United States
Department of
Agriculture

Animal and
Plant Health
Inspection
Service

Veterinary
Services

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Epidemiology and
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Evaluation of the Risk Associated with Proposed Changes to 9 CFR 93.427(b)(2): Importation of Cattle from States in Mexico Where *Rhipicephalus (Boophilus) annulatus* and *microplus* Ticks (Fever Ticks) Exist

December 2006

Safeguarding Animal
Health

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Abbreviations and Definitions

AK	Alaska
APHIS	Animal and Plant Health Inspection Service
B.	*Babesia*
CA	California
CADIA	Center for Animal Disease Information and Analysis
CEAH	Centers for Epidemiology and Animal Health
IA	Iowa
IL	Illinois
KS	Kansas
KY	Kentucky
MO	Missouri
MS	Mississippi
NCIE	National Center for Import and Export
NE	Nebraska
OIE	World Organization for Animal Health
OK	Oklahoma
R.	*Rhipicephalus (Boophilus)*
TX	Texas
US	United States of America
USDA	United States Department of Agriculture
VS	Veterinary Services
WY	Wyoming

Executive Summary

In November 2005, USDA-APHIS submitted proposed amendments to 9 CFR 93.427(b)(2) to the Federal Register for comment. The proposed rule concerned the importation of cattle into the US from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks (Fever Ticks) exist.

Specifically, amendments to 9 CFR 93.427(b)(2) proposed to:

1. Allow importation of cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist into the permanent tick quarantine zone within Texas and to other States

2. Allow cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist to enter the US through the port of San Luis, Arizona

The purpose of this risk assessment is to assess the magnitude of the risk associated with implementing each of the proposed amendments.

The format of this risk assessment conforms to OIE Code Requirements for Risk Analysis. These guidelines state that a risk analysis must start with identification of the hazard and then proceed to the four interrelated steps in a risk assessment (release assessment, exposure assessment, consequence assessment, and risk estimation).

Hazard Identification

The **identified hazard** is the **introduction** into the US of ***Babesia bovis*** and ***Babesia bigemina***, the causative protozoan agents of bovine babesiosis. The last occurrence of bovine babesiosis on the US mainland was in 1943.

Rhipicephalus (Boophilus) microplus and *Rhipicephalus (Boophilus) annulatus* ticks, which are the focus of the proposed rule, are only important to the identified hazard to the extent that these tick species serve as an intermediate host for *Babesia* and *Babesia bigemina*. By virtue of being an intermediate host, these tick species are required for transmission of these protozoal organisms from infected cattle to uninfected but susceptible cattle.

Release Assessment

Based on limited seroprevalence data collected within States in Mexico that export cattle to the US, the probability is high that some Mexican-origin cattle imported into the US will be persistently infected with *Babesia bovis* or *Babesia bigemina* (the identified hazard). However, it is not currently possible to state with any precision how many *Babesia bovis*- or *Babesia bigemina*-infected Mexican-origin cattle are entering the US because no testing of these cattle for these hemoparasites is required as a prerequisite for importation.

In the absence of being able to obtain the necessary data to determine a quantitative estimate of the risk to the US for the release of these hemoparasites into the general US cattle population, in qualitative terms, a high degree of risk exists that *Babesia bovis*- and/or *Babesia bigemina* are entering (released into) the US via Mexican-origin cattle that are carriers of these pathogens.

Exposure Assessment

The proposed changes to 9 CFR 93.427(b)(2) focused exclusively on the legal importation of cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present. Indigenous US cattle can be exposed to the identified hazard (*Babesia bigemina* and/or *Babesia bovis*), following its release into the US, under two circumstances:

1. Legal importation of Mexican-origin cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present and the cattle ARE NOT INFESTED with *Rhipicephalus (Boophilus) annulatus and microplus* ticks but the cattle ARE INFECTED with (carriers of) *Babesia bovis* or *Babesia bigemina*

   a. Entry into permanent tick quarantine zone in Texas

   In the absence of *Rhipicephalus (Boophilus) annulatus and microplus* vector ticks living within the permanent quarantine zone, ordinarily any *Babesia bigemina*- and/or *Babesia bovis*-infected (carrier) Mexican-origin cattle that enter this area will not create a long-term (endemic) animal health problem for susceptible US cattle because the disease would eventually die out. However, this situation is not present currently. *Rhipicephalus (Boophilus) annulatus and microplus* vector ticks are currently present in the permanent tick quarantine zone in Texas. Cattle and free-ranging wild ruminants (e.g. white-tailed deer) serve as a host for these vector ticks within the quarantine zone.

