Sarcocystidae
(*Sarcocystis*, *Frenkelia*)

Genus: *Sarcocystis*

- They develop heteroxene and are obligatory intracellular parasites.
- **Definitive hosts** are carnivores and humans.
- **Intermediate hosts** are various animals (mammalians, birds and reptiles).
  - They form cysts in the tissues.
- Humans serve as intermediate host for some species, while they serve as definitive host for other species.

The definitive hosts

- The pathogens develop in the digestive system of carnivores (Gametogony + Sporogony)
- Oocysts of *Sarcocystis* species are resemble to oocysts of *Isospora* species and have 2 sporocysts and 4 sporozoites inside each sporocyst.
- Oocysts wall breaks down because it is thin. Thus, sporocysts are thrown out with feces of the definitive host.

The oocyst wall has thin structure (0,1 μ m). Therefore, the wall is usually decayed and the sporocysts are thrown out with feces.

The size of oocysts is 15-30x7-18 μ m

Sarcocystis oocysts and sporocysts

There is no micropil, polar granule and residue body in the oocyts.

Sarcocystis sporocyts

The size of spherical sporocysts is 15-19x 8-10 μm.

Intermediate hosts

- The pathogens develop in vascular endothelial cells (Schzigony stage) and skeleton and heart muscles (tissue cysts) of herbivores.
- Size of the tissue cysts varies from a few millimeters to a few centimeters depending on the host and *Sarcocystis* spp.
  - macroscopic cysts
  - microscopic cysts
- Structure and thickness of the cysts wall vary depending on the species.

Inside of mature cysts is divided into several compartments.

Inside of these compartments is filled with banana-like bradyzoites (the size of each is 14 μ).

Melting is seen in the middle of large cysts, so the middle is empty.

The macrocysts of *Sarcocystis* spp. in the esophagus

Sarcocystis spp. cysts

The macrocysts of *Sarcocystis* spp. in the muscles.

Microcyst form of *Sarcocystis cruzi* in the muscle

Bradyzoites of *Sarcocystis cruzi*
inside the cysts

Definitive hosts are carnivores, and the intermediate hosts are herbivores.

1st generation schizonts enter mesenteric endothelial cells.

2st generation schizonts enter capillary vascular endothelial cells.

Second generation merozoites released as a result of disintegration of the schizonts enter the cells of various tissue and organs, and they multiply by endodyogeny within parasitophore vacuoles.

They form banana-shaped bradyzoite by dividing with endodyogeny in the striated muscle fibrils.

Schizogony and cyst stage occur in the intermediate host, and gametogony and sporogony occur in the definitive host.

Sarcocystis

- Pathogenesis
  - No clinical manifestation is seen in the definitive host.
  - In severe cases, anorexia, fever, anemia, loss of weight, decreased productivity and abort can bee seen in the intermediate host.
  - The second schizogony stage in vascular endothelial cells of the intermediate host is more pathogenic than the cysts stage in heart, nervous system and skeletal muscles.
  - Severe acute infections can result in death. The cysts contain sarcocystine, an effective endotoxin.

Diagnosis

- *Sarcocystis*
  - In the definitive hosts:
    - Observation of the sporocysts in stool!
  - In the intermediate hosts:
    - *Sarcocystis* spp. should be considered in weight loss and abort cases.
    - Observation of micro- and macrocysts (*S. gigantae* and *S. medusiformis*) in the muscles including bradyzoites during the necropsy.
    - Serological tests (IFA, ELISA)
    - PCR

Prevention and Control

- The contact between the definitive hosts and intermediate hosts must be prevented.
  - Organs and tissues of the intermediate hosts should not be fed to cats and dogs as raw or undercooked.
- People should not eat fruits and vegetables without washing them thoroughly.

