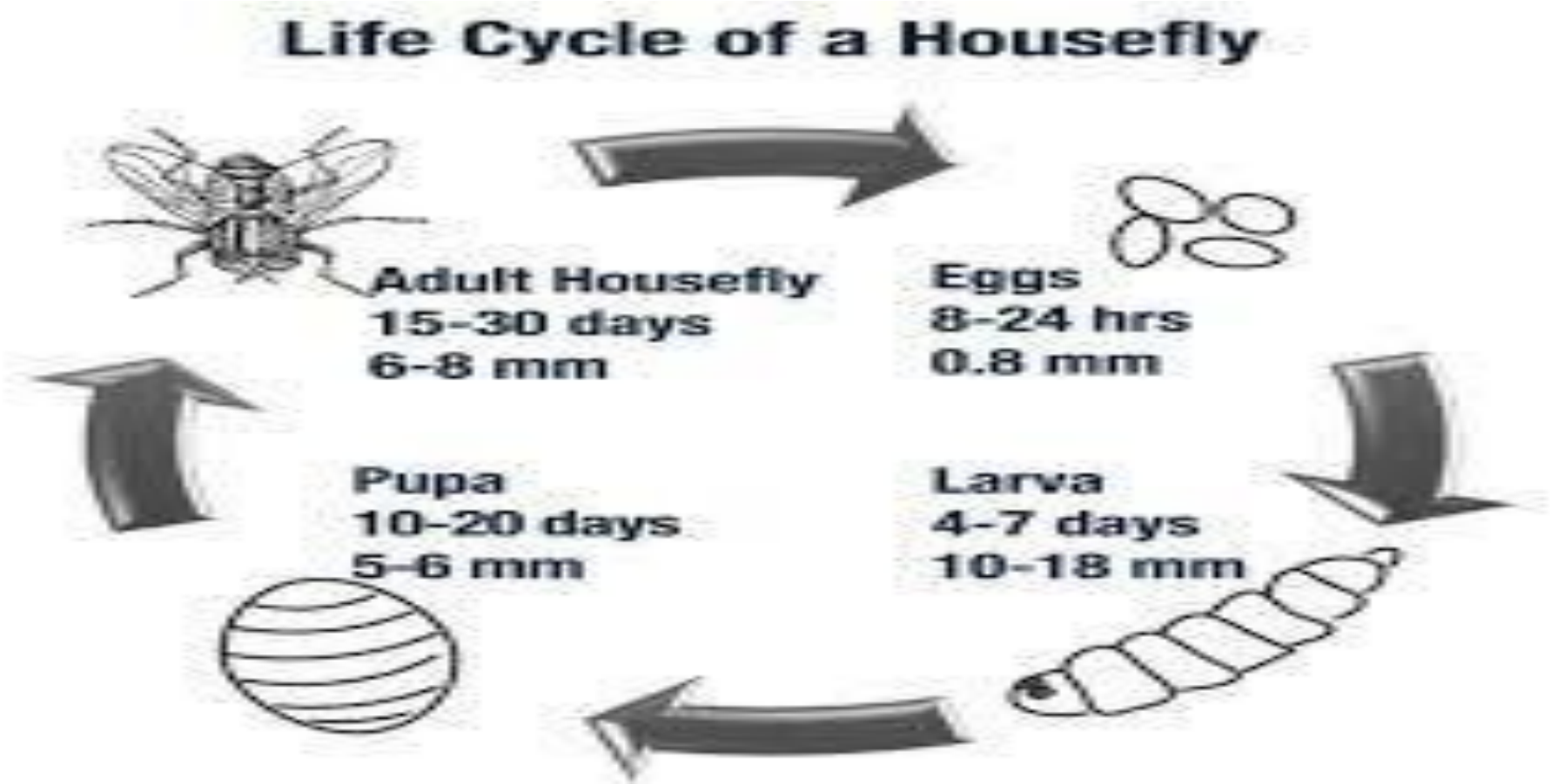
Morphology

- They are greyish to light dark flies.
- They have four distinct dark longitudinal stripes.
- Sticky hairs on pad like structure is main characteristic .
- Themouth parts is sponging type
- The wing venation is different from other flies.
- Life Cycle: Holometabolus





Musca domestica



LIFE CYCLE OF MUSCA FLY

- pathogens are mechanically transmitted by these fly:
- ‘Summer sore’ caused by *Hebronema* spp.
- Musca flies also transmits *Thelazia* and *Parafilaria bovicola* .
- causative agent of Pink eye disease

Stomoxys

- Stable Fly
- Both male and female are haematophagus

Musca	*Stomoxys*
4. Curved end of the 4th longitudinal vein reaches the tip of the 3rd longitudinal vein which is the characteristic differentiating point of this fly from *Stomoxys sp.*	4 Curved end of 4th longitudinal vein does not reach the tip of the 3rd longitudinal vein.
5. A clear longitudinal stripe is present on the abdomen.	5. Three dark spots of different size are present on the 2nd and 3rd abdominal segment.

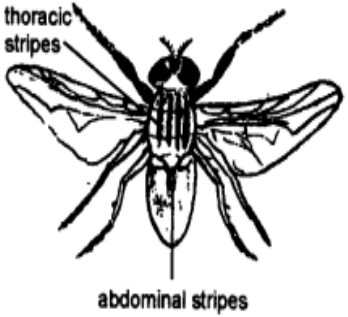


Fig. 110. Musca domestica

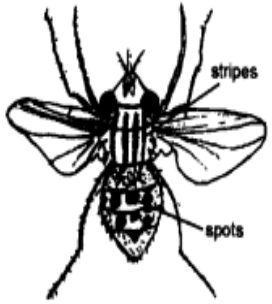


Fig. 111. Stomoxys spp.

FAMILY : OESTRIDAE

- These are medium-sized flies and are non - blood sucking. Though the flies are non - blood sucking they are important in causing nasal myiasis.
- The members coming under the family are called bot flies.
- The flies are ovoviviparous or larviparous.
- Different type of myiasis are caused by these flies.
- The flies have complete parasitic life.
- Mouth parts are nonfunctional (rudimentary) and do not feed.
- Genus : Oestrus & Hypoderma
- Species: *O.ovis & H.lineatum / bovis*

- Oestrus ovis: Sheep nasal fly, Nasal bot fly, Sheep head fly, Sheep gad fly
- The flies are small, the length range being 1 cm or more.
- In between the eyes there are presence of black pits.
- Dark spots and light brown hair are present on the body.
- The mouth is non-functional.

- The flies are larvaeparous and deposit their larvae on the nostril.
- In the nasal area particularly in the nasal passages the larva moults to the 2nd stage larva. Strong hooks are present at the anterior extremity.
- By using the hooks the larvae may reach the base of the horns affecting the turbinate bones and sinuses. In this area the larva transforms into the 3rd stage larva.
- Generally the third stage larvae is sneezed and the pupation occurs on the ground

- The infected sheep shakes its head, has a nasal discharge and sneezes frequently
- The nasal region of the affected sheep is dirty in appearance and hence the condition is sometimes called *'snotty nose'*
- Sometimes from the frontal and maxillary sinus the second stage larvae may accidentally move towards the brain, causing injury to the brain and even erosion of the skull all of which leads to neurological symptoms in sheep which resemble the condition caused by Coenurus cerebralis. Hence the condition is termed as *'False gid'* or '*sturdy'*
- The adult flies cause great nuisance. The animal stops feeding, becomes restless, shake their heads or even press their noses to the ground or between other sheep in an attempt to avoid the fly from larvipositing.

- Genus Hypoderma
- Common name - Warble fly
- Species: H. lineatum & H. bovis
- Common name : Ox warble fly, Heel fly, Cattle grub fly
- Hairy flies resembling like Bees
- Yellow orange colored hair are present on the abdomen which is the characteristic identifying feature of the fly.
- Vestigial mouth parts

Life Cycle

- The adult fly does not feed and only oviposits on the cattle – usually the lower regions of the hind legs, hence the common name *'heel fly'*
- The female flies laid eggs in hairs with a characteristics 'Buzzing sound'.
- Penetrating the hair follicle by the use of the proteolytic enzyme, the larvae enter the inner organs.
- There are specific sites of the two species: Hypoderma bovis larva is found attached to the spinal canal and epidural fat whereas the larva of H. lineatum is attached to the submucosa of oesophagus. In these areas the larvae transform into the 2nd stage.
- From this area the larvae gradually migrate to the skin region where they form swelling. In this swelling the larvae perforate and remain. This is called as the warble stage
- In the spring the larvae fall on the ground and transform into pupa.

- The affected animal become restless.
- Reduction in milk production in milch animals.
- Formation of ‘warble’ under the skin.
- Due to perforation of skin hide quality deteriorate.
- Migration of the larvae through the subcutaneous tissue results in the production of greenish yellow tracts with eosinophilic infiltrations
- The affected beef is called ‘licked beef’ while the gelatinous tracks in the beef are temed *‘butchers jelly’*

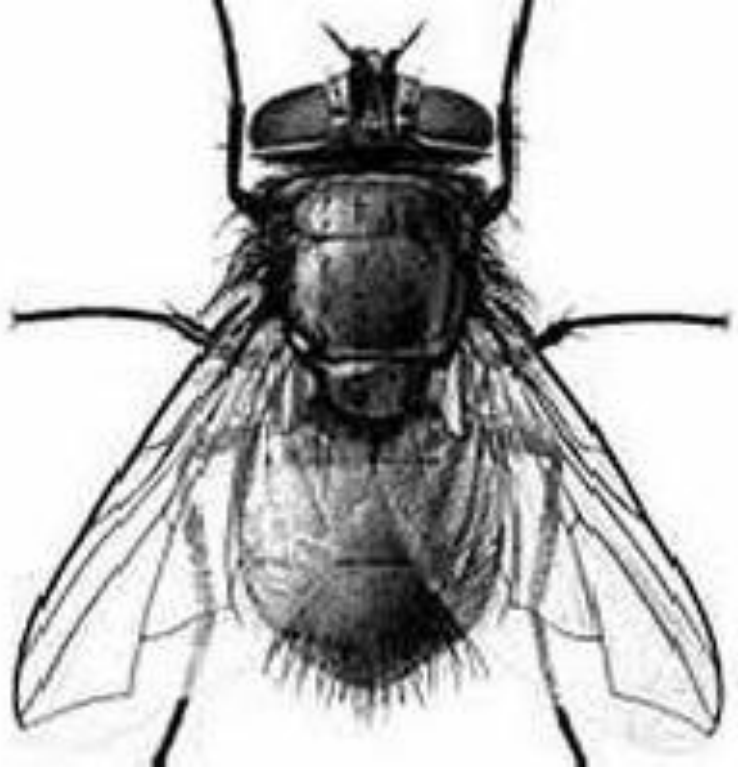
FAMILY : GASTEROPHILIDAE

- Genus : Gasterophilus
- Species : *G.intestinalis(G.equi)*, *G.nasalis*, *G.haemorrhoidalis*
- Common Name : Horse bot fly, Horse grub fly, Intestinal bot fly, Stomach bot
- The fly is a protelean parasite wherein the adult stages are non parasitic and the larval stages are parasitic
- These are medium-sized hairy flies. The flies are the causative agents of the intestinal or gastric myiasis.

