

**HEARTWATER  
STANDARD OPERATING PROCEDURES:  
1. OVERVIEW OF ETIOLOGY AND ECOLOGY**

**FAD PReP**

**Foreign Animal Disease  
Preparedness & Response Plan**



**United States  
Department of  
Agriculture**

United States Department of Agriculture • Animal and Plant Health Inspection Service • Veterinary Services

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The Foreign Animal Disease Preparedness and Response Plan (FAD PReP) Standard Operating Procedures (SOPs) provide operational guidance for responding to an animal health emergency in the United States.

These draft SOPs are under ongoing review. This document was last updated in **September 2013**. Please send questions or comments to:

Preparedness and Incident Coordination  
Veterinary Services  
Animal and Plant Health Inspection Service  
U.S. Department of Agriculture  
4700 River Road, Unit 41  
Riverdale, MD 20737-1231  
Telephone: (301) 851-3595, Fax: (301) 734-7817  
E-mail: [FAD.PReP.Comments@aphis.usda.gov](mailto:FAD.PReP.Comments@aphis.usda.gov)

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**FAD PReP**  
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## **Heartwater**

### Etiology & Ecology Quick Summary

#### Disease

Cowdriosis, Malkopsiekte, Péricardite Exsudative Infectieuse, Hidrocarditis Infeciosa, and Idropericardite dei Ruminanti.

#### Mortality & Morbidity

High morbidity and mortality (>80%) among breeds of cattle, sheep, and goats not native to Africa. Mortality may be below 10% for indigenous breeds.

#### Clinical Signs

There are multiple clinical forms of heartwater. The majority manifest with high fever, respiratory distress, diarrhea, and in some forms, neurologic signs.

#### Susceptible Species

Cattle, sheep, goats, white-tailed deer, and wild African ruminants.

#### Zoonotic Potential

None.

#### Reservoir

Reservoir is believed to be wild African ruminants.

#### Transmission

Vector-borne; transmitted by the bite of *E. ruminantium*-infected *Amblyomma* ticks.

#### Persistence in the Environment

Cannot exist outside of the vector or host.

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## 1.1 Introduction

Heartwater was originally described in a personal diary in 1838 by Louis Trichardt, a Voortrekker (Dutch pioneer) in South Africa. He noted that the majority of his sheep had died approximately 3 weeks after a massive tick infestation. Heartwater is caused by the bacteria *Ehrlichia* (formerly *Cowdria*) *ruminantium* and is transmitted by *Amblyomma* ticks, affecting cattle, sheep, goats, and some wild ruminants; it is often fatal. The World Organization for Animal Health (OIE) includes it as a Listed Disease for 2013.

Endemic in sub-Saharan Africa and a few islands in the Caribbean, this disease is important to the United States due to the proximity of affected islands and the presence of *Amblyomma* ticks in North America that have been shown to be competent vectors for *E. ruminantium*. With that in mind, the United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) has prepared this etiology and ecology standard operating procedure (SOP) to educate stakeholders.

### 1.1.1 Further Information

This document is intended to be an overview of heartwater in domestic livestock. Unless otherwise noted, this document is based primarily on information from the OIE Technical Disease Card (2009). Additional resources and articles referenced in this SOP are listed in Attachment 1.A. Foreign Animal Disease Preparedness and Response Plan (FAD PRoP) documents are available on the APHIS public website ([http://www.aphis.usda.gov/animal\\_health/emergency\\_management](http://www.aphis.usda.gov/animal_health/emergency_management)) or on the APHIS Intranet (<http://inside.aphis.usda.gov/vs/em/fadprep.shtml>, for APHIS employees).

### 1.1.2 Goals

As a preparedness goal, APHIS will provide etiology and ecology summaries for heartwater and update the summaries at regular intervals.

As a response goal, the Unified Command and stakeholders will have a common set of etiology and ecology definitions and descriptions, to ensure proper understanding of heartwater when establishing or revising goals, objectives, strategies, and procedures.

