VETERINARY PROTOZOOLOGY

PROTOZOAN PARASITES OF VETERINARY IMPORTANCE

ERKIHUN AKLILU (DVM, MSc Molecular Biology
Universiti Malaysia Kelantan
Faculty of Veterinary Medicine

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Protozoa

- Protozoans are unicellular, eukaryotic chemoheterotrophic organisms.

- Most protozoa have two stages
  - Trophozoite – the feeding and growing stage
  - Some protozoa will produce a protective capsule called a cyst.
    - A cyst allows the parasite to exist outside of the host and be the infective stage allowing the parasite to get to another host.
Protozoa reproduce sexually and asexually

- **Asexually**: Fission (mitosis), Budding, Schizogony
- **Sexually**: Conjugation, Gamete formation

- **Definitive Host** harbors the sexually reproducing stage of parasite
- **Intermediate Host** harbors asexually reproducing portion of the parasite’s life cycle

**Movement:**

- A single or multiple flagella
- Cilia, Balantidium
- Pseudopodia, Enramoeba
- No obvious means of locomotion, Eimeria
# Protozoa

Table 6  Classification of the Protozoa.

<table>
<thead>
<tr>
<th>PHYLUM:</th>
<th>Protozoa (Unicellular, eukaryotic animals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBPHYLUM:</td>
<td>Sarcomastigophora (locomotion by pseudopodia and/or flagella)</td>
</tr>
<tr>
<td></td>
<td>Balantidium</td>
</tr>
<tr>
<td>CLASS:</td>
<td>Mastigophora (one or more flagella)</td>
</tr>
<tr>
<td></td>
<td>Entamoeba</td>
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<tr>
<td></td>
<td>Leishmania</td>
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<tr>
<td></td>
<td>Trichomonas</td>
</tr>
<tr>
<td></td>
<td>Histomonas</td>
</tr>
<tr>
<td></td>
<td>Hexamita</td>
</tr>
<tr>
<td></td>
<td>Giardia</td>
</tr>
</tbody>
</table>

† Also called Apicomplexa. This alternative name refers to the group’s possession of an ‘apical complex’, a structure which apparently assists penetration of the host cell. It is only visible with the electron microscope.
PROTOZOA
Protozoans of Vet. Importance

**Trypanosomes**

- Found in the bloodstream and tissues of vertebrates
- Distributed throughout the world
- A few species are of overwhelming importance as a serious cause of morbidity and mortality in animals and man in tropical regions
- All are transmitted by arthropod vector, except for *Trypanosoma equiperdum* (venereal)

- Transmission: Either Cyclical or Non-cyclical
  - Cyclical: the arthropod is the necessary intermediate host
  - Non-cyclical: Mechanical transmission by biting flies (*Tabanids and Stomoxys*)
TRYPANOSOMES

‘Tse-tse transmitted Trypanosomoses’- The Salivaria, African Trypanosomoses

- The most significant, compromises livestock production (serious economic challenge)

- All are transmitted cyclically by Glossina in much of sub-Saharan Africa

- Hosts: All domestic livestock, but especially important in cattle. Also common in many wild animals such as the warthog, bush pig and various antelopes.

- Intermediate host: Most species of Glossina, of which G. morsitans is perhaps the most widespread.
TRYPANOSOMES

Salivaria

- **Site:**
  - All three species of trypanosome are characteristically present in the bloodstream.
  - *T. brucei* is also found extravascularly in, for example, the myocardium, the central nervous system and the reproductive tract.

- **Major species:**
  - *Trypanosoma brucei*
  - *T. congolense*: the most common species
  - *T. vivax*.