- **<u>FAMILY : CALLIPHORIDAE: i</u>**ncludes large number of species whose larvae are saprophagus, flesh feeders . Family has 2 subfamilies- Calliphorinae and Sarcophaginae
- **Sub Family: Calliphorinae**
- Genus : *Lucilia* - *L.cuprina* and *L.sericata*
- Genus : *Chrysomia* - *C.bezziana*,
- *Calliphora erythrocephala*, *Callitroga hominivorax*
- These are the *"blow flies"*
- Metallic blue or green in colour

- **Genus *Lucilia* (*L.cuprina* and *L.sericata*)**
- Causes blow fly strike
- Common name: Green bottle flies, Copper bottle flies
- **Genus : *Chrysomia* (*C.bezziana*)**
- Common Name: Old world screw worm
- **Calliphora: Blue bottle flies**
- **Strike/ Myiasis** : caused by the larvae of genus *Lucilia*, *Calliphora* and *Chrysomyia*.

- Subfamily: Sarcophaginae
- Genus Sarcopbaga
- Species - S. dux
- Common name - Flesh fly
- Arista is plumose upto about half of it's length which is very specific character of Sarcophaga spp.
- The thorax has 3 longitudinal stripes.





BLOW FLY

Myiasis

- Infestation of live human and vertebrate animals with the larvae of dipteran fly which atleast for a certain period feed on the host's dead or living tissues, liquid body substances or ingested food
- In sheep it is referred to as "strike" or blow fly myiasis. Generally caused by larvae of Chrysomia, Lucilia, Phormia and Calliphora

- Obligatory myiasis - The larvae perform a parasitic life. Example - Oestrus ovis
- Accidental myiasis - Some flies are not true myiasis causing fly. However, they cause myiasis if the eggs or larvae are accidentally ingested. Example: Drosophila spp
- Facultative myiasis - The flies are not obligatory to the host, however, they take opportunity in the hosts. Different blow flies are the examples of this type of myiasis.

- Gastric myiasis Example -This myiasis is caused by Gasterophilus intestinaiis.
- Nasopharyngeal myiasis Example - This myiasis is caused by Oestrus ovis.
- Occular myiasis - Myiasis occurring in auricular region. Example - This myiasis is caused by Oestnts ovis.
- Cutaneous myiasis- This myiasis is caused by Hypoderma lineatum.
- Traumatic myiasis - This myiasis is caused by Hypoderma lineatum.
- Urogenital myiasis - This is caused by blow fly and flesh tly.

Strike

- Sheep are struck mostly in breech region – breech or crutch strike (Merino breed has narrow breech with excessive wrinkling)
- Around tail – **tail strike**
- In Rams and wethers penile sheath has a narrow opening and is soiled by urine resulting in **pizzle strike**
- Rams with deep head folds or with horns lying close to head – sweaty condition of head results in **poll strike**
- Any wounds can be struck – **wound strike**
- When dorsal region of body is affected it is called **Body strike**

Treatment

- Use of Chemicals/ Insecticides:
  - 5% coumaphos Ivermectin jetting fluid
  - Oral ivermectin / closantel
  - Chitin synthesis inhibitor – cyromazine is a larvicide
  - Synthetic pyrethroids
- Wettable powder formulation of *Bacillus thuringiensis* was found effective against *Lucilia cuprina*
- ***Sterile insect technique (SIT) :*** Release of irradiated sterile male flies into a wild population is called SIT. Female that mate with irradiated males produce eggs that fail to hatch.
- Female killing (FK) system or Genetically impaired female technique (GIFT)
- Screwworm adult trapping system (SWASS)

FAMILY -GLOSSINIDAE

- tse - tse flies
- G. morsitans G. submorsitans G.palpalis
- these flies transmit the human sleeping sickness caused by trypanosome, T. gambiense and T. rhodesiense.
- The antena is trisegmented. The third segment of which is pea -pod shaped(elongated oval).
- In both the male and female, the eyes are dichoptic.
- The wings of the flies are scissor- like which remain folded during rest. This is a characteristic identifying feature of the fly. The wings have hatchet -shaped discal cell.
- Larva capable of moving and feeding

Series : Pupipara

- **Family : Hippoboscidae**
- Genus **:** Hippobosca; Melophagus, Pseudolynchia
- include flies which lay larvae which immediately pupates
- The larvae unlike that of Glossina spp. is incapable of movement, feeding and hence the group has been placed under pupipara
- The members coming under this family are called as keds or fly.

- Species: Hippobosca maculata – cattle ked
- H.capensis – dog ked
- H.equina- equine ked
- Common name: Forest flies, Louse fly, horse keds.
- Host : All types of domesticated animals like ruminants, dog
- These flies are source of great irritation to animals .
- transmission of non- pathogenic *Trypanosoma theileria* to cattle and also transmits *Haemoproteus* spp

Melophagus

- Species : *Melophagus ovinus* Common name : Sheep ked
- Host : Sheep
- The flies are tick -like wingless found in the wool of the sheep.
- flies are of economic significance since the faeces of the flies stain the wool of the sheep.
- Morphology :
  - They are permanent parasite.
  - The body is wingless and leathery.
  - The thorax is brown and abdomen is grayish in colour .
  - The legs are strong and armed with stout.
  - Spread occur from sheep to sheep by contact.

- The parasite live in the wool of the sheep and suck blood. The Continuous blood sucking leads to anaemia. The Produce intense irritation .
- Heavy infestation leads to a condition called ‘sheep cockle or rib cockle’ – the affected skin is pitted due to allergic reaction to the bite of the ked which results in scattered brown nodules on the skin.
- The fleece of the ked produce stains in the wool.
- The keds transmits the non-pathogenic *Trypanosoma melophagium*

- Genus : Pseudolynchia
- Species : P.canariensis (P.moura)
- Common name : Pigeon fly
- These flies carry one important protozoa, Haemoproteus columbae.

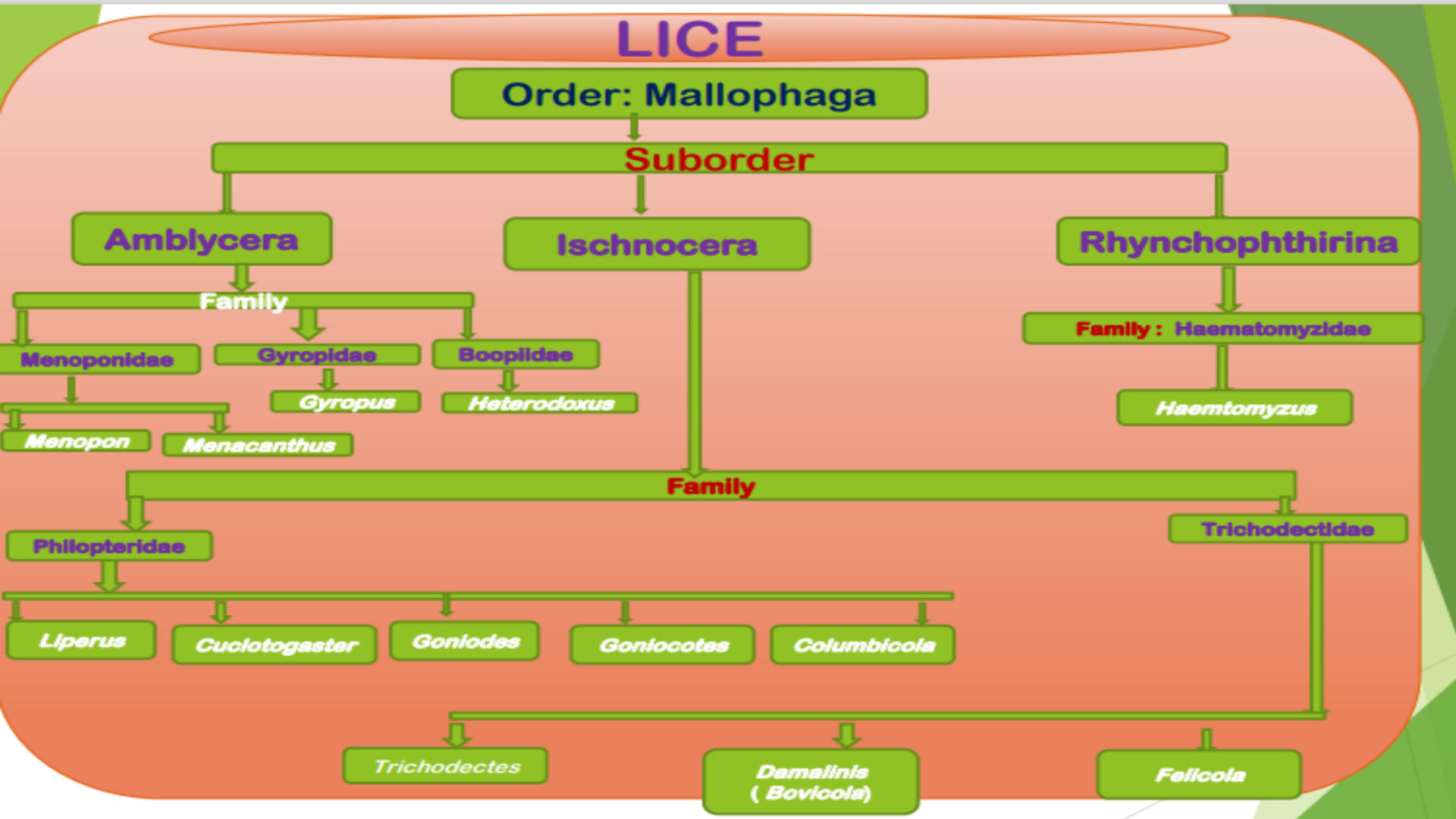
ORDER -HEMIPTERA

- Members – Bugs
- Two families are of importance : 1. Reduviidae 2. Cimicidae
- Life Cycle: Hemimetablous
- Triatoma genus is important. Because this bug acts as the vector of the important disease called Chaga’s disease caused by the T. cruzii