   Given that cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present have been heretofore prevented from entering and remaining within the permanent tick quarantine zone, reversal of this movement restriction automatically increases the risk of exposure of US cattle to babesia organisms. *Rhipicephalus (Boophilus) annulatus and microplus* ticks that currently inhabit the permanent tick quarantine zone will probably find and feed on some of these babesia carriers, become infected with the pathogen, and then transmit it to susceptible US cattle directly through secondary feedings or indirectly through infected (vertically) larvae or nymphs hatched from eggs layed by these ticks that subsequently feed on susceptible cattle.

   b. Movement through port of entry at San Luis, AZ

   Opening this port of entry (POE) to Mexican-origin cattle that may be infected with (carriers of) *Babesia bigemina*- and/or *Babesia bovis* would not create a 'new' risk of exposure of US cattle to these blood-borne pathogens over the risk already present. The number of cattle slated for export from Mexico to the US is not expected to increase above current levels. Thus, the number of cattle that will pass through this proposed POE are expected to come from those that would ordinarily have used other POEs.

c. Entry into States outside permanent tick quarantine zone in Texas

In the past five years, Texas and 11 other States (AK, CA, IA, IL, KS, KY, MO, MS, NE, OK, and WY) have received cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist. If this same mix of States continues to receive these cattle following implementation of the proposed amendments, then the presence of *Babesia bigemina*- and/or *Babesia bovis*-infected (carrier) Mexican-origin cattle within States located outside the permanent tick quarantine zone of Texas would not create a 'new' risk of exposure to these blood-borne pathogens over the risk already present.

2. Legal importation of Mexican-origin cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present and the cattle ARE NOT INFECTED with (carriers of) *Babesia bovis* or *Babesia bigemina*, but the cattle ARE INFESTED with *Rhipicephalus (Boophilus) annulatus and microplus* ticks which are infected with *Babesia bovis* or *Babesia bigemina*

a. Entry into permanent tick quarantine zone in Texas

As a requirement for entry into the US, current Customs procedures require that all cattle originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist must be physically inspected for and found free of live ticks and must be dipped with an acaricide. Unfortunately, follow-up quality assurance data is lacking that documents the efficacy of these procedures in eliminating 100% of *Rhipicephalus (Boophilus) annulatus and microplus* ticks carried on these animals.

Consequently, in the absence of quality assurance data to the contrary, it is presumed that a small number of cattle will harbor live *Rhipicephalus (Boophilus) annulatus and microplus* ticks despite the defined mitigations. Therefore, reversal of this movement restriction automatically increases the risk of exposure of US cattle to babesia organisms through their intermediate host, *Rhipicephalus (Boophilus) annulatus and microplus* ticks.

b. Movement through port of entry at San Luis, AZ

Two issues are important to consider regarding opening the port at San Luis, AZ to the entry of Mexican-origin cattle: (1) whether the port and surrounding area in Arizona provides suitable habitat for the establishment of populations of *R. microplus* and *R. annulatus* ticks and (2) final destination of cattle within the US that originate from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks presently exist.

Regarding the first issue, whether the port of San Luis and the surrounding area in Arizona provides suitable habitat for the establishment of populations of *R. microplus* and *R. annulatus* ticks, it would appear initially that the geographical area surrounding San Luis, Arizona is not conducive to long-term survival of these ticks. Whereas the range of environmental temperatures present in this area seems favorable for tick survival, precipitation levels are probably not. However, only considering general precipitation levels

probably underestimates the likelihood of *Rhipicephalus (Boophilus) annulatus and microplus* ticks surviving because micro-habitats may exist which offer a favorable range of moisture (and humidity) levels. There are approximately 238,900 acres of farm land in the area surrounding San Luis, AZ. The Colorado River and private wells are a source of irrigation water for this area. This additional source of moisture may provide a favorable micro-habitat for the future establishment of *Rhipicephalus (Boophilus) annulatus and microplus* ticks.

Regarding the second issue, final destination of cattle within the US that originate from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks presently exist, States located below latitude 36° N (which have mean annual temperatures > 20° C and favorable precipitation levels) should be considered at higher risk for experiencing an outbreak of babesiosis in indigenous cattle. Obviously, for this to occur Mexican-origin *babesia* carrier cattle, naïve US-origin cattle, and *R. microplus* or *R. annulatus* ticks must be simultaneously present.

c. Entry into States outside permanent tick quarantine zone in Texas

States located below latitude 36° N (which have mean annual temperatures > 20° C and favorable precipitation levels) should be considered at higher risk for experiencing an outbreak of babesiosis in indigenous cattle. Obviously, for this to occur Mexican-origin *babesia* carrier cattle, naïve US-origin cattle, and *R. microplus* or *R. annulatus* ticks must be simultaneously present.

Consequence Assessment

Biological Consequences

The biological consequences of successfully transmitting *Babesia bigemina and bovis* organisms to US cattle are expected to be high (greater than 50%) within herd morbidity and high case fatality rate (50% or greater) in clinically affected animals. If babesiosis becomes endemic, morbidity and mortality rates will subsequently drop to negligible levels in indigenous animals. Although indigenous animals will likely not routinely show clinical symptoms, introduced cattle will be very susceptible to disease.