- **Minor species:**
  - Probably the most important is *T. simiae which is primarily* a parasite of pigs and camels and morphologically resembles *T. congolnse.*
Salivarian trypanosome groups

- *Trypanosoma vivax* – Old and New World of large mammals – Mechanical transmission using many vectors
- *Trypanosoma congoense* – Old World of large mammals – Mouthpart development in *Glossina*
- *Trypanosoma brucei* group
  - *T. brucei brucei* – Nagana in cattle
  - *T. brucei gambiense* – Chronic or West African sleeping sickness
  - *T. brucei rhodesiense* – Acute or East African sleeping sickness All have full development in *Glossina*
- *Trypanosoma evansi* group
  - *T. evansi* – mechanical transmission in many vectors including vampire bats
  - *T. equinum* – mechanically transmitted by horse flies
  - *T. equiperdum* – sexually transmitted
Morphology of Trypanosome

Trypanosoma brucei

Red blood cells

Trypanosome
## Trypanosome

### Tsetse Vectors and Vertebrate Hosts of Human and Animal Trypanosomiasis (From Hoare, 1972)

<table>
<thead>
<tr>
<th>Disease</th>
<th>Disease agent</th>
<th>Vectors</th>
<th>Hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>West African sleeping sickness</td>
<td><em>Trypanosoma gambiense</em></td>
<td>Glossina fuscipes, G. palpalis, G. tachinoides</td>
<td>Humans</td>
</tr>
<tr>
<td>East African sleeping sickness</td>
<td><em>T. rhodesiense</em></td>
<td>G. morsitans, G. pallidipes, G. swynnertoni</td>
<td>Humans, antelopes (bushbuck, hartebeest)</td>
</tr>
<tr>
<td>Nagana</td>
<td><em>T. brucei</em></td>
<td>G. fuscipes, G. longipalpis, G. morsitans, G. palpalis, G. pallidipes, G. tachinoides</td>
<td>All domestic mammals; antelopes (e.g., impala, hartebeest, wildebeest); warthog, hyena, lion</td>
</tr>
<tr>
<td></td>
<td><em>T. suis</em></td>
<td>G. brevipalpis, G. vanhoofi</td>
<td>Suids (domestic pigs, warthogs)</td>
</tr>
<tr>
<td></td>
<td><em>T. congolense</em></td>
<td>G. morsitans group; G. brevipalpis, G. fuscipes, G. palpalis, G. tachinoides, G. vanhoofi</td>
<td>All domestic mammals, elephant, zebra, antelopes (e.g., impala, hartebeest, duiker, gnu), giraffe, bushpig, hyena, lion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Domestic pig, warthog, camel, horse, cattle</td>
</tr>
<tr>
<td>T. simiae</td>
<td></td>
<td>G. austeni, G. brevipalpis, G. fuscida, G. fuscipalpis, G. longipalpis, G. morsitans, G. pallidipes, G. palpalis, G. tachinoides, G. vanhoofi</td>
<td>Cattle, goats, sheep, antelopes (e.g., bushbuck, sitatunga, waterbuck); buffalo, giraffe</td>
</tr>
<tr>
<td>T. uniforme</td>
<td></td>
<td>G. fuscipes, G. palpalis</td>
<td>Domestic mammals (esp. cattle, horses, mule); wild bovids, zebra, antelopes (e.g., impala, hartebeest, gnu); giraffe, warthog, lion</td>
</tr>
<tr>
<td>Nagana or souma</td>
<td><em>T. vivax</em></td>
<td>G. morsitans group; G. fuscipes, G. palpalis, G. tachinoides, G. vanhoofi</td>
<td></td>
</tr>
</tbody>
</table>
African trypanosomiasis - Distribution

West African = *Trypanosoma gambiense*
East African = *Trypanosoma rhodesiense*
African Trypanosomiasis: Resistant and susceptible cattle

- **N'dama**
- **Zebu**
African trypanosomiasis
The tsetse fly

Tsetse flies live today in moist savanna and woodlands, regions with > 500 mm of rain a year.