Louse/Lice

- Order : Mallophaga (Biting lice); Siphunculata/Anoplura (Sucking lice)
- The lice are of great economic significance since they cause loss of morbidity by causing pediculosis.
- Blood suking insects entirely parasitic on animals
- Permanent ectoparasites of birds and mammals
- Body flattened dorsoventrally and covered with small spines and Wings absent
- Spiracles dorsally situated
- Thorax with 3 pairs of legs with 2 segmented tarsus
- Mouth parts adapted for biting or sucking
- Antennae 3-5 jointed
- Metamorphosis incomplete (Egg-Nymph-Adult)- 3 Ecdyses (moults)
- Carriers of bacterial and helminthic diseases
- Highly host specific

- Sexual dimorphism
- Legs terminate in claws, the lice of mammals having one claw on each leg while those of birds have two.
- Abdominal segments often bear dark brown or black areas of thickened chitin called paratergal plates.
- Eyes are absent or reduced but are present in the human head louse (Pediculus humanus) and on the human pubic louse (Phthirus pubis)


LICE
Order: Mallophaga
Suborder
Amblycera
Ischnocera
Rhynchophthirina
Family
Menoponidae
Gyropidae
Boopidae
Gyropus
Heterodoxus
Menopon
Menacanthus
Family : Haematomyzidae
Haemtomyzus
Family
Philopteridae
Trichodectidae
Liperus
Cuciotogaster
Goniodes
Goniocotes
Columbicola
Trichodectes
Damalinis
(Bovicola)
Felicola

Biting louse	Common Name	Important characters
Damalinia (or *Bovicola*)	**Red louse** of cattle	Reddish-yellow colour with brownish transverse bars on its abdominal segments and show **parthenogenesis.**
Trichodectes canis	Yellowish louse of dog	-
Heterodoxus spiniger	**Common dog louse in warmer countries**	**-**
Felicola subrostratus	**Common louse of domestic cat**	**It is nevertheless, true biting lice, with ventral mouth parts and has pointed head, somewhat resembling the anoplurans.**
Haematomyzus elephantis	-	occurs on Indian and African elephants
Polypax spinulosa	**Spined rat louse**	-

Biting louse	Common Name	Important characters
Menacanthus stramineus or *Menopon biseriatum*	Yellow body louse of fowl, turkey and peacock	Eggs, having characteristic filaments on the anterior half of the shell and operculum, are laid in clusters on the feathers near the skin
Menopon gallinae (*Menopon pallidum*)	Shaft louse	Commonest poultry louse occurring usually in abundance throughout the year
Cuclotogaster* (*Liperus*) *heterographus	Head louse	It is a dangerous parasite of chicks and eggs are laid singly on the feathers
Cuclotogaster (*Liperus*) *caponis*	Wing louse of poultry	found mainly on the underside of the wings.
Goniocotes gallinae	**Fluff louse**	Smallest louse of poultry
Goniodes gigas	Large body louse of fowl	Characteristic triangular dark marks on the sides.
Columbicola columbae	pigeons and ducks.	-
Holomenopon leucoxanthum	Shaft louse of duck	-

Order: Anoplura

- It includes sucking lice.
- Usually long, small & pointed head.
- Slow moving and have powerful legs, each with a single large claw.
- Occur exclusively on mammals.

- Three Families:

✓ Haematopinidae

✓ Linognathidae

✓ Pediculidae

Haematopinidae	Linognathidae
Short & conical head , so know as Short nosed louse	Long & pointed head, so known as long nosed louse
All three pairs of legs are almost equal in size.	First pair leg is smallest whereas 3rd pair leg is largest
Presence of dark brown or black thickened chitin called paratergal plates , along the side of abdomen	Paratergal plates absent
Largest louse of mammal	Smaller in size

Hamatopinus spp. (Short nosed louse)

Sucking louse	Host
Haematopinus tuberculatus	**Cattle**
Haematopinus eurysternus	**Buffalo in Asia**
Haematopinus bufali	Buffalo in South Africa
Haematopinus asini	**Equines**
Haematopinus suis	Very large louse of pig

Sucking louse	Common Name	Host
Linognathus vituli	(Long nosed cattle louse or blue louse),	**Cattle**
Linognathus ovillus	Body louse or blue louse or face louse and also most pathogenic louse of Sheep	**Sheep**
Linognathus stenopsis	-	Goats
Linognathus pedalis	Foot louse of sheep	**Sheep**
Linognathus setosus	-	Dog & foxes

Sucking louse	Common name	Host
Solenopotes capillatus	-	Cattle
Microthoracius cameli	-	Camel
Pediculus humanus var capitis	Head louse	Human
Pediculus humanus corporis	Body louse	Human
Pthirus pubis	Pubic or crab louse	Human

LICE

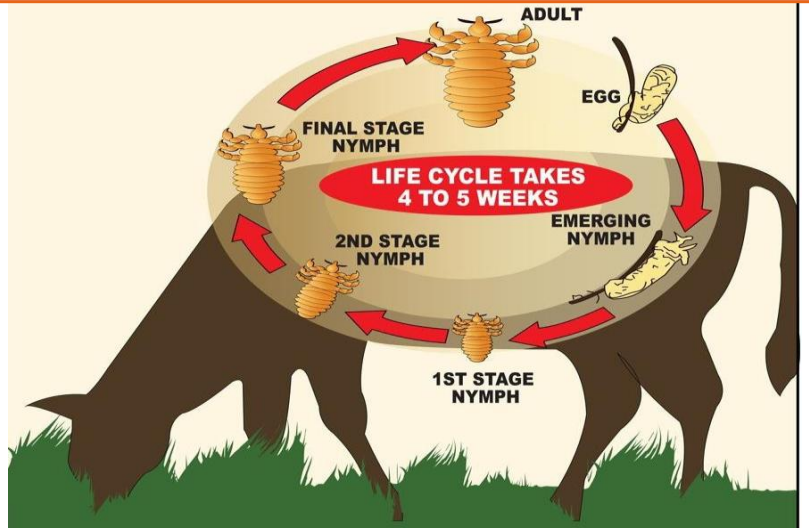
Life-cycle:

Egg/ (Nits) → Nymph (3 stages → Adult

Female louse lays about 200-300 whitish operculated eggs (nits).

Egg hatches to nymph who is similar to adult but smaller in size.





Effects on Host

- The chief effects of lice on their host are due to the irritation they cause. The egg production of birds and the milk production of cattle may fall
- They are numerous in winter, because of longer hair on the host's coat, closer contact of animals and also lack of general vigour
- Hosts become restless, do not feed or sleep well and they may injure themselves or damage their feathers, hair or wool by bitting and scratching the parts of their bodies irritated by the lice
- In mammalian hosts scratching may produce wounds or bruises on the animals, while in sheep the wool is damaged
- It is also soiled by the faeces of the lice
- The coat becomes rough and shaggy and if the irritation is severe, the hair may become matted
- Excessive licking of hairs by calves may lead to formation of "hair-balls" in stomach
- The foot louse of sheep (Linognathus pedalis) is found most frequently around the dew-claws and severe infections may produce lameness

- Polyplax spinulosa transmits Haemobartonella muris.
- Haematopinus suis transmits Swine pox in pig, Eperythrozoon suis.
- Trichodectis canis transmits Dipylidium caninum in human.
- Linognathus setosus transmits Dipetalonema reconditum

Name of lice	Host affected	Site and Common name
Menopon gallinae	Fowl	Shaft …**Shaft louse of fowl**
Menacanthus stramineus	Fowl	Body…**Body louse of fowl**
Trinoton anseris	Goose	Body… **Goose body louse**
Gyropus ovalis	Guinea pig	Body
Heterodoxus longitarsus	Kangaroo	Body
Heterodoxus spiniger	Dog	Body
Damalinia bovis	Cattle	Body… **Red louse of cattle**
D. caprae	Goat	Body
D. equi	Horse	body
D. ovis	Sheep	Body
D. ocellata	Donkey	**Donkey biting louse**
Goniodes gigas	Fowl	Body and feathers

Name of lice	Host affected	Site and Common name
Goniodes dissimilis	Chicken	**Brown chicken louse**
Chelopistes sp	Turkey	Body
Trichodectes canis	Dog	Body
Columbicola columbae	Pigeon	Body
Felicola subrostrata	Cat	**Cat biting louse**
Linognathus vituli	Cattle	Body…**Long nosed louse**
L ovillus	Sheep	**Sheep face louse of sheep**
L. pedalis	Sheep	Foot …**Foot louse**
L. setosus	Dog	Body
L. africanus	Sheep	Body… **Blue louse of sheep**
Haematopinus tuberculatus	Buffalo	Body
H. suis	Pig	Body
H. eurysternus	Cattle	Body… **Short nosed louse of cattle**
H. asini	Equine	Body

Polyplax spinulosa	Rat	**Spined rat louse**
Microthoracius cameli	Camel	Body
Phthirus pubis	Man	Pubic hair …. Crab louse
Pediculus humanus	Man	Human head and body
Cuclogaster heterographus	Fowl	Head.. **Head louse of poultry**
Lipeurus caponis	Fowl	Wing…. **Wing louse of birds**
Goniocotes gallinae	Pheasant and pigeon	Base of the feather…. . **Fluff louse of poultry**
Anaticola crassicornis	Duck	Body
Haematomyzus elephantis	Elephant	Body

