Protozoan Parasites
Transmitted by Arthropod vectors

Spencer Greenwood
Dept. of Biomedical Sciences
Office: 3313 N AVC North Annex
566-6002
892-4686
Sgreenwood@upei.ca
Protozoa Transmitted by Arthropod Vectors

- Arthropods = flies, mosquitoes, ticks, fleas...
Mechanical Vector

- Carry disease organisms on mouth or body parts
  - e.g. Horse flies
    - equine infectious anemia on their mouthparts

© 1998 RKD Peterson
Parasite undergoes development in the arthropod vector

- Definitive host
- Intermediate host
- e.g. *Plasmodium*
  - sexual reproduction in *Anopheline* mosquitoes
  - obligatory vector & definitive host
Hemoflagellates

- **Genera:** *Trypanosoma* & *Leishmania*
- **Life cycle:**
  - One stage in the blood &/or tissues of the vertebrate host
  - Another stage in the intestines of bloodsucking arthropods
Morphology

- Elongate with a single flagellum
- or “rounded” with a non-protruding flagellum
- Kinetoplast
  - sausage
  - disc-shaped
  - mitochondrial DNA
Trypanosomiasis
Section Salivaria

- Develop in the anterior station or front portion of the digestive tract of the arthropod
  - Transmitted via saliva
  - e.g. *Trypanosoma brucei* & *T. congolense*
    - **Vector:** Tsetse flies in Africa
    - **Nagana** a fatal disease of domestic cattle
Trypanosomiasis
Section Stercoraria

- Develop in the posterior station or **hind portion** of the **digestive tract** of the arthropod
  - Transmitted via **feces**
  - e.g. *Trypanosoma cruzi*
    - **Vector**: Triatomine bugs
    - **Chagas disease** in Central & South America & Southern USA
Chagas Disease

*Trypanosoma cruzi*

- Zoonotic
- Central & South America & Mexico infects 12-19 million people
- Maryland, Georgia, Florida, Texas, Arizona, New Mexico, California, Alabama & Louisiana
  - Prevalence in USA is low
  - Sporadic disease episodes
  - **Dogs** can suffer clinical signs of disease, but **cats, armadillos, opossums & raccoons** can serve as reservoirs for the disease agent
Morphology

- **Trypomastigote**
  - Slender, 16-20 µm
  - Pointed posterior end
  - Circulate in blood of vertebrate host
  - Kinetoplast located near the posterior end
  - Flagellum is long & runs out the anterior end
  - Undulating membrane is narrow
Morphology

- **Amastigote**
  - Spheroid, 1.5-4.0 µm
  - Lack flagella
  - Develop within muscle & other tissues in clusters
  - Repeated rounds of asexual division
Morphology

- **Epimastigote**
  - Flagellated with the kinetoplast located between the nucleus & the anterior end
  - Found in the posterior portion of a triatomine bug's gut
Clinical signs

Acute disease

- Dogs
  - Lymphadenopathy, myocarditis, pale mucus membranes, lethargy, hepatosplenomegaly, & tachyarrhythmia
Clinical signs
Chronic disease

- **Dogs**
  - Congestive myocardial failure as the heart becomes enlarged & flabby

- **Humans**
  - Megasyndromes
    - Cardiomyopathy, megacolon, megaesophagus
    - Result from destruction of autonomic ganglia
    - Destroys tonus of the muscularis
Diagnosis

- **Blood smears**
  - Detection of trypomastigotes in blood or lymph within 5 weeks of infection

- **Chronic infections**
  - Culture
  - Serology (IFA)
  - Xenodiagnosis
    - Allow naive triatomine bugs to feed on host then look for parasites in bug's gut
Treatment & Control

- **Treatment**
  - Poor response
  - Only extracellular parasites killed
  - Intracellular stages unaffected by treatment
  - Recrudescence of disease

- **Drugs**
  - Nifurtimox, benzimidazoles & allopurinol may be tried during acute phase of disease

- **Control**
  - Insecticides to arthropod vectors
  - Avoid contact reservoir animals
Leishmaniasis
Leishmania spp.

- **Zoonosis**
- Taxonomy confusing as all species are morphologically identical
- **Vector** - Sandflies
  - *Phlebotomus* in the Eastern Hemisphere
  - *Lutzomyia* in the Western Hemisphere
- Confined primarily to the tropics
Leishmaniasis
*Leishmania* spp.

- **Zoonosis:** several clinical forms in humans, dogs, rodents, wild mammals & now cats (2011)
  - Visceral leishmaniasis
  - Cutaneous leishmaniasis
  - Muco-cutaneous leishmaniasis

- **Visceral leishmaniasis** recently reported in English & American Foxhounds in USA, Southern Ontario & Nova Scotia
Morphology

- **Promastigote**
  - Found in the gut of the vector
  - Flagellum extends forward
  - Kinetoplast near the anterior end

- **Amastigote**
  - Spheroid, 2.5 - 5.0 µm
  - Lack flagella
  - Found in the vertebrate hosts tissue
Epidemiology

- **Endemic**
  - Mediterranean-Southern France, Spain & Italy
  - Asia
  - Africa
  - South & Central America
Epidemiology

- Foxhounds in Oklahoma, Texas, Ohio, New York, Ontario & Nova Scotia
  - Seroprevalence of 41% in a New York colony
- **Transmission**
  - Vertical
    - Transplacental
    - Transmammary
    - Ticks & Fleas (2011)
  - Horizontal
    - Fighting?
    - Blood transfusion
    - Foxhound blood donors?
  - **Important zoonotic disease as dogs & cats too (2011), can act as a reservoir for human infections!**
Destruction of cells from the reticuloendothelial system leads to susceptibility to secondary pathogens.

