East Coast Fever
(Theileriasis, Theileriosis, Rhodesian Tick Fever, Rhodesian Red Water)

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East Coast Fever (ECF) is a highly pathogenic, tick transmitted, febrile infection occurring in cattle, caused by the protozoal parasite Theileria parva, which primarily involves the hemopoietic and lymphopoietic systems. This disease is confined principally to areas of East Africa where the principle vector, Rhipicephalus appendiculatus, occurs.

Etiology: The causative organism, Theileria parva, can be identified in the bovine erythrocyte or as schizonts in the lymphocytes. The erythrocytic forms, often referred to as piroplasms or merizoites, are very pleomorphic ranging in shape from rod to rounded forms. Neitz (1957) described the most commonly occurring rod forms (80%) as being 1.5 - 2.0 u X .5 u, the round forms (12%) 1.0 - 1.2 u in diameter, the oval forms (6%) 1.0 - 1.7 u X 0.6 u, and the Anaplasma like forms (2%) as being 0.5 - 0.7 u in diameter. It is doubtful if positive differentiation of blood forms can be made between T. parva and T. mutans, or T. annulata, however the latter two tend to become more rounded and slightly larger. The blood forms of T. cervi, occurring in white-tailed deer of North America, also closely resemble T. parva. In size the rounded or larger Theileria parasites may resemble the small Babesias, and positive identification based solely on morphology is not always certain.

The lymphocytic or schizogonous forms, sometimes referred to as Koch blue bodies, are present in the early phases of infection, and are diagnostic of Theileria infections when seen. Following attachment and feeding of infected ticks on a susceptible host the infectious organism migrates to lymphatic tissue where it undergoes schizogonous development. Initially macro-schizonts (agamonts) develop which eventually rupture discharging numerous individual macro-schizonts or macro-merizoites. These organisms are thought to re-invade

lymphocytic tissue either forming another macro-schizont or a micro-schizont (gamonts). The micro-schizonts have smaller and more numerous granules which after maturing and freed from the schizont are referred to as micro-merizoites or merizoites. It is thought that these merizoites invade the erythrocytes and become the blood forms observed in these cells. The macro-schizont chromatin granules range in size from 0.4 to 2.0 u averaging 1.2 u, whereas the micro-schizont granules range in size from 0.3 to 0.8 with an average of 0.5 u.

The tick vector becomes infected by the ingestion of blood forms which following a cycle in the tick are returned to the vertebrate host as sporozoites by the tick thus completing the cycle.

As early as 1957 and 1958 the parasites were observed to survive for short periods of time in tissue fragments. Hulliger (1964 and 1965) maintained an apparent schizogonous form of the parasites for several months with repeated subculturing in bovine lymphocytes. Even though an infection could be induced in cattle with this material, the surviving animals, while resistant to the organism present in tissue culture, were susceptible to T. parva via a tick challenge. Malmquist et al in 1970 reported the establishment of 3 spleen cell lines derived from 3 calves experimentally infected with T. parva in which the macro-schizogonous phase of the organism has been maintained for up to 10 months. Growth apparently occurs in lymphoblasts which can readily be subcultured. The infectious particles present in these cultures are capable of inducing infections in cattle indistinguishable from ECF.

History: East Coast Fever was probably first recorded in East Africa during the 16th century by missionaries. It was not until 1898 however, that Koch observed the etiologic agent which he thought to be immature or young forms of Babesia bigemina. In 1903, while investigating death losses in cattle thought to be due to red water, Theiler observed intraerythrocytic forms which were entirely unlike the large, pear shaped, Babesia bigemina.

Theiler concluded that this condition was an entirely new disease entity based on morphology as well as his observation that red water immune cattle were susceptible to this new organism. Theiler (1904) in his description of the parasite called it Piroplasma parvum. When Bettencourt, Franca, and Borges (1907) created the new genus Theileria, which included this organism it was named Theileria parva. Prior to 1900 the disease had been enzootic along the east coast of Africa, having been well known for many generations. Because of the relative isolation from cattle in the interior, infection was generally confined to these coastal areas. By 1910 however, the movement and importation of cattle through and from coastal regions spread this infection throughout much of South Africa, Rhodesia and the inland areas of Tanzania, Kenya and Uganda. It was estimated that between 1910 and 1914 900,000 head of cattle died in South Africa alone (Neitz 1964).