ACAROLOGY

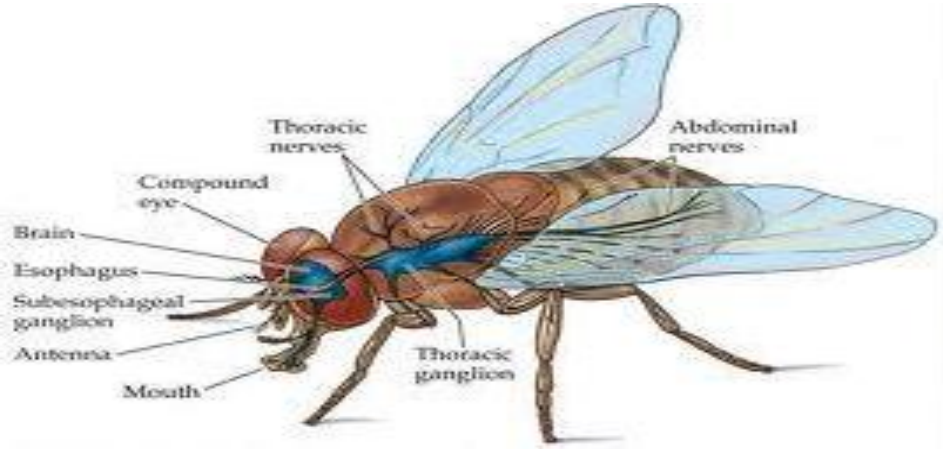
- scientific study of mites and ticks
- Class- ARACHINIDA
- Order-ACARINA
- Suborder
  - Ixodoidea (Hard and Soft ticks)
  - Sarcoptiformes (Mites)
  - Mesostigmata (Gasmasid mites)
  - Trombidiformes (Fruit pests)

INSECTA

1. Three (3) pairs of legs .
2. Body is divided into 3 parts Head, Thorax, and Abdomen .
3. Single pair of sensory antennae .
4. Eyes are absent or reduced but well developed in blood sucking

ARACHINIDA

1. Four (4) pairs of legs .
2. Body is divided into 2 parts Cephalothorax & Abdomen
3. No antennae .
4. Eyes are absent or reduced .





- Ticks mouths have three parts.
- First are the two chelicerae, which the tick uses to cut through the skin of its host.
- Second is the hypostome, a barbed, needle-like structure that it uses to hold itself in the host while it has a nice meal. The barbs point backward which makes it difficult to pull the tick out.

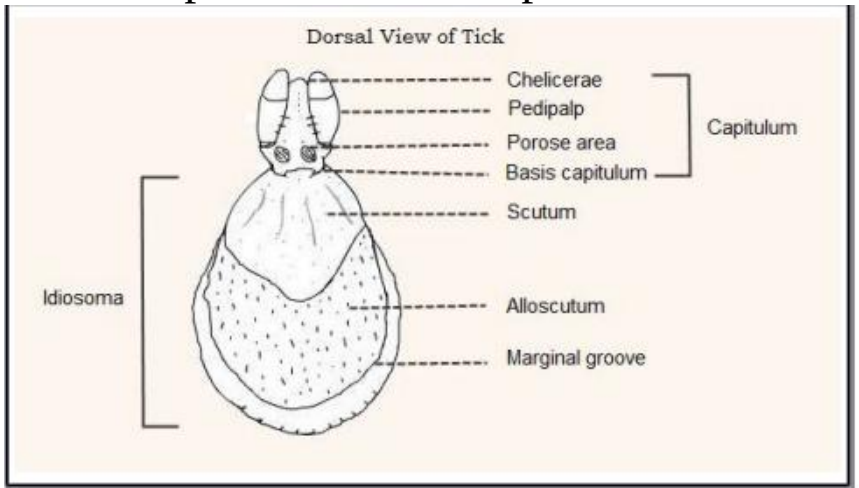
Ixodidae	Argasidae
1. These are called hard ticks.	1. These are called soft ticks.
2. Body is hard with thick plates or ridges	2. These are leathery ticks with tough texture.
3. Mouth parts are clearly visible as these are anterodorsally present. In many ticks there is presence of posterior **festoons** which are the notched appearances having taxonomic importance.	3. Mouth parts are not visible from outside as these areas are present in the anteroventral surface. Posterior notch or the festoons are absent.
4. Eyes are either present or absent but when present, these are located at the sides of the lateral area of scutum.	4. Normally the eyes when present are in the **supracoxal folds** above the legs.
5. Dorsal **scutum** is present in both male and female which is the key to sexual dimorphism. The scutum covers only the anterior third of the female whereas it covers the whole surface in the male. Therefore, the size of the scutum is important in the identification of the male and female.	5. In both male and and female the scutum is absent.

6. The respiratory apparatus or the spiracles are two in number and situated at posterolateral margin of the fourth coxae.	6. The respiratory apparatus or the spiracles are two in number and situated at posterolateral margin of the third coxae.
7. Mating occurs on the host itself.	7. Mating does not occur on the host but this occurs outside of the host.
8. Throughout the entire period of the life cycle only one nymph stage is found.	8. Throughout the entire period of the life cycle several nymph stages are found.
9. The hard ticks feed on the host for a number of consecutive days.	9. The soft ticks take their meal for few minutes.
10. These ticks feed on the host until their full engorgement.	10. The ticks feed on the host intermittently.

- Body consist of
- Capitulum (=Gnathosoma)
- Idiosoma: Idiosoma is further divided into

  o Podosoma which bears the legs and genital pore.

  o Opisthosoma- region posterior to the legs, bears the spiracle and anal aperture.



FAMILY -ARGASIDAE

- SOFT TICKS
- Argasids are soft leathery ticks.
- Sexual differentiation is slight.
- In larva, capitulum is visible from outside but in nymph and adult, capitulum is not visible from outside.
- Eyes may or may not be present. When eyes are present, they are located in the supracoxal folds above the legs.
- In the Argasidae there are several nymphal stages.
- The soft ticks suck their hosts several times but the hard ticks suck the hosts continuously for several days.
- The soft ticks are primarily nocturnal.
- Genera Otobius, Ornithodoros, Argas

Genus	*Argas*	*Otobius*	*Ornithodoros*
Species	*A. persicus*	*O. megnini*	*O. savignyi*
Common name	Fowl Tick	Spinose Ear Tick	Eyeless Tampan

- Genus : Argas
- Species : A. persicus
- Common name : Fowl Tick
- Host : Fowl, Turkey, Pigeon, Duck, Geese, Ostrich, Wild birds
- Location: Adults in cracks and crevices of fowl house, under trees
- Oval to pear-shaped in outline.
- When the ticks are unfed, these look pale yellow in colour. These become darker when they are fed.
- Outer margin is sharp.

Life Cycle

- Developmental stages
- Egg
- Larva
- Nymph (2 nymphal stages)
- Adult
- Act as vector for Aegyptionella pullorum and Borrelia anserina (Fowl Spirochaetosis)

Genus : Otobius

- Species : O.megnini
- Common name : Spinose ear tick
- Host : Dog, Sheep, Horse, Cattle, also goats, pigs, cats, man, rabbits etc
- Location : Nymph and Larva in internal ear
- Adult in cracks of poles, under food boxes or stones
- The most identifying character is the presence of a constriction on the middle part of the body.
- The adults are fiddle/ Violin-shaped having a constriction at the middle.
- The nymph is spiny and for which the nymph is called spinose ear tick.

GENUS- ORNITHODOROS

- Species: o. moubata, O.savignyi
- Ornithodoros moubata
- Common name - Eyeless tampan
- O. moubata is the vector of Borrelia duttoni, a causative agent of African relapsing fever.
- O. savignyi is the eyed tampan which affect fowl, camel and man etc.

Life cycle

- Developmental stages • . Egg • Larva • Nymph (4 nymphal stages) • Adult
- The eggs are laid on the sand and hatch within a week and the larvae come out.
- The main characters of the larvae is that the larvae do not feed.
- The larvae then transform into nymph after a few days.
- The number of nymphal stages is variable and four nymphal stages are required for the formation of male tick and five nymphal stages are required for the formation of female ticks.
- The nymph attacks the host and suck blood and drop on the ground and becomes adult.

Hard Ticks

- Ixodes, Hyalomma, Rhipicephalus (Boophilus), Haemaphysalis, Dermacentor and Amblyomma
- In male, entire dorsal surface is covered by scutum.
- In female, larval and nymphal stages show scutum which covers very small portion of dorsal surface just behind gnathosoma.
- Females are 2 to 3 times bigger than males because females are voracious blood suckers.
- On ventral surface (side) in male ticks certain chitinous plates are present called as ventral plates. These ventral plates are absent in female.

- On anterior end, mouth parts are located on chitinous plate called as “Basis capatulum”.
- Proboscis consist of two pedipalps, two chelicerae and a hypostome so ticks are attached to body of host as mouth parts are inserted to skin have firm grip.
- In some species of ticks, the posterior margin had series of knotches and these are refered as festoons.
- Eyes are present in some species they are located at the level of 2^{nd} coxae.
- In hard ticks, spiracles are present posteriolateral to 4^{th} coxae and depending upon shape of spiracles, different species and also males and females can be identified.
- In addition to these, in some species, colored enamel like areas are present, such ticks are called as “Ornate ticks”e.g. Amblyoma, Dermacentor while others are inornate ticks.