Economic Consequences

Bovine babesiosis is a reportable disease to OIE. If clinical babesiosis occurs in the US in association with the importation of Mexican-origin cattle, the index case will most likely occur in one of the 12 States (AK, CA, IA, IL, KS, KY, MO, MS, NE, OK, TX, and WY) that are currently receiving Mexican-origin cattle. Upon reporting this index case to the OIE, it is presumed that one or more international trading partners will curtail, at least temporarily, importation of live cattle from the US regardless of the bovine babesiosis status of the importing country. Between 2000 and 2005, these 12 States exported $214,683,120 worth of live cattle (e.g. slaughter, breeding, feeding) to 30 countries. Most of this international trade ($213,385,671) occurred during 2000-2003. International trade with these 12 States has fallen

dramatically during 2004 and 2005. In 2004, Brazil and Mexico imported live cattle worth $591,953 and in 2005, seven countries (Canada, India, Israel, Japan, Mexico, Suriname, and Venezuela) imported $705,493 worth of cattle.

Data were not available, in terms of numbers of cattle or dollar amount, to summarize the extent of interstate trade occurring between these 12 States and the remaining US states.

In the absence of reinfection (i.e. vector ticks are not present to transmit the pathogen between infected and non-infected cattle), babesiosis in a cattle herd will gradually disappear. Consequently, eradication of *Rhipicephalus (Boophilus) annulatus and microplus* ticks has been the preferred method of eliminating babesiosis from a cattle population. Fiscal Year 2005 data for the Cattle Fever Tick Eradication Program Expenses in Texas ($6,152,933) was used as guidance to estimate a per animal cost to eradicate *Rhipicephalus (Boophilus) annulatus and microplus* ticks from quarantined cattle herds. The estimated cost was $649.59 per head. This cost does not include the replacement cost of an animal.

Risk Estimation

Important data deficiencies precluded being able to complete a quantitative risk assessment whereby the output for risk estimation is expressed numerically. Instead, preparation of this document was qualitative in nature. The outputs for the likelihood of the outcomes, including overall risk estimation, are expressed in qualitative terms such as 'high'or 'low'. Overall, the paucity of available data creates a high level of uncertainty surrounding the conclusions presented in this section of the document.

Based upon present information, the overall risks associated with babesiosis occurring in indigenous US cattle as a result of the following proposed amendments to 9 CFR 93.427(b)(2) are:

1. Importation of Cattle into the Permanent Tick Quarantine Zone in Texas and to Other States from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* Ticks Exist

The risk is high that indigenous cattle within the permanent tick quarantine zone in Texas will experience an outbreak of babesiosis if cattle originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist are allowed to co-mingle over several months duration.

This conclusion is based upon (1) documented current presence of *Rhipicephalus (Boophilus) annulatus and microplus* vector ticks in the designated permanent tick quarantine zone of Texas and (2) seroprevalence data out of Mexico that shows high exposure rate of cattle to *Babesia bigemina* and/or *Babesia bovis* in areas that also harbor *R. annulatus* and *R. microplus* ticks. Undoubtedly, a portion of the animals from any consignment of cattle originating from these States in Mexico will be persistently infected with *Babesia bigemina* and/or *Babesia bovis*. They will serve as the source of infection for susceptible US-origin cattle, provided *Rhipicephalus*

(Boophilus) annulatus and microplus vector ticks effectively transmit the pathogen to naïve cattle.

If *Babesia bigemina*- and/or *Babesia bovis*-infected Mexican-origin cattle are allowed to flow into US States located below latitude 36° N. (i.e. States with mean annual temperatures > 20° C), the risk of exposure of indigenous cattle in these States to babesiosis is high (provided that the tick vector and babesia-carrier Mexican-origin cattle are also present and in contact with naïve US cattle).

2. Importation of Cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* Ticks Exist through Port of Entry of San Luis, Arizona

If current trends prevail regarding the US destination for cattle that originate from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist, no cattle should remain in Arizona. However, should this trend change and some of these cattle eventually reside in Arizona and carry live *Rhipicephalus (Boophilus) annulatus and microplus* ticks with them, it cannot be ruled out that micro-habitats (e.g. along rivers, irrigated pasture land maintained by ranchers) will exist in this area which will support establishment of viable populations of these vector ticks.

Introduction

The cattle fever tick (*Rhipicephalus (Boophilus) annulatus*) and the southern cattle tick (*Rhipicephalus (Boophilus) microplus*) are vectors for *Babesia bovis* and *Babesia bigemina* infection (referred to as babesiosis or piroplasmosis) in cattle (USAHA 1998). These protozoan organisms infect red blood cells. The resulting clinical signs of disease are associated with a severe and often fatal anemia.