Tsetse flies carry a parasite which can infect livestock and people with trypanosomiasis (sleeping sickness).
Distribution of the following Tsetse species groups in Africa: morsitans group (savanna); fusca group (forest); palpalis group (riverways).
African trypanosomiasis
Life cycle
Class Coccidia

- Two families of veterinary importance: *Eimeriidae and Sarcocystidae*

**Eimeriidae**
- Mainly intracellular parasites of the intestinal epithelium
- Three genera of considerable veterinary importance
  - *Eimeria, Isospora and Cryptosporidium*
  - *Eimeria and Isospora cause coccidiosis*

**Eimeria**
- **Hosts:** Poultry, cattle, sheep, goats, pigs, horses and rabbits.
- **Site:** Epithelial cells of the intestine and in two species the kidney and liver respectively.
## Class Coccidia

### Table. The major features of the life cycles of important Coccidia

<table>
<thead>
<tr>
<th></th>
<th>Eimeria</th>
<th>Isospora</th>
<th>Cryptosporidium</th>
<th>Toxoplasma</th>
<th>Sarcocystis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Life cycle</strong></td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Indirect or direct</td>
<td>Always indirect</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Also between intermediate hosts</td>
<td></td>
</tr>
<tr>
<td><strong>Infective stage</strong></td>
<td>Oocyst (4 sporocysts each with 2 sporozoites)</td>
<td>Oocyst (2 sporocysts, each with 4 sporozoites)</td>
<td>Very small oocyst with 4 sporozoites</td>
<td>Bradyzoite cysts</td>
<td>Bradyzoite cysts</td>
</tr>
<tr>
<td>for final host</td>
<td></td>
<td></td>
<td></td>
<td>Tachyzoites</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Small oocyst</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2 sporocysts each with 4 sporozoites)</td>
<td></td>
</tr>
<tr>
<td><strong>Infective stage</strong></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Bradyzoite cysts</td>
<td>Sporocyst (4 sporozoites)</td>
</tr>
<tr>
<td>for intermediate host</td>
<td></td>
<td></td>
<td></td>
<td>Tachyzoites</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Oocyst</td>
<td></td>
</tr>
<tr>
<td><strong>Asexual phase</strong></td>
<td>Single host</td>
<td>Usually single host</td>
<td>Single host</td>
<td>Many hosts</td>
<td>Many hosts</td>
</tr>
<tr>
<td><strong>Sexual phase</strong></td>
<td></td>
<td></td>
<td></td>
<td>Cat</td>
<td>Dog and cat</td>
</tr>
</tbody>
</table>
Class Coccidia

Eimeria

• Important Species:

  • *Eimeria tenella*, *E. necatrix*, *E. brunetti*, *E. maxima*, *E. mitis* and *E. acervulina* ——— chickens
  • *E. meleagrimitis* and *b. adenoeides* ——— turkeys
  • *E. anseris*, *E. nocens* and *E. truncata* (kidney) ——— geese
  • *E. zuernii*, *E. bovis* and *E. alabamensis* ——— cattle
  • *E. crandallis*, *E. ovinoidalis*, *E. bakuensis* ——— sheep
  • *E arloingi* and *E. ninakohlyakimovue* - goats
  • *E. debliecki* ——— pigs
  • *E. leuckarti* ——— horses
  • *E. flrrvescens*, *E. intestinalis* and *E. stiedae* (liver) ——— rabbits.
Toxoplasma

- Single species: *Toxoplasma gondii*
- Definitive host - cat,
- Oocyst shed in feces
- Form trophozoites-tachyzoites(fast)
- Multiply in host tissues-all cells except RBCs
- Intracellular parasite ruptures cells

**Signs and Symptoms of Toxoplasmosis**
- Fever, malaise, sore throat, swelling of lymph nodes
- Immune system contains disease-chronic infection
- Tissue cyst forms containing bradyzoites
- Reactivate later when immune system breaks down
- Can form lesions on eyes or any other organ
Toxoplasma

Life cycles

- Humans ingest undercooked meat or contact with cat feces - contain oocysts

- Trophozoites released and feed on bacteria and fecal material

- Most have mild symptoms unless immunocompromised
Toxoplasma Transmission

- Ingestion of oocysts
  - Definitive host
  - Faeces
  - Ingestion of oocysts
    - Domestic animals
  - Faecal contamination of hands or food
  - Ingestion of contaminated food

- Carnivorism
  - Predation
  - Secondary host
  - Congenital transmission
    - Organ transplant or blood transfusion
    - Congenital transmission
Toxoplasma Transmission

A fetus may contract toxoplasmosis through the placental connection with its infected mother.