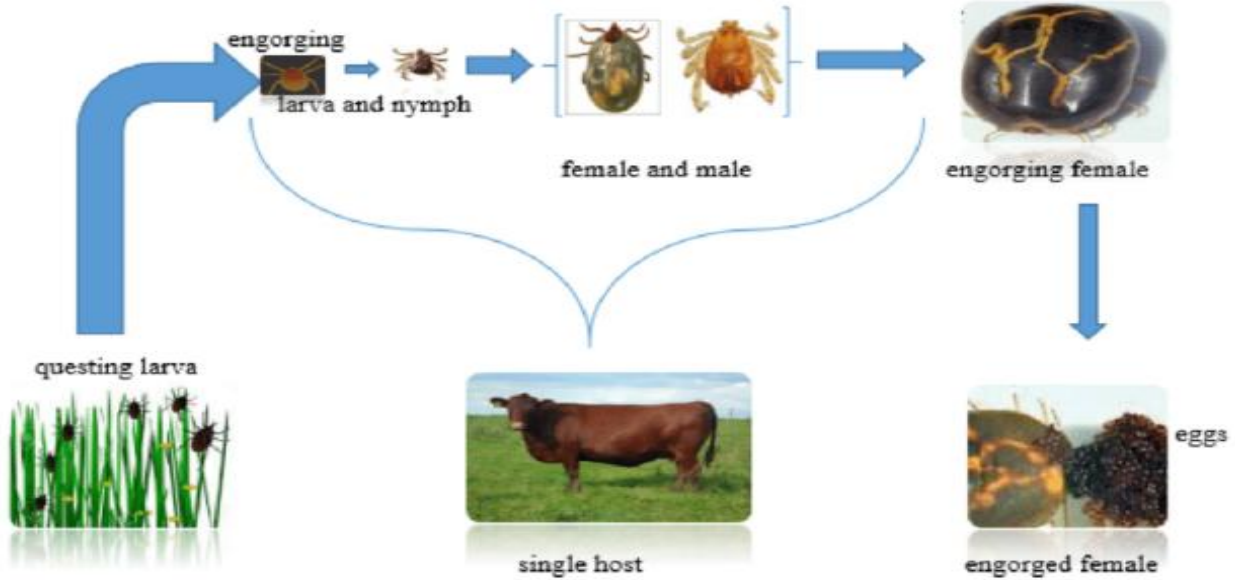
Life cycle of hard ticks

- Female ticks after engorgement drop down from body of host. In cracks and crevices they lay eggs.
- The period between dropping of female ticks from body of host till deposition of eggs is known as “Preoviposition period”
- The egg laying is a continuous process which is extended over a period of few days and this period is known as “Oviposition period” and all the eggs are laid during these period.
- One female lays around 4,000 to 18,000 eggs during her life span

- Eggs - spherical and yellowish brown in colour and laid in masses.
- Eggs are cemented to each other by sticky substance. Then eggs hatch and larvae comes out.
- The larva has three pairs of legs and on dorsal side short scutum is prsesent. Larvae climb on grass blades, plant and remain at tip of grass blades and while animal is passing, they attach themselves to body of host.
- The larval stages which are present at tip of grass blades, are also referred as “Seed Ticks”.
- Larval stages feed upon host blood and moult to nymphal stages. There is only one nymphal stage in life cycle of hard ticks.
- The nymphal stages suck blood and moult to adult stages. Then the copulation occur and subsequently adult stages start sucking blood and engorged females drop from body of host and lay eggs in cracks and crevices where as male remain on body of host for one month.
- Female ticks die immediately after deposition of eggs. All stages are parasitic.

One Host Tick

- In this case, both the moults occur on the body host and since host is required only once for completion of life cycle, tick is known as one host tick.e.g. Boophilus microplus.



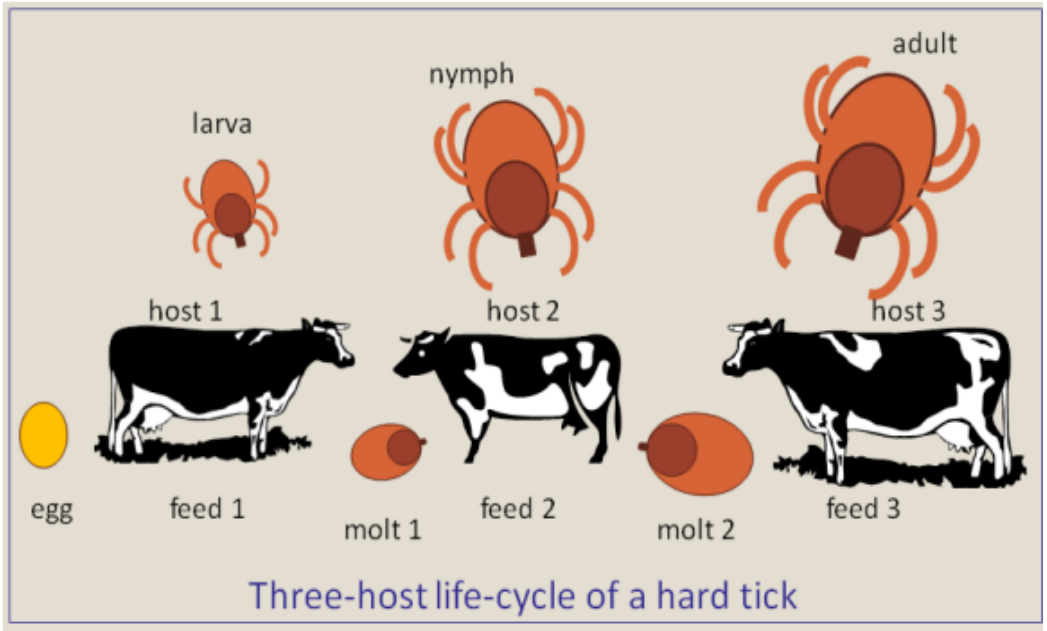
Two Host Tick

- In this case, either same or different host is required twice, and 1st moult occurs on the body of host whereas 2nd moult occurs on the ground, hence it is called as two host tick. e.g. Rhipicephalus evertsi, Rhipicephalus bursa.



Three Host tick

- In this case, both the moults occur on the ground, host is required for three times for the completion of life cycle, therefore ticks are known as “Three Host Ticks.” e.g. Haemaphysalis, Hyalomma, Amblyomma and Ixodes.



Genus – Ixodes

- Palpi long, inornate, eyes and festoons absent, ventral surface of male armed with pregenital, median, anal, epimeral and adanal shields.
- Stigmatic plates oval in male and circular in female.
- *Ixodes ricinus*: Castor bean tick or sheep tick
- Three host tick - It is responsible for transmission of Babesia divergens, Babesia bovis, Anaplasma marginale, Lyme disease, virus of louping ill, Coxiella burnetti, Tick borne encephalitis
- Ixodes holocyclus – paralysis tick of Australia
- Ixodes scapularis- shoulder tick or black legged tick.

Genus – Boophilus

- Anal groove absent in female, faint in male and surrounding the anus posteriorly.
- Inornate, eyes present, festoons absent, palps and hypostome short, palps with prominent transverse ridges, coax-I bifid, spiracles circular or oval.
- Males are provided with adanal or accessory shields and a caudal process, fourth pair of legs are ordinary in size
- *Boophilus microplus*:One host tick, also called tropical cattle tick
- It is responsible for transmission of Babesia bigemina, Anaplasma marginale and Coxiella burnetti.
- *Boophilus annulatus*- one host tick also called north American tick transmits Babesia bigemina in America
- *Boophilus decoloratus*- one host tick also called blue tick

Genus – Hyalomma

- Inornate, sometimes ornate, eyes present, festoons present or absent, hypostomes and palpslong , male with a pair of adanal shields and sometimes accessory adanal shields, spiracles comma shaped in males and triangular in female
- The basis capitulum is characreristic which is subtriangular dorsally.
- Usually two host tick, though three hosts may be used by some species.
- Important species – *Hyalomma anatolicum anatolicum*, *Hyalomma marginatum*, *H. dromedarii*
- Significance: It transmits *Theileria annulata*, *Theileria parva*, *Theileria dispar, Babesia caballi*, *Babesia equi*, *Coxiella burnetti*

- Tick paralysis is tick-borne disease that is caused by a neurotoxin produced in the tick's salivary gland. After prolonged attachment, the engorged tick transmits the toxin to its host. The incidence of tick paralysis is unknown. Patients can experience severe respiratory distress.

Genus- Rhipicephalus

- Usually inornate, eyes and festoons present, hypostomes and palpi short, basis capituli hexagonal dorsally, coxae-I with two strong spurs, males with adanal shields and usually also accessory adanal shields, frequently with a caudal prolongations when engorged, spiracles are comma shaped, short in female and long in male
- Dorsally basis capitulum is hexagonal.
- Rhipicephalus appendiculatus: Brown ear tick, three host tick
- It transmits Theileria parva, Theileria mutans, Hepatozoon canis, viruses of Nairobi sheep disease, louping disease. In heavy infection, tick toxicosis may occur.
- Rhipicephalus sanguineus: Brown dog tick, three host tick
- Rhipicephalus evertsi: Red legged tick, two host tick
- Rhipicephalus bursa: Two host tick

Genus: Haemaphysalis

- Ticks are inornate, eyes are absent, festoons present, palps usually short and conical, the second articles having conspicuous lateral projections. The trochanter of the first pair of legs bears a dorsal process. Spiracles are ovoid or comma shaped in females and ovoidin males.
- Rectangular basis capitulum
- Salient characteristic feature is palpal segments. The second palpal segment is very characteristic as this segment causes lateral projection which projects behind the margin of the basis capitulum.
- Ventral surface of male is without plates.
- Species usually of small size
- Haemphysalis leachi leachi The yellow dog tick, three host tick

- Rickettsia rickettsii, causative agent of Rocky Mountain spotted fever transmitted by these ticks
- The tick transmits the bacteria through transovarial transmission to its host.
- Kysanur Forest Disease: by H. spinigera