Species name	Synonym	Intermediate host	Definitive host	Pathogenicity
S. bovicanis	*S. cruzi*	Cattle	Dog	+
S. bovifelis	*S. hirsuta*	Cattle	Cat	-
S. bovihominis	*S. hominis*	Cattle	Human	-
S. fusiformis	*S. levinei*	Water buffalo	Dog	-
S. ovicanis	*S. tenella*	Sheep	Dog	+
S. arieticanis		Sheep	Dog	+
S. ovifelis	*S. gigantae*	Sheep	Cat	-
S. medusiformis		Sheep	Cat	-
S. capracanis	*S. moulei*	Goat	Dog	+
S. hircicanis		Goat	Dog	-
S. moulei		Goat	Cat	-
S. equicanis	*S. bertrami*	Horse	Dog	-
S. fayeri		Horse	Dog	-
S. neurona	*S.* sp.	Horse	Opossum	+
S. cameli	*S. cameli*	Camel	Dog	-
S. porcifelis		Pig	Cat	
S. porcihominis	*S. suihominis*	Pig	Human	
S. lindemanni		Human	?	
S. cuniculi		Rabbit	Cat	+
S. horvathi		Chicken	Dog	-
S. rileyi		Duck	Skunk	-

EQUINE PROTOZOAL MYELOENCEPHALITIS (EPM)

- It is a disease that manifests itself in the horses with neurological symptoms.
- Etiological agents of the disease is *Sarcocystis neurona*.
- Definitive host is opossum. Gametogony and and sporogony stages occur in the small intestine of opossum and mostly oocysts are disintegrated and thrown out as sporocysts with feces.

EQUINE PROTOZOAL MYELOENCEPHALITIS (EPM)

- The sporozoites released from sporocysts in the intestine of cats undergo schizogony stage in the vascular endothelial cells.
- Sarcocysts including bradyzoites are formed by merozoites located in CNS of cats.
- The protozoa also locate in brain and spinal canal of horses.

Genus: *Frenkelia*

- Intermediate hosts are mouse and some rodents.
- Definitive hosts are raptors such as buzzards and hawks.
- The morphological and biological features of this protozoa are resemble to *Sarcocystis* spp.

Hepatozoidae, Klossiellidae

Genus: *Hepatozoon*

- Biology of these parasites, which have complex life cycle, passes between vertebrate hosts (mammals, birds, reptiles and amphibious animals) and invertebrate hosts (ticks, mites, mosquitoes, lice and other blood-sucking arthropods).

Genus: *Hepatozoon*

- The species belonging to this genus are found in mammals, reptiles and birds.
- *Hepatozoon americanum* and *H. canis* cause clinical diseases in dogs.
- The parasites locate in blood, liver, kidney and skeletal muscles of vertebrates.

Morphology and Development

- *Hepatozoon americanum* is transmitted by *Amblyomma maculatum,* while *H. canis* is transmitted by *Rhipicephalus sanguineus* ticks
- Transmission is occurred by eating of ticks infected with *Hepatozoon* spp. oocysts.
- Gametogony and sporogony stages undergo in the digestive system of ticks, while asexual stage (merogony) occurs in endothelial cells of internal organs or liver of dogs.

Hepatozoon canis gamonts located inside of neutrophils

Clinical Manifestations

- The parasitemia ratio in the leucocytes is 0.1% in *H. americanum* infection, while the ratio is 1-5% (sometimes can reach up to 70%) in *H. canis* infection.
- *H. canis* causes mild infection (subclinical) in dogs. Clinical infection caused by *H. canis* is generally accompanied by the other tick-borne pathogens (*Anaplasma* spp, *Ehrlichia*, spp. *Babesia* spp.).

Diagnosis, treatment, prevention

- The disease can be diagnosed by observation of the gamonts inside of lymphocytes (neutrophils, sometimes monocytes) on Giemsa-stained blood films or observation of the schizonts in slides prepared from spleen and bone marrow.
- Imidocarb dibropionate is used in treatment.
- Struggle with vector ticks is important in the prevention.

Genus: *Klossiella*

- Species belonging to this genus uses single host and merogony and gametogony stages develop in different regions of the same host.
- The meronts and merozoites are encountered in Bowman capsules, while the gamonts and gamets are encountered in the kidney tubules.
- Zygote is inactive. Typical oocysts are not formed. Sporocyst and sporozoites develop inside a membrane.

Klossiella

- *Klossiella equi*
  - In horse, donkey and zebra.
- *Klossiella muris*
  - In laboratory mice.
- *Klossiella kobaye*
  - In Guinea pig.