Babesiosis was endemic in cattle in 14 southern US States and the southern part of CA when Congress authorized the cattle fever tick eradication program in 1906 (Graham et al 1977, Hourrigan 1977). Over the next several decades eradication efforts were successful in these States in eliminating *R. annulatus* and *R. microplus* tick vectors and *Babesia bovis* and *Babesia bigemina* disease organisms (Hourrigan 1977). In 1938, eight counties in Texas that bordered Mexico (Figure 1) were designated as a permanent quarantine area for *Rhipicephalus (Boophilus) annulatus and microplus* ticks, a distance of nearly 500 miles along the Rio Grande River (Del Rio, Texas to the Gulf of Mexico) (Graham et al 1977). At that point in time, a cooperative program was established between the State of Texas and USDA-APHIS-VS to manage, operationally, cattle entering and leaving this quarantine area (US National Archives and Records Administration 2006a, Texas Administrative Code 2002). *Rhipicephalus (Boophilus) annulatus* and *R. microplus* ticks were officially eradicated from the continental US in 1961, except within the counties under permanent quarantine in Texas (Graham et al 1977).

Figure 1. Counties in Texas designated as permanent quarantine areas for *Rhipicephalus (Boophilus) annulatus* and *microplus* ticks.

In November, 2005, APHIS submitted proposed amendments to 9 CFR 93.427(b)(2)) to the Federal Register for comment (Federal Register 2005). That rule concerned the importation of

cattle into the US from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks (fever ticks) exist.

Specifically, amendments to 9 CFR 93.427(b)(2) proposed to:

1. Allow importation of cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist into the permanent tick quarantine zone within Texas and to other States

2. Allow cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist to enter the US through the port of San Luis, Arizona

The purpose of this risk assessment is to assess the magnitude of the risk associated with implementing each of the proposed amendments.

Section 1: Risk Assessment Guidelines

A risk assessment starts with the identification of a hazard and then proceeds to four interrelated steps: release assessment, exposure assessment, consequence assessment, and risk estimation (World Organization for Animal Health (OIE) 2005).

Section 2: Hazard Identification

Hazard identification involves identifying the pathogenic agent(s) which could potentially produce adverse consequences associated with its importation into a region (World Organization for Animal Health (OIE) 2005).

The **identified hazard** is the **introduction** into the US of ***Babesia bovis*** and ***Babesia bigemina***, the causative protozoan agents of bovine babesiosis.

Rhipicephalus (Boophilus) microplus and *Rhipicephalus (Boophilus) annulatus* ticks, which are the focus of the proposed rule, are only important to the identified hazard to the extent that these tick species serve as intermediate hosts for *Boophilus bovis* and *Boophilus bigemina*. By virtue of being intermediate hosts, these tick species are required for transmission of these protozoal organisms from infected cattle to uninfected but susceptible cattle.

2.1. *Babesia bigemina*

Babesia bigemina is a protozoan parasite that is pleomorphic and characteristically observed microscopically by the pear-shaped bodies joined at an acute angle within a mature erythrocyte (USAHA 1998). This protozoan parasite is transmitted by an intermediate arthropod host, *Rhipicephalus (Boophilus) annulatus*. Round forms measure 2 µm in diameter and the pear-shaped, elongated ones are 4-5 µm in diameter.

Babesia bigemina is widespread in cattle and occurs wherever *R. annulatus* ticks are encountered, which includes North and South America, Southern Europe, Africa, Asia, and

Australia (USAHA 1998). Babesiosis also occurs on the Caribbean and South Pacific islands. Cattle are the principal hosts of *B. bigemina*, but water buffalo and African buffalo may also become infected.

Ticks acquire babesial infection during their feeding on infected animals (USAHA 1998). The infection is then passed to the ovaries of the feeding tick, and thus the emerging larvae carry the infection. Protozoal organisms continue to develop within the larvae, and transmission usually occurs in the new host during the nymphal and adult stages. *Rhipicephalus (Boophilus) annulatus*, *R. microplus*, and *B. decoloratus* are the principal vectors of *B. bigemina* . Mechanical transmission is possible, but it is not efficient enough to maintain infection in the absence of specific tick vectors.

Natural transmission of *B. bigemina* to cattle occurs by the feeding of infected nymphal and adult ticks (USAHA 1998). However, transmission is not instantaneous. The efficiency of transmission of babesiosis is a function of the average number of ticks that bite each animal per day, the proportion of these ticks that are infected with *Babesia annulatus and microplus*, and the proportion of infected bites that successfully infect the host (Mahoney 1969). In one area of Australia in which bovine babesiosis was enzootic, transmission of *B. bigemina* to individual cattle by the one-host tick, *R. microplus*, occurred only once in about every 100 to 200 days (Mahoney 1969). Following blood inoculation, the incubation time may be 4-5 days or less, depending on the size of the inoculum (USAHA 1998).

Calves normally are reasonably resistant to infection (USAHA 1998). In older animals, clinical signs can be very severe; however, differences in pathogenicity may occur with various *B. bigemina* isolates associated with different geographic areas. In Australia, *B. bigemina* rarely causes disease, but in the Western Hemisphere it is highly pathogenic.