## 1.2 Purpose

The purpose of this document is to provide responders and stakeholders with a common understanding of the disease agent.

## 1.3 Etiology

### 1.3.1 Name

Heartwater most likely takes its name from the characteristic edema of the pericardium seen during the course of disease. It is also known as cowdriosis (after Edmund Cowdry, who

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confirmed that heartwater was a rickettsial disease), as well as Malkopsiekte, Péricardite Exsudative Infectieuse, Hidrocarditis Infeciosa, and Idropericardite dei Ruminanti.<sup>1</sup>

### 1.3.2 Bacterial Characteristics

Heartwater is caused by *Ehrlichia* (formerly *Cowdria*) *ruminantium*, a member of the order Rickettsiales which are Gram-negative, obligate intracellular bacteria found in ticks, lice, fleas, mites, chiggers, and mammals.<sup>2</sup> *E. ruminantium* is a pleomorphic coccus, typically occurring in clumps within the capillary endothelial cells of its vertebrate host. There are several different genotypes/strains of *E. ruminantium* that may differ in virulence.

## 1.4 Ecology

### 1.4.1 Susceptible Species

Cattle, sheep, goats, and some wild African ruminants including blesbok, black wildebeest, blue wildebeest, African (Cape) buffalo, eland, giraffes, greater kudu, sable antelope, lechwe, steenbok, springbok, and sitatunga are all susceptible. Some non-African ruminants such as the Timor deer and chital of southern Asia and the white-tailed deer of North America have been infected experimentally, as have non-ruminants such as ferrets, laboratory mice, four-striped grass mice, and multimammate mice.<sup>3</sup> Multiple other species are believed to be susceptible but remain unconfirmed.

Domestic ruminants appear to be more susceptible to *E. ruminantium* infection than wild ruminants. However, domestic ruminants indigenous to Africa, such as African breeds of sheep and goats, typically have greater resistance to the disease and usually experience a milder course of infection. *Bos indicus* (Zebu) cattle breeds are generally more resistant to heartwater than *Bos taurus* (European) breeds.

### 1.4.2 Reservoir and Carriers

Because of the inapparent or mild disease that is experienced by African wild ruminants, it is believed that they can serve as the reservoirs for heartwater. Most of the wild ruminants listed in the Susceptible Species section are believed to potentially serve as reservoirs. Animals that recover from infection remain carriers with lifelong immunity to the particular strain with which they were infected.

### 1.4.3 Distribution

Heartwater is found where the *Amblyomma* ticks are present: sub-Saharan Africa, Madagascar, Reunion, Mauritius, Zanzibar, the Comoros Islands, and Sao Tomé. Heartwater is also endemic on three Caribbean islands: Guadeloupe, Marie-Galante, and Antigua. Figure 1-1 presents

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<sup>1</sup> Center for Food Security and Public Health (CFSPH), Iowa State University. 2007. "Heartwater." *Technical Factsheet*. [www.cfsph.iastate.edu](http://www.cfsph.iastate.edu).