The mother may be infected by:

- Improper handling of cat litter
- Handling or ingesting contaminated meat
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Babesia

- Are intraerythrocytic parasites of domestic animals
- Cause anaemia and haemoglobinuria.
- Transmitted by ticks (in which the protozoan passes transovarially, via the egg, from one tick generation to the next).
- The disease, babesiosis, is particularly severe in naive animals introduced into endemic areas
- Babesiosis is a severe constraint on livestock development in many parts of the world
- **Hosts:** All domestic animals.
- **Intermediate hosts:** Hard ticks of the family Ixodidae
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Babesia

Site:
- Babesia lie singly or in pairs inside the red blood cells.

Species:
- *Babesia divergens*, *B. major*, *B. bigemina*, *B. bovis*—cattle
- *B. molasi*, *B. ovis*—sheep and goats
- *B. caballi*, *B. equi*—equines
- *B. perroncitoi*, *B. tralirmanni*—pigs

Diverse forms of *Babesra divergens* in bovine red cells.
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Babesia

Epidemiology

- The epidemiology of babesiosis depends on the interplay of a number of factors and these include:

1. *The virulence of the particular species of Babesia*
   - E.g. *B. divergens* in cattle and *B. canis* in dogs are relatively pathogenic while *B. major* in cattle and *B. ovis* in sheep usually produce only mild and transient anaemia

2. *The age of the host*
   - There is an inverse age vs resistance relationship

3. *The immune status of the host*

4. *The level of tick challenge*

5. *Stress*
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Babesiosis of Cattle (Caused by B. bigemina and B. bovis)

- **Disease:** Babesiosis (bovine), Texas fever, red water fever, piroplasmosis.
- **Host:** Cattle, deer.
- **Habitat:** Erythrocyte.
- **Identification:** Trophozoites usually pyriform, may be round or oval, characteristically in pairs. Size is 2-3 µm in diameter and 4-5 µm long.
- **Transmission:** By the one-host tick Boophilus
- **Diagnosis:** Confirmed by detection of characteristic forms of the parasite within the erythrocyte.

Treatment
- Imidocarb and the diamidine derivatives such as diminazene aceturate, amicarbalide and phenamidine, are all effective against B. Bovis and A. bigemina, especially if given early in the disease.

Vaccination
- Vaccination of cattle against both B. bovis and b. bigemina infection is commonly practiced in many countries by inoculating blood from donor animals.
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Canine Babesiasis [Caused by Babesia canis (Piroplasma canis)]

- **Disease:** Babesiasis (canine), malignant jaundice, biliary fever, canine piroplasmosis.
- **Host:** Dog and wild carnivores.
- **Habitat:** Erythrocyte.
- **Identification:** Organism pyriform, 4-5 µm long. Usually 1 pair to a cell, occasionally several pairs are seen in 1 erythrocyte.
- **Transmission:** Bite of the infected ticks *Rhipicephalus sanguineus* and, probably, *Dermacentor spp.*
- **Signs and pathogenicity:**
  - Infection varies from quite mild to severe with the strain of the organism.
  - Young and old dogs become infected.
PIROPLASMIDIA

Canine Babesiosis

- Signs and pathogenicity:
  - Infection varies from quite mild to severe with the strain of the organism.
  - Young and old dogs become infected
  - less severe disease occurs in young animals.
  - Incubation period is 10-21 days in naturally infected animals.
  - Usual signs are fever of 102-105°F.
  - Loss of condition, anemia, icterus, prostration, and death.
  - In chronic forms of the disease signs are vague.
  - The patient may be listless, weak, and emaciated and have intermittent fever
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Canine Babesiasis