- Spleen & bone marrow undergo compensatory production of macrophages to the detriment of RBC production which results in hepatosplenomegaly.

Pathogenesis
Clinical signs

- Variable & not specific
  - Visceral & cutaneous forms can occur
  - Alone or in combination
  - Epistaxis, seizures, hair loss, abnormal nail growth, skin lesions (ulcers), swollen limbs & joints
  - Chronic wasting, kidney failure, liver failure
  - Death
Fine needle aspirates (FNA)
- Amastigotes detected in lymph nodes, bone marrow & spleen
- BUT are often ‘negative’ even when the dog is infected

Serum - antibody detection
- IFA
- ELISA

Q-PCR
- Iowa State University & CDC
Treatment & Control

- **Treatment**
  - Difficult
  - Current drugs **do not cure**
  - Drugs to reduce the clinical signs
    - meglumine antimoniate with allopurinol
    - aminosidine & amphotericin B
  - Multiple dose regimens
  - Depend on the patient's condition & owner compliance
  - Relapse is common
    - weeks, months or years later
Control & Treatment

- **Vector control is essential**
  - Insecticide collars, shampoos or sprays
  - Especially in patients under treatment
  - Residual insecticide spraying of houses & animal shelters may help
  - **BUT**...Vertical & Horizontal as well...?
Piroplasmosis

- Apicomplexan parasites of blood cells in vertebrates
- Transmitted by a tick vector
Bovine Piroplasmosis

- **Babesia bigemina** - Babesiosis, Texas fever or red-water fever
  - Serious & often fatal disease of cattle worldwide
  - Eliminated in the USA since 1940 due to eradication of vector **Boophilus annulatus**

---

*Image of cattle with Babesia bigemina symptoms*
Bovine Piroplasmosis

- *Babesia bovis, Babesia divergens, Babesia argentina*
  - Causes red-water fever throughout the world
  - Except in Canada & USA
  - *B. bovis* is more pathogenic than *B. bigemina* in Australia & Mexico
Bovine Piroplasmosis

- *Theileria* spp.
  - Important pathogens of cattle in Africa, Southern Europe & Asia
  - *Theileria parva*
    - East Coast fever
    - African cattle with significant mortality
Canine piroplasmosis

- *Babesia canis* & *Babesia gibsonii*
  - Cosmopolitan in distribution
  - Cause of occasional disease in dogs in the USA
- **Vector:**
  - Brown Dog Tick
  - *Rhipicephalus sanguinensis*
Feline piroplasmosis

- *Cytauxzoon felis*
  - Sporadic
  - Usually fatal disease of domestic cats in South-Central USA
  - Bobcat is the natural reservoir for the disease
- **Vector:**
  - American Dog Tick
  - *Dermacentor variabilis*
  - under experimental conditions
Equine piroplasmosis

- *Babesia caballi* & *Babesia equi*
  - Acute or chronic disease of horses worldwide
  - Occasionally in the USA
  - **Vector:**
    - *Dermacentor*
    - *Rhipicephalus*...
Babesia microti

- Normally a parasite of voles & mice
- Human infections have occurred in North-Eastern USA

Vector:
  - The Deer Tick
  - Ixodes scapularis
Morphology

- **Babesia** spp.
  - Merozoites found in erythrocytes of the vertebrate host
    - Piriform, 3-5 μm
    - Amoeboid, 2-4 μm in diameter
    - Size is species dependent
  - Blue cytoplasm with red chromatin mass when stained with Wright-Geimsa
**Morphology**

- *Cytauxzoon felis*
  - signet-ring like forms
    - 1-1.2 µm in diameter
    - found in erythrocytes
  - merozoites
    - 0.1-0.2 µm in diameter
    - found within monocytes in spleen, lymph nodes, lungs, liver & kidneys
Piroplasm Life Cycle
Babesia, Theileria & Cytauxzoon

1. Tick takes a blood meal (sporozoites introduced into host)
2. Mouse
3. gamete
4. Tick takes a blood meal (ingests gametes)
5. oocyst enters salivary gland
6. Sporozoite
7. merozoite
8. Transmitted from human-to-human via blood transfusion
9. Trophozoite

= Infective Stage
= Diagnostic Stage

http://www.dpcidcdc.gov/dpx
Epidemiology

- **Babesia spp.**
  - Disease is rare
  - Seroprevalence
    - 46% in Florida greyhounds
    - 55% in Pit Bull terriers in South-Eastern USA

- **Cytauxzoon felis**
  - Disease occurs sporadically
    - South-Eastern & South-Central USA
  - Natural infections in cats result in near 100% mortality
Pathogenesis

*Babesia* spp.