Signs: The first indication of infection occurs as an increase in temperature (41.1° to 42.2°C). Koch bodies may occur in the regional lymph nodes several days before fever and erythrocytic forms 2 to 17 days after the rise of temperature. Later there is obvious swelling of superficial lymph glands, inappetence, rumen atony, drop in milk production, excessive salivation and lacrimation, diarrhea, emaciation, serous nasal discharge, acceleration of respiration, and pronounced dyspnea shortly before death. The course of the disease is usually 8 to 25 days with an average of 15 days. Jaundice and anemia are not outstanding features of T. parva infections even though drops in packed cell volumes do occur especially in protracted cases. Generally the morbidity among susceptible cattle will approach 100% with a 95% mortality. Among indigenous cattle and young calves raised in enzootic areas the mortality may be less, with as many as 75% of adult cattle and even a higher percentage of calves recovering.

Incubation Period: According to Neitz (1957) the incubation period is 8-25 days with an average of 13 days following infestation by infected ticks.

Pathologic Changes:

Postmortem Lesions: The carcass is usually emaciated with froth coming from the nostrils. The subcutaneous and intramuscular areas may be yellow and infiltrated with clear serous fluid to give them a gelatinous appearance. The pathologic lesions are dominated by a proliferation and enlargement of the lymphoid tissue, including Peyer's patches. There appear to be liver and kidney infarcts which are really perivascular proliferative foci of lymphocytes. The lungs are generally saturated with clear edematous fluid. There may be marked petechial hemorrhages on serous and mucous surfaces throughout the abdominal and thoracic cavities. Neitz (1948) has reported intramuscular hemorrhages. In cases of central nervous system involvement (Turning-disease Mettam, 1934 and Mettam and Carmichael, 1936) there may be perivascular lymphocytic infiltrations, and lymphocytic embolisms of the cerebral vessels.

Microscopic Pathology: An initial intense lymphocytic hyperplasia is noted, particularly in the local nodes. The hyperplasia is of a lymphoreticular type with a rapid multiplication of reticular cells, and large and medium lymphocytes. De Koch (1957) and Barnett (1960) observed that the early lymphocytic hyperplasia was replaced by regressive changes in the lymphoid tissue beginning about the fourth to sixth day involving depletion of the lymphocytes, disruption and destruction of the lymphocytopoietic centers, and a progressive toxicosis of cells associated with cellular destruction.

Diagnosis:

A. In the Field: A febrile highly fatal disease associated with enlarged lymph nodes and pulmonary edema in an area of R. appendiculatus infestation is suggestive of ECF. A history of failure to spray or dip at the usual intervals, and the presence of R.

appendiculatus on the animals would further suggest a diagnosis of ECF.

B. Laboratory: A Giemsa-stained smear from a lymph node biopsy, taken preferably from the parotid or pre-scapular nodes, should be examined for Koch blue bodies (macro or micro-schizonts). The presence of these bodies is diagnostic of theileriosis, and depending on the history and symptomatology diagnostic of ECF. The presence of blood forms on Giemsa-stained blood smears are also diagnostic of theileriosis. These simple criteria are generally adequate to differentiate the disease from viral or bacterial infections.

In recent years greater attention has been displayed in the development of specific serologic tests for the diagnosis of ECF. A specific agar gel precipitin test was demonstrated by Gourlay and Brocklesby in 1967, and in 1968 Schindler and Mehlitz reported using a Coons test and the complement-fixation tests. These workers have used these procedures more as tools in studying antigenic similarities between theilerial infections rather than attempting to adapt them as routine diagnostic procedures. Burridge has described an indirect fluorescent antibody test to detect specific Theileria antibodies which has been useful in measuring an immune response to vaccinated cattle.

