THEILERIOSIS IN WILDLIFE

AETIOLOGY

Classification of the causative agent

Theileria spp. are apicomplexan protozoa in the order Piroplasmida, family *Theileridae*, and genus *Theileria*. These are obligate intracellular tick-borne pathogens. Novel, unnamed species of *Theileria* are frequently being discovered, especially in wild African mammals. Wildlife serve as reservoir hosts for several *Theileria* species that can ultimately spread to livestock. Of particular concern to domestic species are *T. parva* (which causes East Coast fever), *T. annulata* (which causes tropical theileriosis), and *T. orientalis* (which causes *Theileria*-associated bovine anaemia or Oriental theileriosis).

The life cycle of *Theileria* in a tick and in a mammalian host is complex. *Theileria* spp. can be grouped into "transforming" and "non-transforming". This grouping is based on whether or not the parasite can infect and successfully replicate within leukocytes. Non-transforming species include: *T. cervi*, *T. orientalis*, *T. mutans*, and *T. velifera*. Transforming species include: *T. parva* and *T. annulata*. While transforming species are considered more pathogenic, non-transforming species can still cause morbidity and mortality because piroplasms may cause severe anaemia.

For the purpose of voluntary reporting on non OIE-notifiable disease in wildlife, "theileriosis in wildlife" refers to **theileriosis in all non-domestic species**. Information on infections of **theileriosis in domestic species** is discussed individually in a separate technical card.

Resistance to physical and chemical action

Temperature:	Not applicable
pH:	Not applicable
Chemicals/Disinfectants:	Not applicable
Survival:	Obligate intracellular parasites

EPIDEMIOLOGY

When sporozoites first enter a mammalian host via the feeding tick, they infect leukocytes and develop into merozoites. Afterwards, they lyse leukocytes and travel to red blood cells to become piroplasms. Larval or nymphal ticks ingest the red blood cells containing piroplasms; piroplasms transform into zygotes in the tick gut, and become motile kinetes that infect tick gut epithelial cells. These kinetes travel to the haemolymph, after which they infect the tick salivary glands. The tick moults into its next life stage along with the parasite, which undergoes sporogony (multiplication of sporozoites) in the salivary gland and is again injected into the mammalian feeding site by the ticks.

Hosts

- *T. annulata, T. parva*
  - African buffaloes (*Syncerus caffer*)
  - Domestic cattle (*Bos indicus*, *Bos taurus*)
- *T. bicornis*
  - Black rhinoceroses (*Diceros bicornis*)
- *T. brachyuri*
  - Quokkas (*Setonix brachyurus*)
- *T. cervi*

    - Red deer (*Cervus elaphus*)
    - White-tailed deer (*Odocoileus virginianus*)
- *T. damae*
    - Sika deer (*Cervus nippon*)
- *T. equi*
    - Grévy's zebras (*Equus grevyi*)
    - Malayan tapirs (*Tapirus indicus*)
    - Plains zebras (*Equus quagga*)
    - South American tapirs (*Tapirus terrestris*)
- *T. gilberti*
    - Gilbert's potoroos (*Potorous gilbertii*)
- *T. gorgonis*
    - Blue wildebeest (*Connochaetes taurinus*)
- *T. orientalis*
    - Domestic cattle (*Bos indicus*, *Bos taurus*)
    - Water buffalo (*Bubalus bubalis*)
    - Yaks (*Bos grunniens*)
- *T. ornithorhynci*
    - Platypus (*Ornithorhynchus anatinus*)
- *T. ovis*
    - Chamois (*Rupicapra rupicapra*)
- *T. penicillata*
    - Woylies (*Bettongia penicillata ogilbyi*)
- *T. tarandirangiferis*
    - Reindeer (*Rangifer tarandus tarandus*)
- *T. taurotragus*
    - Elands (*Taurotragus oryx*)
- *T. youngi*
    - Woodrats (*Neotoma* spp.)
- *Theileria* spp. (multiple species associated with infection in the following animals)
    - Bandicoots (order Peramelemorphia)
    - Blue wildebeest (*Connochaetes taurinus*)
    - Chinese water deer (*Hydroptes inermis argyropus*)
    - Common tsessebes (*Damaliscus lunatus*)
    - Giraffes (*Giraffa camelopardalis*)
    - Grants' gazelles (*Nanger granti*)
    - Gray duikers (*Sylvicapra grimmia*)
    - Greater kudus (*Tragelaphus strepsiceros*)
    - Roan antelope (*Hippotragus equinus*)
    - Waterbucks (*Kobus ellipsiprymnus*)
    - Wild boars (*Sus scrofa*)

Transmission

- Feeding ticks excrete *Theileria* sporozoites in saliva when feeding
    - Transstadial transmission
    - The specific tick species that spread *Theileria* are largely unknown in wildlife species (see "**Sources**" for specific tick hosts)
- Infected blood from contaminated needles
- Biting flies (*Stomoxys calcitrans*)
- Sucking lice (*Linognathus vituli*)
- Transplacental transmission

Sources

- Ticks
    - *Hyalomma* spp.
        - *T. annulata*

    - Lone star tick (*Amblyomma americanum*)
        - *T. cervi*
        - *T. tarandirangiferis*
    - Other tick hosts include *Rhipicephalus* and *Ixodes* spp.
- Biting flies
- Sucking lice
- Blood

Occurrence

T. cervi has been found in white-tailed deer from several states in the United States, including Oklahoma, Missouri, Texas, Georgia, Florida, South Carolina, Delaware, Maryland, and Virginia. The lone star tick is the primary vector for *Theileria* in these regions. Theileriosis has caused pathology in Russian reindeer since the early 1900s. *T. damae* has been reported in sika deer from Japan. The exact tick hosts for *Theileria* spp. in Europe are unknown, though are thought to include *Hyalomma*, *Rhipicephalus*, and *Ixodes* species. *Rhipicephalus* spp. have been implicated as the vector of *Theileria* spp. in African mammals. In Australia, *T. orientalis* is spread by *Haemaphysalis longicornis* ticks. An infection of *T. equi* in a South American tapir in Brazil was thought to have come from an *Amblyomma* tick species.