The first clinical signs are usually a high fever (up to 41.5^{o} C; 106.7^{o} F), anorexia, ruminal atony, and isolation from the rest of the herd (USAHA 1998). Cattle may stand with an arched back, have a roughened hair coat, and exhibit dyspnea, tachycardia, and pallor. Anemia is a contributory factor to the weakness and loss of condition seen in cattle that survive the acute phase of the disease. Anemia may occur very rapidly along with severe hemoglobinemia and hemoglobinuria. Clinical course will usually pass within a week, and if the animal survives, there is usually severe weight loss, drop in milk production, possible abortion, and a protracted recovery. Mortality is extremely variable and may reach 50 percent or higher, but in the absence of undue stress most animals will survive.

Most cattle that survive clinical illness establish immunity and eliminate the parasites from the peripheral blood. However, a persistent subclinical infection may last for years in a small percentage of cattle (Mahoney et al 1972, Mahoney et al 1973, Callow et al 1974, Johnston et al 1978, Figueroa et al 1992). These animals are the source of infection for herd mates.

2.2. *Babesia bovis*

Babesia bovis is a small pleomorphic babesia typically identified as a single body, as small round bodies, or as paired, pear-shaped bodies joined at an obtuse angle within the mature erythrocyte

(USAHA 1998). The round forms measure 1-1.5 μm in diameter and the pear-shaped bodies 1.5 by 2.4 μm in diameter.

Babesia bovis usually occurs in the same areas as *B. bigemina* and in association with *Rhipicephalus (Boophilus) annulatus and microplus* ticks (USAHA 1998). However, in some parts of Europe *B. bovis* is found where these ticks do not occur, suggesting the presence of other vectors.

Although cattle are the principal hosts of *B. bovis*, it is probable that infections can be maintained in other ungulates such as buffalo. There are reports in the literature of human cases due to *B. bovis* (USAHA 1998).

The same ticks (*R. annulatus, R. microplus*) that transmit *B. bigemina* are usually capable of transmitting *B. bovis* (USAHA 1998). In Europe, *Ixodes ricinus* is thought to be the vector involved in transmission of B. bovis (USAHA 1998).

Babesia bovis has a longer incubation time than *B. bigemina* (USAHA 1998). However, since *B. bovis* is transmitted by the larval stage of the tick vector rather than by the nymphal and adult stages, its prepatency (measured from the time of tick infestation) is only slightly longer than that of *B. bigemina*. With blood inoculation, the incubation time is usually 10-14 days; however, this can be shortened by large inoculums.

Infections of *B. bovis* resemble, in many respects, those seen with *B. bigemina*, but there are some characteristic differences. Hemoglobinuria and hemoglobinemia are not as consistently seen in infections with *B. bovis*, although they may occur. The level of anemia is frequently less severe, but central nervous system involvement (manifested as incoordination) is more common. It is generally conceded that *B. bovis* is the more virulent of the two organisms. This is particularly so in Australia and to a lesser extent in Africa and the Western Hemisphere.

Section 3: Release Assessment

A release assessment describes the biological pathway(s) necessary for an importation activity to introduce pathogenic agents into a particular environment and estimates the probability of that occurring (OIE 2005).

3.1. Importation of Cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* Ticks Exist into the Permanent Tick Quarantine Zone within Texas and to Other States

3.1.1. Background Information

The last occurrence of bovine babesiosis on the US mainland was in 1943 (World Organization for Animal Health (OIE) 2006a).

Health requirements that govern cattle originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist (US National Archives and Records Administration 2006b) state, in part, that cattle shall be:

- Accompanied by a certificate issued by a veterinarian that States that cattle have been inspected and found visibly free from fever ticks and any evidence of communicable disease, and that, as far as it has been possible to determine, they have not been exposed to any such disease, except splenetic, southern, or tick fever, during the 60 days immediately preceding their movement to the port of entry
- Dipped in an acaricide within 7 to 12 days before being offered for entry
- Physically examined by an APHIS inspector and if found free from ticks they shall be given one dipping in one of the permitted dips 7 to 14 days after the date of the original dipping performed at the origin of the consignment

If a consignment is found to be infested with fever ticks (*R. microplus* and *R. annulatus*), the entire lot of cattle shall be rejected and will not be again inspected for entry until 10 to 14 days after the cattle have again been dipped (US National Archives and Records Administration 2006b). The conditions at the port of entry shall be such that the subsequent movement of the cattle can be made without exposure to fever ticks.

The aforementioned health requirements are not changed by the proposed amendments to 9 CFR 93.427(b)(2).