C. Differential: In addition to T. parva Koch bodies may be found in animals infected with T. mutans, T. annulatus, and T. lawrencei. These bodies are rare however in T. mutans which generally produces only a mild infection with rapid recovery followed by premunition, or a carrier infection. T. mutans is readily transmitted by blood inoculation which is not true of T. parva. Koch bodies are common

in T. annulata infections which generally are milder than infections due to T. parva. Theileria annulata is not known to occur in Africa south of the Sahara, and is generally confined to North Africa, Southern Asia and parts of Southern Europe. Theileria lawrencei is thought to be a primary pathogen for the African buffalo, and on occasion produces a relatively severe infection in cattle (Corridor Disease, Neitz, 1955). Transmission of T. lawrencei from cattle to cattle is however reported by Matson (1967).

Barnett and Brocklesby (1966) reported the serial passage in cattle of T. lawrencei (Kenya) isolated from buffalo in Kenya. After 7 cattle passages of T. lawrencei (Kenya) it was indistinguishable from T. parva based on morphology, pathogenicity and cross immunity trials. These authors conclude T. lawrencei had become indistinguishable from T. parva hence the validity of T. lawrencei is highly questionable.

Serologic and immunologic comparisons of T. parva, T. lawrencei and T. mutans by Schindler, Mehlitz, and Matson (1969) and by Schindler and Mehlitz (1968) have shown antigenic similarity in these organisms. An antigen common to all three Theileria was demonstrated with the suggestion that lawrencei was intermediate between parva and mutans.

Prognosis: East Coast Fever in susceptible stock is frequently severe with mortality approaching 95%. The prognosis in such animals is very poor. The prognosis may be more favorable in indigenous Zebu type cattle, where mortality may be much lower.

Epizootiology:

A. Geographic Distribution: East Coast Fever is epizootic in East Africa. The disease was introduced into Rhodesia by a shipment

of cattle from Tanganyika in the early part of this century. From Rhodesia, it spread southward to Mozambique (formerly Portuguese East Africa), the Transvaal, Sawziland, Natal, and the Eastern Cape Province of South Africa, westward to the Belgian Congo and north to Uganda, Kenya, and the Sudan. The disease has also appeared in Zanzibar, probably exists in Ethiopia and Southern Somalia, and has been suspected but not confirmed in some areas of West Africa.

The Republic of South Africa and Mozambique have reportedly eradicated the disease through intensive tick control, quarantine, and slaughter of all cattle associated with isolated outbreaks.

B. Transmission: Stage to stage transmission of *T. parva* is predominantly accomplished by the 3 host tick *Rhipicephalus appendiculatus*. Transovarial transmission does not occur. Several other species of ticks have been demonstrated as capable of transmitting the infection and these include *Rhipicephalus ayrei*, *R. capensis*, *R. evertsi*, *R. jeanelli*, *R. neavei*, *R. simus*, *Hyalomma anatolicum*, *H. dromedarii*, and *H. truncatum*. Transmission of the parasites by these vectors is on a stage to stage basis.

Martin *et al* in 1965 reported that *R. appendiculatus* became non-infective within 34-40 weeks after moulting, even though capable of feeding for as long as 15 months. Ticks infected with *T. parva* could transmit the parasite to cattle 24 hours after being placed on the host.

Hosts: East Coast Fever is primarily a disease of cattle, however, both the African buffalo and the Indian water buffalo are susceptible. The Indian water buffalo appears to be equally as susceptible as cattle. The African buffalo, while a potential carrier, is relatively resistant to *T. parva*, however it may show moderate to severe response to *T. lawrencei*.

If however, lawrencei is a strain of T. parva, as suggested by Barnett and Brocklesby (1966), then the role of the buffalo in the epidemiology of ECF must be reconsidered. Most wild antelopes in East Africa carry intra-erythrocytic piroplasms that are morphologically indistinguishable from those of T. parva. It is not known if these parasites are pathogenic to the host in which they are found, nor is it known if these piroplasms are transmissible to cattle. One such Theileria has been transmitted from eland to cattle.