There is a high prevalence of *T. ovis and T. capreoli* in Chinese water deer in the Republic of Korea. *Theileria* spp. have caused death in roan and sable antelope calves and have decreased these antelope populations in South Africa.

For more recent, detailed information on the occurrence of this disease worldwide, see the OIE World Animal Health Information System - Wild (WAHIS-Wild) Interface [http://www.oie.int/wahis_2/public/wahidwild.php/Index].

DIAGNOSIS

While theileriosis infection in deer is usually subclinical, clinical signs can be exacerbated by heavy *Theileria* burden, poor nutrition, or other infections, especially in fawns. Clinical signs of theileriosis in tapirs have not been reported. Anaemia in mammalian hosts is due to the lysing of red blood cells by piroplasms.

Clinical diagnosis

Common clinical signs of theileriosis include fever, icterus, anaemia, and enlarged peripheral lymph nodes. Reindeer infected with *Theileria* spp. may present with anorexia, weight loss, ataxia, anaemia, mucoid faeces and icterus. *Theileria* infection in elands results in diarrhoea and poor body condition. Haemoglobinuria has been reported in elands, giraffes, and roan antelopes.

Lesions

- The following lesions can be present in several different organs, including liver, lymph nodes, spleen, and kidney:
    - Multifocal to diffuse schizont infiltration
    - Disseminated foci of necrosis and haemorrhage
    - Petechiae and ecchymoses on serosal and mucosal surfaces
- Oedema (brain, lymph nodes, lungs)
- Fibrinous exudate (lung)
- Enteric haemorrhage
- Hepatomegaly
- Effusions in thorax, pericardium, or abdomen
- Splenomegaly with red or white pulp hyperplasia
- Leukocyte hyperplasia causing lymphadenopathy

Differential diagnoses

- Adenovirus
- Anaplasmosis
- Babesiosis
- Leptospirosis
- Heavy tick infestations and other causes of anaemia

Laboratory diagnosis

Samples

For isolation of agent

- Liver
- Lymph node
- Lung
- Spleen
- Whole blood

Serological tests

- Serum

Procedures

Identification of the agent

- Giemsa-stained blood smear
    - Detects piroplasms in blood
    - *Theileria* and *Babesia* spp. can appear very similar
- Impression smear
    - Schizonts can be found in lymph node biopsies
- Polymerase chain reaction (PCR)
    - Unable to identify new *Theileria* spp.
- Real-time PCR (qPCR)
- Reverse line blot (RLB) hybridization assay
    - Unable to identify new *Theileria* spp.

Serological tests

Different species of *Theileria* may cross-react with each other

- Antibody capture enzyme-linked immunosorbent assay (ELISA)
- Indirect fluorescent antibody test (IFA)
    - Cross-reactivity may occur between *T. parva* and *T. taurotragi*

PREVENTION AND CONTROL

Sanitary prophylaxis

- Use acaricides on livestock and pastures
- Utilise rotational grazing on pastures to allow ticks carrying*Theileria* spp. to die before livestock are reintroduced
- Build fences to prevent interaction between wildlife and livestock
- Do not reuse needles between animals to avoid bloodborne/iatrogenic transmission
- Cull infected animals in non-endemic areas where the parasite has been recently introduced

Medical prophylaxis

- Vaccines are available for tropical theileriosis (*T. annulata*) and East Coast fever (*T. parva*), though are not generally administered to wildlife.
    - The vaccine against tropical theileriosis is live attenuated
    - There is concern about vaccinating animals against East Coast fever because vaccinated animals may become carriers. Vaccinating cattle against East Coast fever involves injecting them with several *T. parva* strains and treating them with an antibiotic (most commonly a long-acting tetracycline).

POTENTIAL IMPACTS OF DISEASE AGENT BEYOND CLINICAL ILLNESS

Risks to public health

- There is no known risk of *Theileria* spp. infection to humans

Risks to agriculture

- *Theileria* spp. can cause economic and production losses to farmers
    - Several *Theileria* spp. infect various ruminant species, including buffalo, cattle, and sheep
    - *T. parva*, the causative agent of East Coast fever, is spread by African buffalo and can be a threat to cattle herds in southern, central, and eastern Africa
    - African buffalo are also carriers of *T. parva lawrenci*, the causative agent of corridor disease in cattle
    - *T. cervi* is a threat to farmed white-tailed deer
    - Imported animals from countries naïve to *Theileria* spp. may be at risk for fatal infection with the pathogens if introduced to an endemic area

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The OIE will periodically update the OIE Technical Disease Cards. Please send relevant new references and proposed modifications to the OIE Science Department (scientific.dept@oie.int). Last updated 2020. Written by Samantha Gieger and Erin Furmaga with assistance from the USGS National Wildlife Health Center.