Genus - Dermacentor

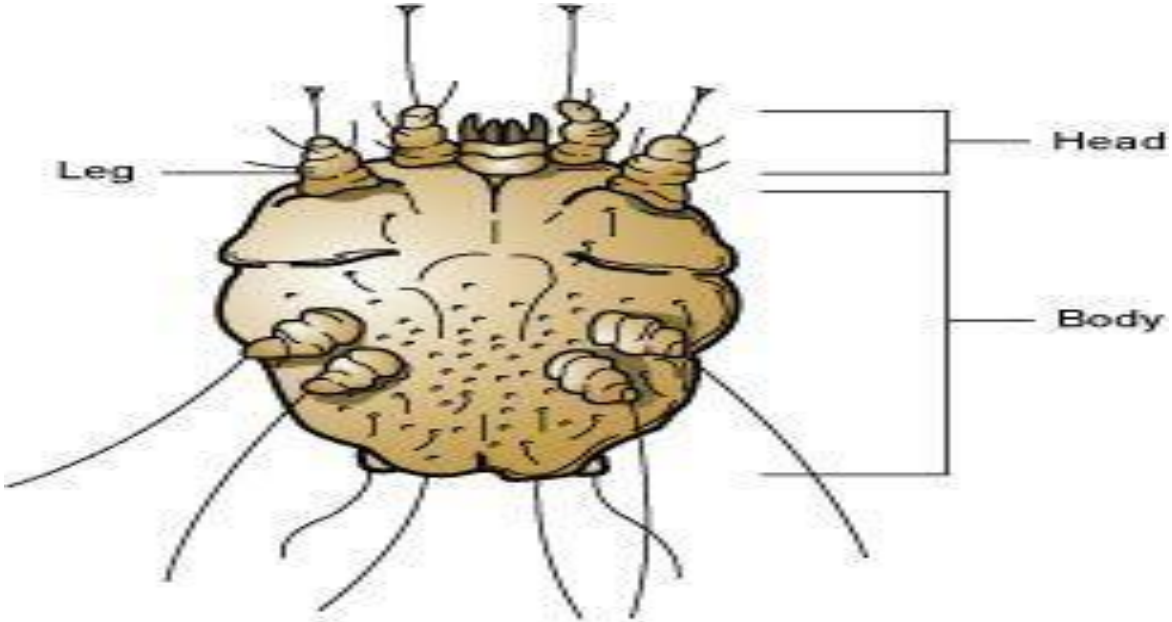
- Usually ornate, eyes and festoons are present, Hypostomes and palps short, coxa-I bifid and coxa IV of male much larger than coxae I to III. No plates on ventral surface of male.
- Dermacentor reticulatus: Three host tick It transmits Babesia caballi, B. equi and B. canis.
- Dermacentor andersoni: Three host tick, transmits rocky mountain spotted fever, tularemia (Pasteurella tularensis) to man, equine encephalomyelitis, Anaplasama marginale, Babesia canis, Coxiella burnetti, Leptospira pomona. It also causes tick paralysis in man and animals.
- Dermacentor variabilis- American dog tick, three host tick
- Dermacentor nitens- tropical host tick, one host tick It transmits equine piroplasmosis.

Genus: Amblyomma

- Usually ornate, eyes and festoons present, hypostomes and palps long, males without ventral plates, but small chitinous plates may be present close to the festoons. The species are usually large and broad.
- Ambylomma hebraeum: Also called bont tick, three host tick
- Ambylomma variegatum- also called variegated tick or tropical bont tick, three host tick. It transmits heart water disease in cattle and sheep, Nairobi sheep disease and Coxiella burnetti.
- Ambylomma americanum- also called lone star tick.

Character	Ticks	Mites
Size	Macroscopic	Mostly microscopic
Eye	Usually present	Usually absent
Basis capituli	Well developed	Not well developed
Legs	Laterally situated and uniform in shape	Last two pairs of leg are situated posteriorly. legs of some mites bear stalk and/or sucker at the terminal part
Type of parasite	Temporary	Permanent
Location on host	On the skin	beneath the skin
Hairs and bristles	Not prominent	Prominent

Mites



- Mange: disease caused by mites
- **Sub-order :**

✓ **Gamasida (Mesostignmata)**

✓ **Actinedida (Prostigmagta)**

✓ **Acaridida (Astigmata)**

✓ **Oribatida (Cryptostigmata)**

Family: Sarcoptidae

- **Globular shaped body**
- **Scales and spines - present on the dorsal surface.**
- Four pairs of legs are present.
- Bell shaped suckers are present in 1st and 2nd pair of legs in females and 1st, 2nd and 4th in male while the 3rd pair of legs in the male and the 3rd and 4th in the female end in bristle.
- Pedicels which bear suckers or bristles are non- segmented.
- Male has no adanal suckers (Copulatory discs).
- Mites create burrow, in the skin causing marked thickening rather than scabs formation.
- *Sarcoptes* & *Notoedres*

Sarcoptes

- Species - *Sarcoptes scabiei*
- **Body is globular with short legs which scarcely project beyond the body margin.**
- **3rd and 4th pairs of legs do not project beyond the body margin**
- **Dorsal surface has the numerous transverse ridges and triangular scales on the dorsal surface of body.**
- **Anus is terminal**

- Transmission: Infection is spread mainly by contact by the wandering larvae, nymphs and fertilized young females.
- through fomites i.e. grooming tools, clothing, blanket etc.
- Female mites lays about 35-50 egg in the tunnel of the upper layer of skin.
- Eggs hatch into larvae. Larvae burrow into the superficial layer of skin layer and create a small pockets in which larvae molt in to nymphal stages.
- Male mites die after mating and female extend the pockets and form a new tunnels.
- Entire life-cycle is completed on the host in 17-21 days.

Pathogenesis

- Mites create burrow in the skin causing marked thickening rather than scabs formation.
- Mites suck lymph and may also feed on young epidermal cells.
- Female mites burrows into the epidermis and forms molting pockets and tunnels.
- The burrowing and feeding activities of the mites cause irritation and consecution itching leading to exudation and formation of crusts .
- Skin become thickened and wrinkled due to proliferation and keratinization of connective of skins.
- Hair losses (alopecia) leading to bald patches on the skin.
- Secondary bacterial infection may occurs
- Scabies is an itchy skin condition caused by a tiny burrowing mite called Sarcoptes scabiei.

- Clip the hairs around lesion and scrap the edges of skin lesions with the help of a blunt scalpel or blade to extent that a little blood begins to ooze through the abrasions .
- Collect the scraping materials on a plane paper.
- Skin scrapings should be taken from moist part near the edge of the lesion avoiding the inclusion of large amount of dry crust, hair or wool. It is also desirable to take scrapings from more than one lesions.
- Boil the scraping materials in 10 percent KOH to dissolve debris.
- After cooling pour the materials into centrifuge tube and centrifuge for 2 minutes at 2000 rpm.
- Take one drop of sediment on a glass slide , cover with cover slip and examine under low power (40X) of microscope for the presence of mites.

- Species: Notoedres cati
- Host: Cat and sometimes rabbit
- Morphology: Similar to Sarcoptes but the differentiating characters are: Anus is dorsal and sub-terminal position whereas anus is terminal in Sarcoptes.

Cnemidocoptes

- C. mutans - Causes 'scaly leg 'of poultry. The mites cause lesion on the legs wherefrom the exudates come out and the skin becomes thickened. The scales are detached from the area.
- C. gallinae":' causes 'depluming itch'of poultry.
- The mites affect the shaft of the feathers. The area becomes inflamed. The continuous irritation caused by the mite results in itching. The birds pluck the feathers by their beaks or the feathers automatically fall down.
- *Cnemidocoptes pilae*: It caused tassel foot in fowl

Family : Psoroptidae

- Members (*Psoroptes, Chorioptes and Otodectes)* are non- burrowing mites.
- Do not burrow in to the dermis and feed generally on skin scales but few also suck tissue fluid or blood and causing the formation of thick heavy scabs rather than thickening of the skin.
- Oval in shaped body with no scale and spine.
- All legs are projected beyond the body margin.
- Anus is terminal and the male has adanal suckers.

Mites	Salient features
Psoroptes	**Host-specific, legs projecting beyond the body margin, male has posterior two abdominal lobes, bell shaped suckers on pedicels (three-jointed).**
Chorioptes	**Unjointed Pedicels. Suckers are present on legs of male and in females on 1st and 2nd pair of legs. 4th pair of legs is small in female.**
Otodectes	**Pedicels are unjointed. Suckers are present on all legs of male and in females on 1st and 2nd pair of legs. The 4th pair of legs are small for female.**

Species	Host
Psoroptes ovis	sheep and rarely cattle
Psoroptes equi	Horse
Psoroptes natalensis	Cattle and water buffalo
Psoroptes cuniculi	Rabbit, goat, sheep, horse etc.

- ## Pathogenesis:
- It is a type of non-burrowing mite.
- It causes **sheep scab (sheep scabies)** in sheep.
- Mites pierce the skin and suck host's lymph and cause irritation and inflammation.
- Exudation of lymph coagulates to form crusts.
- ## Clinical signs:
  - Rubbing and scratching of the affected areas against hard objects.
  - Wool becomes loose and fall out or it pulled up by the infested sheep during biting and scratching of the lesions
- Sheep scab is most active during autumn and winter while latency tends to occur in summer due to less active feeding and decreased oviposition by the mites.

- *Psoroptes cuniculi* found mainly in the ear canal of rabbits, deer and goat and leading to **ear canker** commonly in laboratory rabbits.

- Symptoms of ear canker are repeated shaking of the head, scratching, crust formation leading to a septic otitis media and loss of balance may also occur.

- *Psoroptes natalensis* is called body mite of domesticated cattle.

- *Otodectes cynotis* is commonest mange of cats and dogs and cause ear or otodectic mange (**Otitis externa**) or otoacariosis in the dog, cat, fox and other carnivores.
- It causes shakes head and scratches the ears, ears droop and haematoma of ear.

Genus: *Chorioptes*

- *Chorioptes bovis*
- Non-burrowing mite.
- It causes **leg mange** or **foot and tail mange** or **symbiotic mange** or **scrotal mange** or **barn itch** or **itchy disease** which affects usually the long hair fetlock region of horse and is characterized by itching and scab-like lesion.
- Affected horses rub, stamp, scratch and bite the legs and kick frequently especially at night.
- In cattle, camel and in wild ruminants, the root of the tail are generally affected.
- *Chorioptic* mange is most prevalent during the winter.

Family: Demodicidae
Genus*: Demodex*

- Genus: *Demodex*
- Common Name: Follicle mite
- General Characters

- Highly host specific.
- Elongated body (cigar shaped) divided into head, thorax with four-pairs, five segmented stumpy legs
- Transversely striated abdomen
- Usually found as commensal
- Eggs are spindle- shaped.