- Destruction of erythrocytes
  - Hemolytic anemia
  - Clogging of capillaries in various organs by parasitized cells & free parasites
  - Anoxia, accumulation of toxic metabolites, hemorrhaging & organ failure
Pathogenesis
Cytauxzoon felis

- **Leukocytic phase**
  - Mononuclear cells & macrophages
  - Leukocytes engorged with schizonts
    - Blood flow obstructions in the liver, lung, lymph nodes, spleen & bone marrow

- **Erythrocytic Phase**
  - Destruction of erythrocytes
    - Hemolytic anemia

Clinical signs

- Hemolytic anemia, depression, anorexia, pyrexia, splenomegaly, icterus, dehydration
- *Cytauxzoon* is a rapidly progressing fatal disease in cats
Diagnosis

*Babesia* spp.

- History, clinical signs, serology
- Blood smear
  - Trophozoites in erythrocytes
  - Collect blood from ear or toe nail as parasites are more common & numerous in capillary blood
Diagnosis
Cytauxzoon felis

- History & clinical signs
- Blood smear
  - Presence of organism in peripheral blood
    - Erythrocytic phase
- Tissue impression smear
  - Observation of organism in tissue impression
    - Leukocytic phase
Control & Treatment

- Control ticks to prevent infection
- *Babesia* spp.
  - Diaminazene I.M. or phenamide S.C.
    - these drugs are not approved for use in horses
- *Cytaxzoon*
  - No treatment has proven effective
Malarias
Apicomplexan - *Plasmodium, Heamoproteus* & *Leucocytozoon*

- *Plasmodium spp.*
  - Malaria in humans & non-human primates, rodents, birds & reptiles

- Transmission
  - Mammals by anopheline mosquito
  - Birds by culicine mosquito
- 300-500 million people are infected with malaria each year
  - 1-3 million people die from malaria each year
  - 90% of deaths due to *Plasmodium falciparum*
Tycoon gives £15m malaria grant

Scientists have been given a $30m (£15.1m) grant by Microsoft tycoon Bill Gates to improve the treatment and control of malaria in pregnancy.

The Liverpool School of Tropical Medicine, which has now been given more than $100m (£50.4m) by Gates, will lead the project with 30 worldwide partners.

Malaria is a major cause of severe maternal anaemia and low birth weight in infants, increasing risk of death.

About 50m women a year are affected by malaria across the world.

The Gates Foundation awarded the school a $50m grant in 2005 and grants totalling $27m in 2007 to research diseases.

Scientists estimate that more effective control of malaria during pregnancy could save the lives of up to 100,000 women and newborns a year.
**Causative agent & Host Range**

- *Leucocytozoon* spp.
  - Over 60 species known to infect birds
  - Parasites of domestic & wild birds
  - Transmitted by the Black Fly
    - *Simulium* spp.
  - *L. simondi* - infects ducks & geese
  - *L. caulleryi* - infects chickens
  - *L. smithi* - infects turkeys
Leucocytozoon spp. Life Cycle
Epidemiology

- **L. simondi**
  - Ducks & geese throughout Canada & USA

- **L. smithi**
  - Turkeys in North America
  - Wide spread in adult turkeys in the Southern USA

- **L. caulleryi**
  - Only in South Carolina
  - Common in Japan & South-East Asia
Pathogenesis

- Destruction of infected host cells resulting in anemia, leukocytosis, splenomegaly & hepatomegaly
- Visible white dots in affected organs
  - Megaloschizonts
  - Obstruction of circulatory system by infected cells & parasites
Clinical signs

- Young birds
  - Most susceptible
  - Acute onset of anorexia, listlessness, laboured breathing, anemia, diarrhea with green droppings
    - Significant death loss within 24 hours of clinical signs
    - Appear 10-19 days post exposure
Clinical signs

- Older birds
  - Chronic infections
    - Low mortality, become thin & listless
    - Decreased egg production, egg weight & hatchingability
    - Recovered birds harbour parasite in blood for over a year & often for life
    - Develop immunity but carrier?
Diagnosis

- **Blood Smear**
  - Observation of gametocytes in stained thin blood smears

- **Histopathology**
  - Identification of schizonts in tissue

- **History & clinical signs**

- **PCR test**
  - New - research only

http://www.wildlife-museum.org/hospital/research/researchDetails.php?researchID=4

http://www.natur.cuni.cz/~parazit/milenaweb/milena-1.htm
Control & Treatment

- Control Black Fly vector to prevent infections
  - Keep domestic birds separated from wild birds (reservoir)
Control & Treatment

- Treatment is usually not effective
  - Preventive medication is the norm
    - Sulfadimethoxine & pyrimethamine combinations
    - Clopidol has been approved by the FDA for control of infections in turkeys
Arthropod Parasites:
Ticks
Mites & Lice