- **Diagnosis:** Demonstration of parasite in the erythrocyte, best accomplished by taking capillary smears from the margin of the ear.
- **Control:**
  - Tick control and treatment of infected individuals.
- **Treatment**
  - Acriflavine and trypaflavine have both given good results.
  - Phenamidine is less toxic and quite effective.
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Theileria

- The diseases caused by several species of *Theileria* are a serious constraint on livestock development in Africa, Asia and the Middle East
- Theileriosis limits the movement of cattle between countries
- Can result in production losses and high mortality in susceptible animals
- Theileria are widely distributed in cattle and sheep in Africa, Asia, Europe and Australia
- Have a variety of tick vectors
- Are associated with infections which range from clinically inapparent to rapidly fatal.
PIROPLASMS

Theileriosis
East Coast Fever,
Corridor Disease,
Theileriasis,
January Disease,
Zimbabwean Tick Fever,
African Coast Fever;
Tropical Theileriosis,
Mediterranean Coast Fever,
Mediterranean Theileriosis
Theileriosis

- The two diseases with the greatest economic impact in cattle:
  - East Coast fever (infection with *Theileria parva*) and
  - *Tropical theileriosis* (infection with *Theileria annulata*).

- Minor and mildly pathogenic species infecting cattle include
  *T. mutans* and *T. taurotragi* in Africa and *T. sergenti* in Asia.

- *Theileria lestoquardi*, which causes a severe disease with a high morbidity and mortality rate, is the most important species in sheep and goats.
**Theileriosis**

Table. A comparison of three species of Theileria of veterinary importance.

<table>
<thead>
<tr>
<th>Species</th>
<th>Host</th>
<th>Vector</th>
<th>Disease</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>T. parva</em></td>
<td>Cattle</td>
<td><em>Rhipicephalus</em></td>
<td>East Coast Fever</td>
<td>East and Central Africa</td>
</tr>
<tr>
<td><em>T. annulata</em></td>
<td>Cattle</td>
<td><em>Hyalomma</em></td>
<td>Mediterranean or tropical theileriosis</td>
<td>North Africa, South Europe, Middle East, Asia</td>
</tr>
<tr>
<td><em>T. hirici</em></td>
<td>Sheep/Goats</td>
<td><em>Hyalomma</em></td>
<td>Malignant ovine (caprine) theileriosis</td>
<td>North Africa, South Europe, Middle East, Asia</td>
</tr>
</tbody>
</table>
PIROPLASMSIDIA

Theileriosis

Geographic Distribution

- T. parva (East Coast fever) is found in sub-Saharan Africa.
- T. annulata (tropical theileriosis) occurs from southern Europe and the Mediterranean coast through the Middle East and North Africa, and into parts of Asia.
- T. mutans has been found in African and on some Caribbean islands.

East Coast Fever (Caused by T. parva)

- Disease: Theileriosis (bovine), East Coast fever.
- Host: Cattle, water buffalo, white-tailed deer.
- Habitat: Erythrocytes, lymphocytes, histiocytes, and occasionally endothelial cells.
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Theileriosis

Transmission

- Theileria spp. are transmitted by ticks acting as biological vectors
- *Rhipicephalus appendiculatus* is the most important vector for *T. parva*
- But *R. zembeziensis* and *R. duttoni* carry this organism in parts of Africa. *T. annulata* is transmitted by ticks in the genus Hyalomma.
- Hyalomma spp. are also the vectors for *T. lestoquardi, T. ovis* and *T. separatata*
- *T. buffeli* and *T. sergenti* are transmitted by *Haemaphysalis* spp.
- *T. mutans* and *T. velifera* are transmitted by *Amblyomma* spp.
- Ticks in the genus *Rhipicephalus* spread *T. taurotragi*
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Theileriosis

Clinical Signs

- In East Coast fever, the clinical signs include
  - Generalized lymphadenopathy, fever, anorexia and loss of condition with decreased milk yield.
  - Terminally ill animals often develop pulmonary edema, severe dyspnea and a frothy nasal discharge.