Limited information has been published concerning the prevalence of babesiosis in Mexican-origin cattle. In the early 1980's, a serologic survey for babesiosis in cattle (1885 head; 40 herds) was conducted in Mexico in the northern States of Nuevo Leon, Tamaulipas, and Coahuila that border Texas (Teclaw et al 1985a). Thirty-eight out of 40 herds (95%) and 37 out of 40 herds (92.5%) were positive for *B. bigemina* and *B. bovis*, respectively. Within-herd prevalence rates ranged from 0 to 100%, but averaged 56% and 50% for *B. bigemina* and *B. bovis*, respectively. During this same time period in the central Mexican state of San Luis Potosi, 27 out of 73 (36.9%) and 4 out of 35 (11.4%) animals at risk seroconverted to *B. bigemina* and *B. bovis* infections, respectively (Teclaw et al 1985b). Twenty-eight out of 31 (90.3%) and 12 out of 31 (38.7%) cattle from a herd in the central Mexican state of Vera Cruz seroconverted to *B. bigemina* and *B. bovis*, respectively, over a 10-week time period (Teclaw et al 1985b). In a 1993 study conducted in the southern Mexican state of Yucatan that involved 421 cattle, the prevalence of *B. bigemina* and *B. bovis* was 66.7% and 60.1%, respectively (Figueroa JV et al 1993). In a more recent study (Solorio-Rivera et al 1999) conducted in the same state, the seroprevalence of Babesia bovis in 399 cattle from 92 farms was 73.8% (66.3-81.3%). Overall, these studies clearly indicate that *B. bigemina*- and *B. bovis*-infected cattle can be found in the northern, central, and southern regions of Mexico on the ranches studied.

It appears that most cattle will eliminate this infection but a portion of them (approximately 10%) will likely remain persistently infected, sometimes for years (Mahoney et al 1973, Johnston et al 1978). These persistently infected animals are the source of babesial organisms transmitted via *Rhipicephalus (Boophilus) annulatus and microplus* tick vectors to susceptible (naïve) animals.

The Government of Mexico lists the States of Sonora, Aguascalientes, and Tlaxcala along with the Federal District as areas free of *Rhipicephalus (Boophilus) annulatus and microplus* ticks: (SAGARPA 2006). Presumably, the absence of vector ticks in these States gives rise also to babesia-free cattle. States in Mexico that are partly free of vector ticks include Baja California, South Baja California, Chihuahua, Coahuila, Nuevo Leon, Tamaulipas, Durango, Zacatecas, the plateau of San Luis Potosí, Guanajuato, Hidalgo, State of Mexico, and Puebla (SAGARPA 2006). However, APHIS currently does not officially recognize any State in Mexico as a tick-free area (NCIE 2006).

Cattle that have been exposed to *B. bigemina* and/or *B. bovis*, or that have been infested with or exposed to fever ticks, may be imported from Mexico for admission into the US only at designated land border ports in Texas (Brownsville, Del Rio, Eagle Pass, Hidalgo, Laredo, or Presidio) or at the port of Santa Teresa, NM (US National Archives and Records Administration 2006c).

The future number of cattle (as well as place of origin, purpose for entry, and destination) that enter Texas is not expected to change significantly from historical levels because of the proposed rule change.[a] Likewise, the proposed rule is not expected to cause an increase in the number of cattle, beyond current levels, going into States other than Texas.[a] The intended destination for these cattle is also not expected to change.[a]

3.1.2. Analysis of Data

During the five year period, 2000-2005, 72,320 shipments of cattle originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist were presented to US ports of entry in Texas and NM.[b] Out of these shipments, 1853 (2.6%) were rejected (i.e. not allowed to cross the Mexico-US border) for tick-associated violations of health requirements. Explicit reasons for these violations were not always given.

No quality assurance data was found that examined the efficacy of mitigations (two acaracide treatments and physical examination of animal for ticks) to prevent live *Rhipicephalus (Boophilus) annulatus and microplus* ticks from entering the US on Mexican-origin cattle. For the purposes of this risk assessment, the 'failure rate' of mitigations was defined as the number of Mexican-origin cattle subsequently found to carry live *Rhipicephalus (Boophilus) annulatus and microplus* ticks on their body following additional physical inspection after reaching their final US destination.

Current US animal health regulations do not require certification that cattle originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist are free of *B. bigemina* and *B. bovis* as a prerequisite for importation.

Between January 1, 2000 and December 31, 2005, five Texas ports and one NM port received cattle that originated from States in Mexico where *Rhipicephalus (Boophilus) annulatus and*

[a]Personal communication. Dr. Arnaldo Vaquer, Senior Staff Veterinarian, Technical Trade Services Team, USDA-APHIS-VS-NCIE, Riverdale, MD

microplus ticks exist.[b] According to port veterinarians,[c] all cattle entering the Texas ports of Del Rio, Eagle Pass, Hidalgo, and Laredo during this time period originated from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist. The port located in Presidio, TX received approximately 90% of its imports from those States whereas the port in Santa Teresa, NM received approximately 25% of its cattle imports from those states.[c]

During this five year period, 5,117,814 head of cattle (average=852,969 head annually; range=492,395–1,049,707 head) passed through ports designated to handle cattle that originate from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist.[b] Over two-thirds of the cattle (3,421,305) were consigned to entities in Texas (presumably outside the eight counties within the permanent tick quarantine area) for feeding (3,402,519 head), breeding (10,744 head), competition (1,007 head), slaughter (34 head), and other (5,157 head) purposes. The remaining 1,696,509 head of cattle were dispersed to 11 States (AK, CA, IA, IL, KS, KY, MO, MS, NE, OK, and WY).[b] Most of these imported cattle were consigned for feeding purposes (1,638,149 head).[b] Other reasons for importation included breeding (432 head), commercial (7228 head), competition (50,261 head), or other (439 head) purposes.