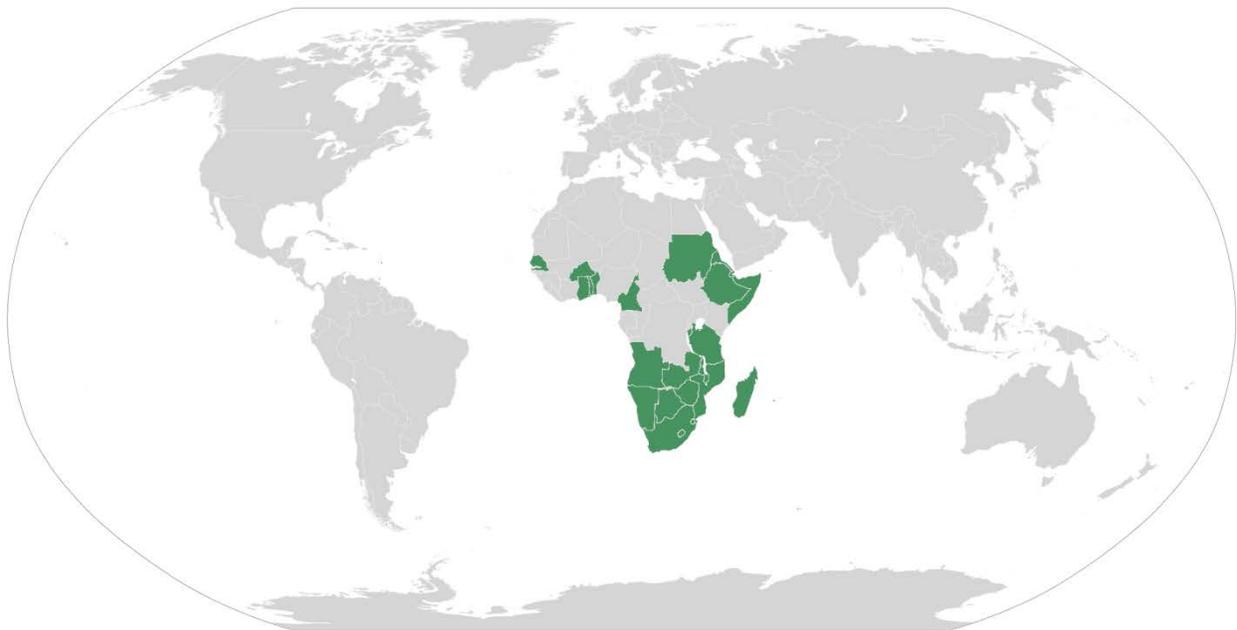
<sup>2</sup> Walker DH. Rickettsiae. In: Baron S, editor. *Medical Microbiology*. 4th edition. Galveston (TX): University of Texas Medical Branch at Galveston; 1996. Chapter 38. Available from: <http://www.ncbi.nlm.nih.gov/books/NBK7624/>.

<sup>3</sup> Center for Food Security and Public Health (CFSPH), Iowa State University. 2007. "Heartwater." *Technical Factsheet*. [www.cfsph.iastate.edu](http://www.cfsph.iastate.edu).

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countries that have experienced heartwater from 2005 to the present, based on the data available in the OIE World Animal Health Information Database in disease timelines and disease distribution maps.

**Figure 1-1. Distribution of Heartwater, 2005–2012**



#### 1.4.4 Introduction and Transmission

Heartwater is transmitted via the bite of the *Amblyomma* tick. Larval, nymphal, and adult stage ticks can acquire the pathogen from infected animals, but nymphs and adults are responsible for transmission. The pathogen is passed to each stage of the tick (transstadial transmission), but not from adult female to egg to larva (transovarial transmission). The tropical bont tick (*A. variegatum*) is the most important vector because of its widespread distribution. Other competent vectors include *A. hebraeum*, *A. gemma*, *A. lepidum*, *A. astrion*, and *A. pomposum*, which are all native to Africa. Many other *Amblyomma* ticks have been shown to experimentally transmit heartwater, including two North American species that can be found in parts of the United States: *A. maculatum* (Gulf Coast tick) and *A. cajennense* (Cayenne tick).

#### 1.4.5 Incubation Period

On average, the incubation period is 2 to 3 weeks—but it may vary from 10 days to 1 month.

#### 1.4.6 Clinical Signs

There are several different forms of heartwater. Variations are due to host susceptibility, virulence of the pathogen, and infective dose.

The peracute form is characterized by a brief fever, severe respiratory distress, hyperesthesia (hypersensitivity), lacrimation (tears), severe diarrhea, and sudden death. This form of heartwater is relatively rare and mostly experienced by breeds of sheep that are not native to Africa.