Control and Eradication:

A. Preventive Measures: Regular dipping to control the vector, quarantine, and slaughter of infected stock under some conditions, has been successful in eliminating infection in South Africa, and to a more limited extent in Rhodesia. A combination of quarantine and tick control is probably the most practical approach in containing the disease in enzootic areas. Dipping or spraying twice weekly is essential for tick eradication, but in practice a 7 to 10 day dipping interval is usually adequate. The arsenicals, BHC, and toxaphene are used in dips and sprays for this purpose. Newer compounds with longer residual action might reduce the frequency of dipping.

B. Treatment: No effective therapy exists for ECF. Administration of chlortetracycline at the rate of 12-15 mg/kg when given very early in the course of infection may reduce the severity of infection. Good care and management of calves in enzootic areas has reduced mortality.

C. Sanitation and Disinfection: Sanitation and disinfection, aside from that involved in control and elimination of ticks, do not contribute to an abatement of the disease incidence in enzootic areas.

D. Immunization: There is not at present a practical immunization procedure in routine use. There are now indications that vaccines may be developed in the near future considering the advent of new techniques including growth of the organism on tissue culture, radiation, and new methods of isolating infectious particles from ticks to artificially induce infection. Recovery from ECF may confirm a solid, sterile immunity, however in some instances carrier infection may persist (Neitz, 1964). Mild strains of T. parva can be used to induce protective immunity, but the lack of a practical delivery system has limited the use of these organisms. In the past ECF, has not been readily transmitted by the needle inoculation of infected bovine tissues, but infected tissue cultures, and infected tick tissues have been shown to readily induce an immunizing infection (Cunningham, 1970). Barnett (1957) and Wilde (1968) noted that the severity of infection is related to the level of exposure, and cattle recovering from mild infections induced by low level exposures are solidly resistant to T. parva tick challenge. Controlled infections might therefore, be of value in preventing ECF.

Under experimental conditions the occurrence of antigenic variants appear easily induced with Theileria. The possibility of such variants crossing an immunologic barrier is one which must be kept in mind when and if a vaccination program for ECF reaches the point of common use.

APPENDIX 2

Microbiological Procedures:

Piroplasma and Koch bodies from blood, lymph nodes and spleen.

Histological Examination:

Lymphatic hyperplasia, small *piroplasma* in red cells and Koch bodies in white cells.

Serologic Tests:

Agar gel precipitin test, complement-fixation, Coons test, and indirect fluorescent antibody.

Animal Inoculation:

Tick transmission is the most consistant means of reproducing infection. Animal inoculation with tissues of infected animals is only sporadically successful. The injection of infected tick tissues, or lymphoblast tissue cultures are more consistent in artificially inducing infections in susceptible cattle. Laboratory animals are refractory to infection.

APPENDIX 5

Description:

A highly pathogenic, tick transmitted, febrile disease of cattle affecting primarily the hemopoietic and lymphopoietic systems.

Cause and Distribution:

The protozoan - Theileria parva. East Africa.

Host:

All bovine species. African buffalo. Indian water buffalo.

Signs:

Swelling of the lymph nodes draining the area where infected ticks have fed. Sudden febrile response --105-106°F. Lachrymation, nasal discharge, corneal opacity. Diarrhea, lung-edema, emaciation. Course 8 to 25 days.

Pathology:

Lungs are generally edematous also subcutaneous and intramuscular edema, Highly variable areas of petechial hemorrhages, extending through the thoracic and abdominal cavities. Proliferation and enlargement of lymphoid tissue, including enlarged Peyer's patches and raised grey-white areas of proliferative foci of lymphocytes on the liver and kidneys resembling infarcts.

Diagnosis:

Field - A highly febrile and fatal disease associated with regional lymph node enlargement. Differential - Demonstration of Koch's bodies in lymphoid tissue and parasites in blood smears.

Incubation Period:

8 to 25 days with an average of 13 days.

Mode of Transmission:

Stage to stage transmission principally by the tick Rhipicephalus

APPENDIX 5 (Continued)

appendiculatus. Six other species of Rhipcephalus and three species of Hyalomma capable of transmission.

Period of Communicability:

R. appendiculatus may harbor infection as long as 34 weeks. Cattle and African buffalo may become carriers of infection for an undetermined period.

Control Measures:

Tick control by frequent dipping (7-10 day intervals), strict quarantine, restriction on all movement of cattle and in some instances slaughter.

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