Lymph nodes swelling in *T. parva* infected cattle
Theileriosis

- Petechiae and ecchymoses may be found on the conjunctiva and oral mucous membranes.
- Petechial haemorrhage on the surface (epicardium) of the heart caused by T.parva.
- Petechial haemorrhage on the intestinal serosa caused by T.narva.
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Theileriosis

- Lacrimation, nasal discharge, corneal opacity and diarrhea can also be seen.
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Theileriosis

Diagnosis

- In sick animals, macroschizonts are readily detected in biopsy smears of lymph nodes

Theileria spp, macroschizonts (Koch’s blue bodies’) and microschizonts in lymph node smears
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Theileriosis

Diagnosis

- In dead animals, impression smears of lymph nodes and spleen
- In advanced cases, Giemsa-stained blood smears show piroplasms in the red cells, up to 80% of which may be parasitized
- Indirect FAT

Treatment

- Tetracycline for early stage of infection
- For clinical cases: naphthaquinone compounds parvaquone and buparvaquone and the anti-coccidial drug halofuginone.
PIROPLASMIDIA

Theileriosis

Vaccination

- Great efforts have been made to develop a suitable vaccine, but these have been thwarted by the complex immunological mechanisms involved in immunity to East Coast Fever and by the discovery of immunologically different strains of *T. parva* in the field
<table>
<thead>
<tr>
<th>Arthropod vectors</th>
<th>Diseases grouped by causative agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosquitoes</td>
<td>Viruses: yellow fever, dengue, Rift Valley fever, myxomatosis; eastern equine encephalomyelitis, western equine encephalomyelitis, Venezuelan equine encephalomyelitis, St. Louis encephalitis, LaCrosse encephalitis, Japanese encephalitis, Murray Valley encephalitis, Chikungunya fever, O'nyong nyong fever, Ross River fever, West Nile fever. Protozoans: malaria. Filarial nematodes: Wuchererian filariasis, Bancroftian filariasis, dog heartworm</td>
</tr>
<tr>
<td>Black flies</td>
<td>Filarial nematodes: human onchocerciasis (river blindness), bovine onchocerciasis</td>
</tr>
<tr>
<td>Biting midges</td>
<td>Viruses: bluetongue disease, epizootic hemorrhagic disease, African horse sickness, leucocytozoonosis, Oropouche fever. Filarial nematodes: equine onchocerciasis, mansonellosis</td>
</tr>
<tr>
<td>Tsetse flies</td>
<td>Protozoans: African trypanosomiasis, nagana</td>
</tr>
<tr>
<td>Triatomeine bugs</td>
<td>Protozoans: American trypanosomiasis (Chagas disease)</td>
</tr>
<tr>
<td>Lice</td>
<td>Viruses: swine pox. Bacteria: epidemic typhus, trench fever, louse-borne relapsing fever</td>
</tr>
<tr>
<td>Fleas</td>
<td>Viruses: myxomatosis. Bacteria: plague, murine (endemic) typhus, tularemia</td>
</tr>
<tr>
<td>Ticks</td>
<td>Viruses: tick-borne encephalitis, Powassan encephalitis, Colorado tick fever, Crimean-Congo hemorrhagic fever, African swine fever. Bacteria: Lyme disease, Rocky Mountain spotted fever, Boutonneuse fever, tick-borne ehrlichiosis, Q fever, heartwater fever (cowdriosis), anaplasmosis, tick-borne relapsing fever, avian spirochetosis, theileriosis (East Coast fever), bovine dermatophilosis. Protozoans: babesiosis</td>
</tr>
<tr>
<td>Mites</td>
<td>Bacteria: tsutsugamushi (scrub typhus), rickettsialpox</td>
</tr>
</tbody>
</table>