The acute form of disease starts with a high fever that lasts for 4 to 5 weeks and then drops suddenly before death. Along with fever, those affected with the acute form experience loss of appetite, listlessness, diarrhea (especially cattle), and shortness of breath characteristic of lung edema. Infected animals also experience neurologic signs such as walking in circles, sucking movements, muscle tremors, and anxious or aggressive behavior. Neurologic signs become more severe as the animal nears death; signs include opisthotonos (rigid back, head thrown back), pedaling, and frothing at the mouth.

The subacute form of heartwater is characterized by prolonged fever, coughing, and mild incoordination. Recovery or death occurs within 1 to 2 weeks.

Mild or subclinical infections are also possible and most likely to affect young animals, the partially immune, indigenous breeds, and some wild ruminants. For this form, the only sign of illness may be a transient fever.

### 1.4.7 Morbidity and Mortality

As the disease presentation is variable, so is the outcome. Morbidity depends on the degree of tick infestation, prior exposure (current immunity), and level of tick protection. Once signs have developed, mortality is often 80 percent or higher among non-African sheep, goats, and cattle. The mortality rate in indigenous breeds may be below 10 percent. Animals that recover develop complete immunity against that strain.

## 1.5 Environmental Persistence of Heartwater

As an obligate intracellular pathogen, *E. ruminantium* is unable to survive outside of the host. In addition to being susceptible to the environment in general, it is heat labile. Table 1-1 describes the physical and chemical resistance and survival properties of *E. ruminantium*.

**Table 1-1. Physical and Chemical Resistance of *E. ruminantium***

Action	Resistance
Temperature	Heat labile and loses its viability within 12–38 hours at room temperature. Infective stabilates can be cryopreserved in DMSO (dimethyl sulfoxide) or sucrose-potassium phosphate-glutamate medium. Infective half-life of thawed stabilate kept on ice is only 20–30 minutes.
pH	Not applicable.
Disinfectants	Not applicable.
Survival	The heartwater organism is extremely fragile and cannot persist outside of a host for more than a few hours. Because of its fragility, the organism must be stored in dry ice or liquid nitrogen to preserve its infectivity.

Source: OIE, 2009. "Heartwater—Cowdriosis." *Technical Disease Card*. [www.oie.int](http://www.oie.int).

## 1.6 Risk of Introduction to the United States

As previously mentioned, there are species of *Amblyomma* ticks within the United States that are competent laboratory vectors for heartwater. Given that heartwater is endemic on the islands of Guadeloupe, Marie-Galante, and Antigua in the Caribbean, there is a chance that infested ticks or, perhaps less likely, infected animals, could make their way to the U.S. mainland. While not

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from the Caribbean, imported reptiles from Africa have been found to be infested with *E. ruminantium*-competent ticks after importation to the United States.<sup>4</sup>

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<sup>4</sup> Burrige MJ, Simmons LA, Simbi BH, Peter TF, Mahan SM. 2000. "Evidence of *Cowdria ruminantium* infection (heartwater) in *Amblyomma sparsum* ticks found on tortoises imported into Florida." *J. Parasitol.* 86(5): 1137–1140.

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## Attachment 1.A References and Resources

Burridge MJ, Simmons LA, Simbi BH, Peter TF, Mahan SM. 2000. “Evidence of *Cowdria ruminantium* infection (heartwater) in *Amblyomma sparsum* ticks found on tortoises imported into Florida.” *J. Parasitol.* 86(5): 1137–1140.

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## Attachment 1.B Abbreviations

APHIS	Animal and Plant Health Inspection Service
CFSPH	Center for Food Security and Public Health
DMSO	dimethyl sulfoxide
FAD PReP	Foreign Animal Disease Preparedness and Response Plan
OIE	World Organization for Animal Health
SOP	standard operating procedure
TDD	telecommunications device for the deaf