3.1.3. Conclusion

The probability is high that some Mexican-origin cattle that cross the Mexico-US border will be persistently infected with *B. bigemina* and/or *B. bovis*. This is an unknown number because Mexican-origin cattle are not tested for babesiosis as a prerequisite for importation into the US. Because of mitigations (serial acaricide dips, physical inspection) that are in place, the probability is low, but probably not 'zero', that these cattle will also be carrying live *Rhipicephalus (Boophilus) annulatus and microplus* ticks (larvae, nymphs, and/or adults) when entering the US. In order to assign a 'zero' probability of live *Rhipicephalus (Boophilus) annulatus and microplus* ticks coming in on Mexican-origin cattle, follow-up quality assurance data (e.g. additional physical inspection of cattle for ticks) is needed after these cattle reach their US destination.

3.2. Importation of Cattle through Port of San Luis, Arizona from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* Ticks Exist

3.2.1. Background Information

San Luis, Arizona is currently operating as a port of entry for cattle from Mexico. However, as per current animal health rules (US National Archives and Records Administration 2006b, US National Archives and Records Administration 2006c) entry is restricted only to cattle that have not been exposed to *B. bigemina* and/or *B. bovis* or been infested with or exposed to *Rhipicephalus (Boophilus) annulatus and microplus* ticks.

[b] VS Import Tracking System, USDA-APHIS-VS-CEAH

[c] Telephone interview conducted by Elizabeth B. McKenna, Data Manager, USDA-APHIS-VS-CEAH-CADIA, Fort Collins, CO

Health requirements which govern cattle originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist are not changed by this proposed amendment to 9 CFR 93.427(b)(2).

As a result of the proposed rule change it is anticipated that the increase in cattle traffic, above current levels, through this port will come from cattle originating in western States of Mexico that would otherwise have entered through ports in Texas and NM.[a] Likewise, the number of cattle passing through TX and NM ports are expected to drop by the number of animals re-routed through the San Luis, Arizona port of entry.[a]

As stated previously, the probability is high that a portion of the animals from any consignment of cattle originating from States in Mexico where *Boophilus*-species ticks exist will be persistently infected with *B. bigemina* and/or *B. bovis*

3.2.2. Analysis of Data

Between 2000-2005, 295,872 cattle (average=49,312 head annually; range=19,690-69286 head annually) passed through this port.[b] As per entry requirements, all animals were consigned from States in Mexico that are free of *Rhipicephalus (Boophilus) annulatus and microplus* ticks.[c]

3.2.3. Conclusion

Since it is anticipated that the traffic through this port of entry will consist of those cattle that would otherwise have entered through ports in TX and NM, the risk of release of *babesia annulatus and microplus* is not increased over what is the current situation. In other words, whatever the number may be of babesia-infected Mexican-origin cattle (as well as the number of Mexican-origin cattle that may still be infested with *Rhipicephalus (Boophilus) annulatus and microplus* ticks despite mitigations) that are currently entering through existing ports of entry, that number will remain the same; only the number of cattle distributed to ports of entry in TX, NM, and AZ will change.

Section 4: Exposure Assessment

An exposure assessment initially describes the biological pathway(s) necessary for exposure of animals and/or humans in an importing country to the hazards released from a given risk source (OIE 2005a). This is followed by an estimate (qualitative or quantitative) of the probability of the exposure(s) occurring.

Viable pathways by which cattle in the US can be exposed to *Babesia bovis* or *Babesia bigemina* (the identified hazard) include:

1. Legal importation of Mexican-origin cattle that are infected with *Babesia bovis*- or *Babesia bigemina*
2. Legal importation of Mexican-origin cattle infested with *Rhipicephalus (Boophilus) annulatus and microplus* ticks which, in turn, are infected with *Babesia bovis* or *Babesia bigemina*

3. Illegal importation of Mexican-origin cattle infected with *Babesia bovis*- or *Babesia bigemina*
4. Illegal importation of Mexican-origin cattle infested with *Rhipicephalus (Boophilus) annulatus and microplus* ticks which, in turn, are infected with *Babesia bovis* or *Babesia bigemina*
5. Movement back and forth between Mexico and the US of *Babesia bovis*- or *Babesia bigemina*-infected stray Mexican-origin cattle
6. Movement back and forth between Mexico and the US of stray Mexican-origin cattle infested with *Rhipicephalus (Boophilus) annulatus and microplus* ticks which, in turn, are infected with *Babesia bovis* or *Babesia bigemina*
7. Movement back and forth between the US and Mexico of free-ranging wildlife (e.g. White-tailed deer, Nilgai) infested with *Babesia bovis*- or *Babesia bigemina*-infected *Rhipicephalus (Boophilus) annulatus and microplus* ticks
8. Unintentional mechanical transport by people of *Rhipicephalus (Boophilus) annulatus and microplus* ticks that are infected with *Babesia bovis* or *Babesia bigemina*