- Location: Hair follicles and sebaceous glands of animals in a characteristic head-downward posture. Usually found as commensal

Species	Hosts
Demodex canis	Dog
Demodex cati	Cat
Demodex bovis	Cattle
Demodex ovis	sheep
Demodex caprae	Goat
Demodex equi	Horse
Demodex phylloides	Pig
Demodex folliculorum	Man

Pathogenesis

Demodex species live as commensals in the hair follicles and sebaceous glands of most mammals and may erupt in dogs when immunosuppressants are given.

Two forms of canine demodicosis:

I. **Squamous demodicosis**: less serious. It causes alopecia, and thickened and wrinkled skin with a mousy odour. Hyperpigmentation occurs giving the skin a coppery-red colour.

II. Pustular demodicosis: severe form and follows bacterial (*Staphylococcus pyogenes albus* or other allied bacteria) invasion of the lesions. Pustular demodicosis is commonly called **red mange** because serum, pus and blood ooze out from the formed pustules.

- Demodectic mange is also called **red mange** or **follicular mange** or **puppy mange**.
- Death in canine demodicosis occurs due to toxaemia or emaciation.
- **Absence of pruritis in the demodectic mange infection.**
- **Canine demodicosis generally occurs at the age of 3-9 months of age.**
- ***Demodex* itself is thought to cause a cell mediated immunodeficiency which suppress the Normal T-lymphocyte response**

Treatment

- Effective treatment depend upon the type of demodicosis:

❖ Localized demodicosis: lesion heals spontaneously and treatment is not necessary. Application of Benzoyl peroxide is effective.

- Generalized demodicosis:

✓ Application of acaricide like Amitraz, Ivermectin etc. are effective.

✓ Application of Benzoyl peroxide shampoo for bathing.

✓ Broad spectrum antibiotic to treat secondary pyoderma.

✓ Steroids are contraindicated in any kind of demodicosis.

Mesostigmata/Gamasida

Species	Hosts	Common Name / location
Dermanyssus gallinae	poultry	Red mite of poultry
Ornithonyssus bursa	Fowl	Tropical fowl mite
Ornithonyssus bacoti	Cattle	Tropical rat mite
Pneumonyssus caninum	Dog	Found in nasal passage of dog
Raillietia auris	Cattle & buffalo	Found in ear of cattle & buffalo

Family: Trombiculidae

- **Commonly called chigger mites or harvest mites or velvet mites.**
- *Trombicula autumnalis* found on vertebrates including man & poultry.
- Feed on the body of skin by the feeding tube i.e. stylostome.
- Symptoms includes intense itching and dermatitis
- Caused “heel bug” of racehorses.

Diagnosis

- Samples to be required for the Diagnosis of Various Parasites :

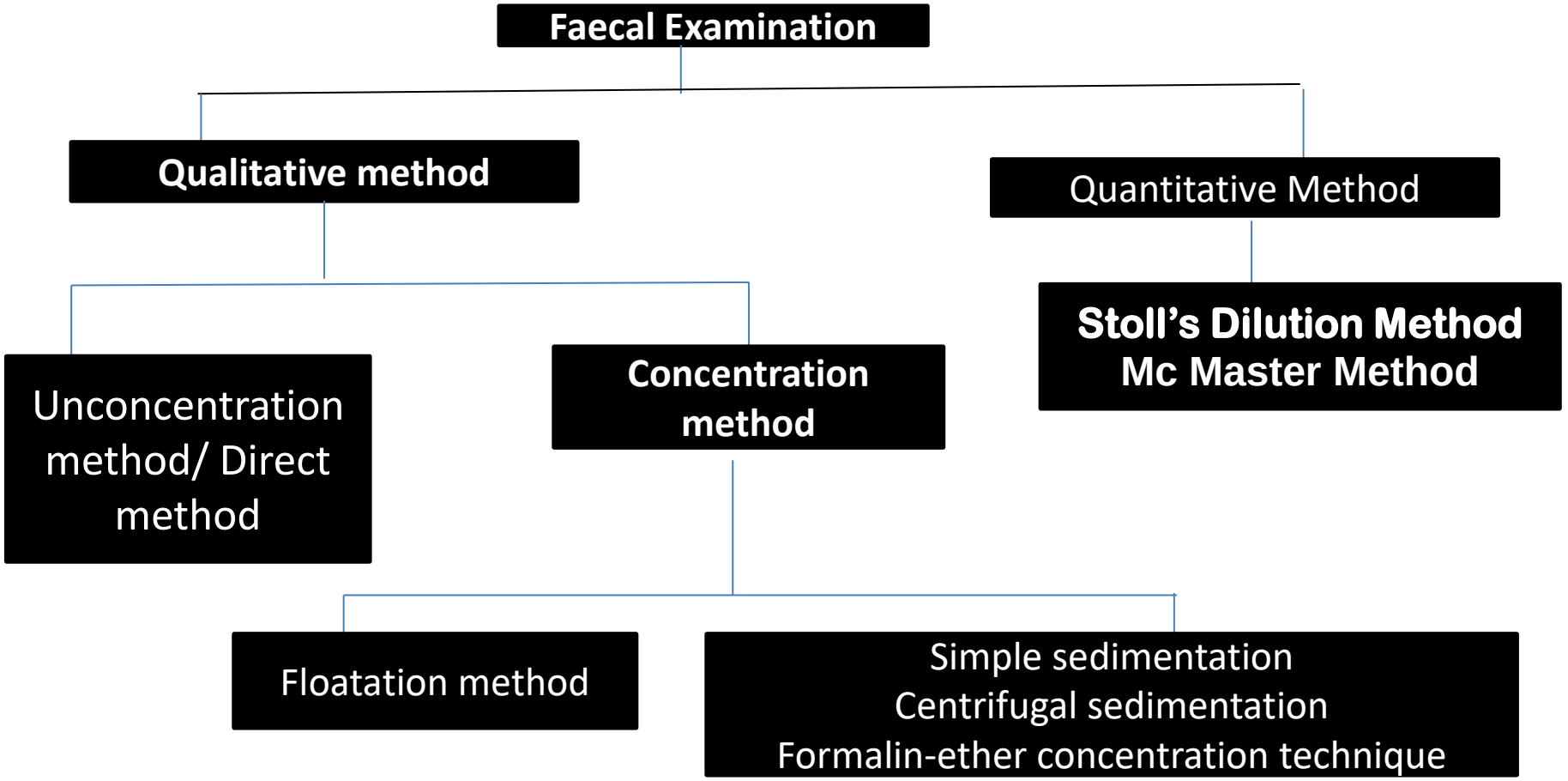
✓ Faeces ✓ Blood ✓ Nasal scraping ✓ Urine ✓ Lymph node biopsy ✓ Skin scraping ✓ Sputum

- Nasal discharge :- For the diagnosis of Schistosoma nasale.
- Urine sample :– For the diagnosis of kidney worms (Stephanurus dentatus in pig & Dictophyma renale in dog) and Schistosoma haematobium.

Faecal Examination Techniques

- ❖ Faecal samples – for the diagnosis of Gastrointestinal helminths parasites.
- In faeces, adult parasite, eggs, larvae, cysts, trophozoites or oocysts of parasite may be found.
- Preservation of collected faecal samples – 10 % Formalin or 70 % Ethyl alcohol.

Faecal Examination Techniques



Floatation Method

- Principle- When worms eggs are suspended in a liquid with a specific gravity higher than that of eggs, the latter will float up to the surface.
  - Common saturated solution used in floatation technique: Sodium chloride (specific gravity- 1.20), Sugar (specific gravity- 1.12-1.30), Zinc sulphate, Magnesium sulphate etc.
  - This method is not suitable for eggs of trematodes or most cestodes but is useful for the majority of nematode eggs as the formers do not float

400. (Figure 2)

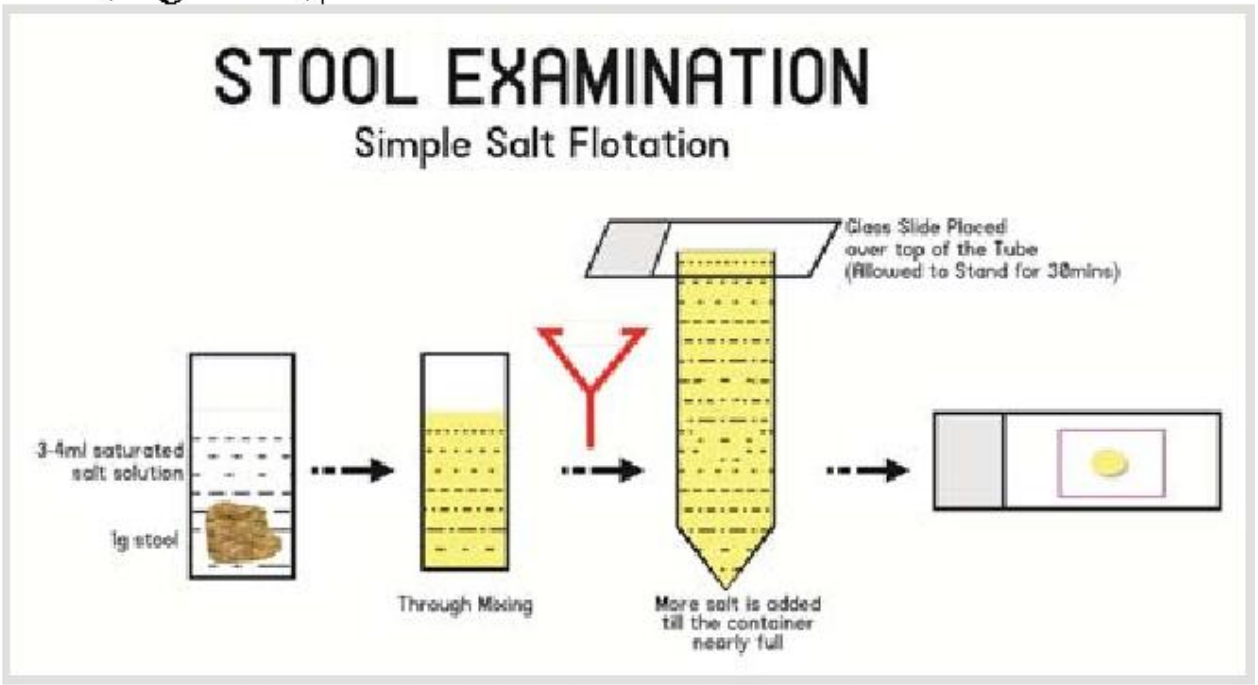
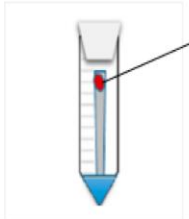
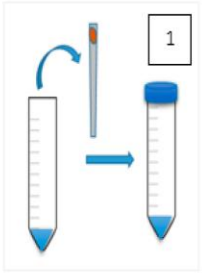


Figure 2: Salt flotation technique

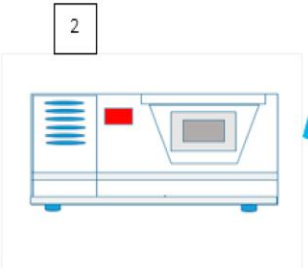
- Sedimentation Method:-
  - Light infections as well as heavy infection can be diagnosed.
  - Low specific gravity of most helminthes eggs are separated from the faecal samples.



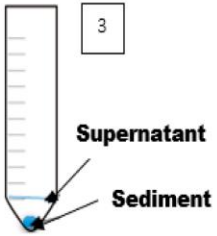
Filter paper strip with stool sample



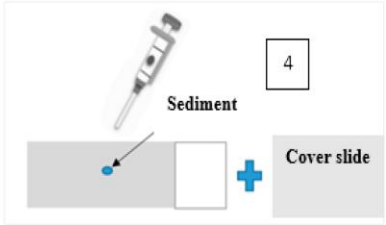
Remove the strip and close the tube



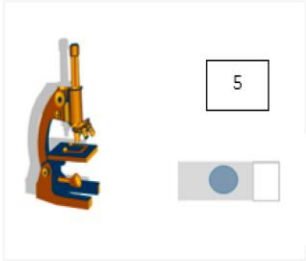
Centrifuge the sample at 1500 rpm for 2 minutes



Discard the supernatant



Using a pipette, remove the sediment, place it on a slide and re – cover it with a cover glass.



Read the slide with the 10x power objective of the microscope

Quantitative Examination of Faeces

- Egg Counting Methods:
- For accurate information regarding to severity of infection egg count methods are very useful by estimating eggs per gram (EPG) of feces.
- It is quantitative method.

- 3 gram faeces are taken in a test tube graduated to 45 ml.
- Fill the test tube up to the 45 ml mark with N/10 NaOH (4 g NaOH in 1 liter water) and add sever small glass beads and homogenize the faecal samples.
- 0.15 ml mixed suspension is drawn with a graduated pipette and placed on a slide and a cover slip applied on it.
- Count the total number of eggs and multiply by 100, which indicate the number of egg per gram of faces.
- For counting trematode as well as nematode eggs.

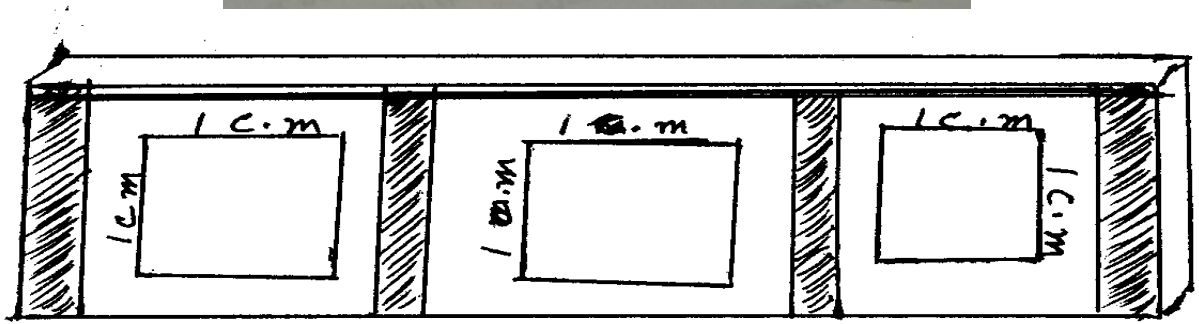
- Mc Master Method:-

Procedure -

- In this method a special counting is used for the estimation of no. of egg or larvae per gram of faces.
- Counting slide having two counting chamber is made of two glass slides separated by three or four narrow transversely placed strips of glass 1.5 mm thick, so that two or three spaces of 1.5 mm depth are obtained between the two slides. On the under surface of the upper slide an area of 1 cm2 is ruled over each space.
- The volume underneath this ruled area will therefore be 0.15 ml.

Mc Master Method:-





Mc Master Slide

- Weigh 3 g of faces and add 42 ml water in a container.
- Homogenize and pour the suspension through a tea strainer.
- Take 15 ml of the filtrate in to a centrifuge tube and centrifuge at 2000 rpm for 2 minutes.
- Pour off the supernatant, agitate sediment and add saturated sodium chloride solution to 15 ml mark of centrifuge tube.
- Mix the solution thoroughly and fill the chambers of Mc Master slide.
- Examine one chamber under microscope and multiply number of eggs or larvae under one etched area by 100 or two chambers and multiply by 50 to arrive at the number of eggs per gram (EPG) of faeces.

Eggs per gram (EPG) counts in different animals Vs levels of infection: -

Parasite	Animal	level of infection		
		Mild	Moderate	Severe
Nematodes	Cattle	50-300	300-600	>600
	Sheep	100-500	500-2000	2000-6000
	Horse	500	800-1000	1500-2000
Fasciola spp.	cattle	10-100	100-200	>200
	Sheep	50-300	300-600	>600

Blood Smear Examination

- ***Theileria, Babesia* spp.: Inside RBCs**
- ***Trypanosoma* spp.: - in blood plasma.**
- ***Hepatozoon canis*:- inside neutrophil**
- **Microfilaria of filarial worms: in blood plasma.**
- ***Anaplasma marginale*:- near margin of RBCs.**
- ***Ehrlichia* spp.:- inside leucocytes**

- Knott’s Technique :- o It is used for the diagnosis of microfilariae of Dirofilaria immitis and Dipetalonema spp. through lyses of the red blood cells.
- Lymph Gland Biopsy:- Result: Schizont stages (Koch’s blue bodies) of Theileria species found inside the cytoplasm of lymphocyte

SKIN SCRAPING METHOD

- Used for the diagnosis of parasitic mites. Mites causing a skin disease in animals called mange.
- Procedure:
  - Clip the hairs around lesion and scrap the edges of skin lesions with the help of a blunt scalpel or blade to extent that a little blood begins to ooze through the abrasions .
  - Collect the scraping materials on a plane paper.
  - Skin scrapings should be taken from moist part near the edge of the lesion avoiding the inclusion of large amount of dry crust, hair or wool. It is also desirable to take scrapings from more than one lesions.
  - Boil the scraping materials in 10 % KOH to dissolve debris.
  - After cooling pour the materials into centrifuge tube and centrifuge for 2 minutes at 2000 rpm.
  - Take one drop of sediment on a glass slide , cover with cover slip and examine under low power (40X) of microscope for the presence of mites.

Antihelmintic resistance

Techniques for detecting anthelmintic resistance

Test	Spectrum	Application
A. *In vivo*		
1. FECRT	All	Widespread
2. Critical anthelmintic test	Anthelmintics	Limited
3. Controlled slaughter test	Anthelmintics	Limited
B. *In vitro*		
1. Egg Hatch assay	BZ	Widespread
2. Larval Paralysis assay	LEV/MT	Limited
3. Larval Development assay	BZ, LEV, IVM	Commercialised

Faecal egg count reduction test (FECRT)

- a diagnostic tool that measures the effectiveness of anthelmintics against gastrointestinal parasites
- Compare egg count before and after treatment

General Control Measures of Parasitic Infections

- Chemotherapy
- Immunological control
- Biological Control
- Intermediate hosts control
- Pasture management
- Managemental control
- Genetic control

- Chemotherapy (Antiparasitic drugs) is still considered as the most important control measures against parasitic infections.
- Anthelmintics
- Insecticides
- Acaricides
- Antiprotozoal drugs

Anthelmintics	Effective against
Fenbendazole	**Usually Nematodes and tapeworms**
Praziquantel	**Tapeworms & Schistosomes**
Oxyclozanide	***Fasciola* spp. (Liver fluke) and Amphistomes**
Triclabendazole	***Fasciola* spp.**

- Insecticides : Act against insects (Flies, lice, ticks , mites etc.) e.g. D.D.T., Cypermethrin, Deltamethrin etc.
- Acaricides : Drugs which act against ticks and mites. e.g. Amitraz, Deltamethrin etc.

Antiprotozoal drugs	Effective against Protozoa
Buparvaquone (Butalex)	***Theileria* spp. (Theileriosis)**
Quinapyramine sulphate and Quinapyramine chloride (Triquin)	***Trypanosoma* spp. (Trypanosomosis)**
Isometamedium chloride	***Trypanosoma* spp.**
Diminazene aceturate	***Babesia* spp. (Babesiosis), *Trypanosoma* spp., *Theileria* spp.**
Imidocarb	***Babesia spp.***
Metronodazole	***Entamoeba* spp. (Amoebic dysentery)**

Immunoprohylaxis

Commercial available vaccines	Used for the parasitic disease
Raksha vac-T	Theileriosis
Coccivac	Poultry coccidiois
Livacox	Poultry coccidiois
TickGard	*Boophilus microplus* tick
Gavac	*Boophilus microplus* tick
Dictol	*Dictyocaulus viviparous*

Genetic control

- To develop genetically parasite resistance animals.
- Examples-
- N’ Dama cattle is resistance to trypanosomosis.
- Red Massai sheep is resistance to haemonchosis.
- Garole sheep is resistance to fasciolosis.
- Our Desi breed of cattle i.e. Bos indicus is resistance to Theileriosis