The proposed changes to 9 CFR 93.427(b)(2) focused exclusively on the legal importation of cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present. Indigenous US cattle can be exposed to the identified hazard (*B. bigemina* and/or *B. bovis*), following its release into the US, under two circumstances:

(1) Legal importation of Mexican-origin cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present and the cattle ARE NOT INFESTED with *Rhipicephalus (Boophilus) annulatus and microplus* ticks but the cattle ARE INFECTED with (carriers of) *Babesia bovis* or *Babesia bigemina*

(2) Legal importation of Mexican-origin cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present and the cattle ARE NOT INFECTED with (carriers of) *Babesia bovis* or *Babesia bigemina*, but the cattle ARE INFESTED with *Rhipicephalus (Boophilus) annulatus and microplus* ticks which are infected with *Babesia bovis* or *Babesia bigemina*

Thus, this section of the risk assessment will focus exclusively on these two pathways.

4.1. Background Information

In order for babesiosis to become established in US cattle, susceptible indigenous cattle must be exposed both to *B. bigemina*- and/or *B. bovis*-infected Mexican-origin cattle along with *Rhipicephalus (Boophilus) annulatus and microplus* vector ticks.

As stated previously, the probability is high that a portion of the cattle from any consignment originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist will be persistently infected with *B. bigemina* and/or *B. bovis*.

Both temperature and relative humidity are key factors governing tick survival and establishment of viable populations of ticks (Estrada-Pena 2001). For example, environmental temperatures below 20° C prevent transovarial transmission of *B. bigemina* and/or *B. bovis* (Mahoney et al 1972, Friedhoff et al 1981). Ineffective transovarial transmission of these babesia organisms means that future generations of ticks will not carry the disease. The threshold temperature of 20° C begins to appear in States at approximately latitude 36° N (Estrada-Pena 2005). Nearly the entire state of Texas lies below latitude 36° N (Figure 2).

Rhipicephalus (Boophilus) annulatus and microplus ticks complete their life cycle by alternating a blood feeding phase on a single host with an off-host phase (Teel et al 1996). During the latter phase gravid females lay eggs and larvae are produced. Classically, larvae prefer to climb upon vegetation and wait for an opportunity to attach to the next bovine host (Teel et al 1996). Thus, the intended destination (pasture versus drylot) for Mexican-origin cattle within the permanent tick quarantine zone seems to be important for assessing risk of disease transmission between cattle.

To complete their life cycle, gravid *Rhipicephalus (Boophilus) annulatus and microplus* females lay eggs in the environment (Teel et al 1996). Hatched larvae prefer to ascend vegetation in order to transfer to the next bovine host (Teel et al 1996). If environmental factors are favorable (warmth, moisture, humidity, shelter provided by organic material), ticks can live off of their host for a few months. Thus, the intended production site (pasture versus drylot) for Mexican-origin cattle at their intended US destination seems to be important for assessing risk of disease transmission between cattle.

Research has shown that only one infected tick is required to successfully transmit *B. bigemina* (Mahoney et al 1971). However, transmission of the disease by an infected tick is not instantaneous. The efficiency of transmission of babesiosis is a function of the average number of ticks that bite each animal per day, the proportion of these ticks that are infected with *Babesia annulatus and microplus*, and the proportion of infected bites that successfully infect the host (Mahoney 1969). In one area of Australia in which bovine babesiosis was enzootic, transmission of *B. bigemina* to individual cattle by *R. microplus* occurred only once in about every 100 to 200 days (Mahoney 1969).

This particular proposed amendment to 9 CFR 93.427(b)(2) is not expected to influence final destinations for future shipments of cattle that enter through ports in TX and NM.[a]

4.2. Analysis of Data

In recent years, the number of *R. annulatus* and *R. microplus* tick infestations has increased in the designated permanent tick quarantine zone of Texas (Hillman 2005). A historic high of 117 *Rhipicephalus (Boophilus) annulatus and microplus* tick infestations was identified in 2005. Whereas the vast majority of these infestations were found in the quarantine zone, others occurred immediately outside this zone. For fiscal year 2006, 65 *Rhipicephalus (Boophilus) annulatus and microplus* tick infestations have been detected; 50 infestations within the designated permanent tick quarantine zone and 15 infestations immediately outside this zone

(Welch 2006). Thus, evidence exists that the tick vectors for bovine babesiosis are present in and immediately adjacent to the permanent tick quarantine zone in Texas.

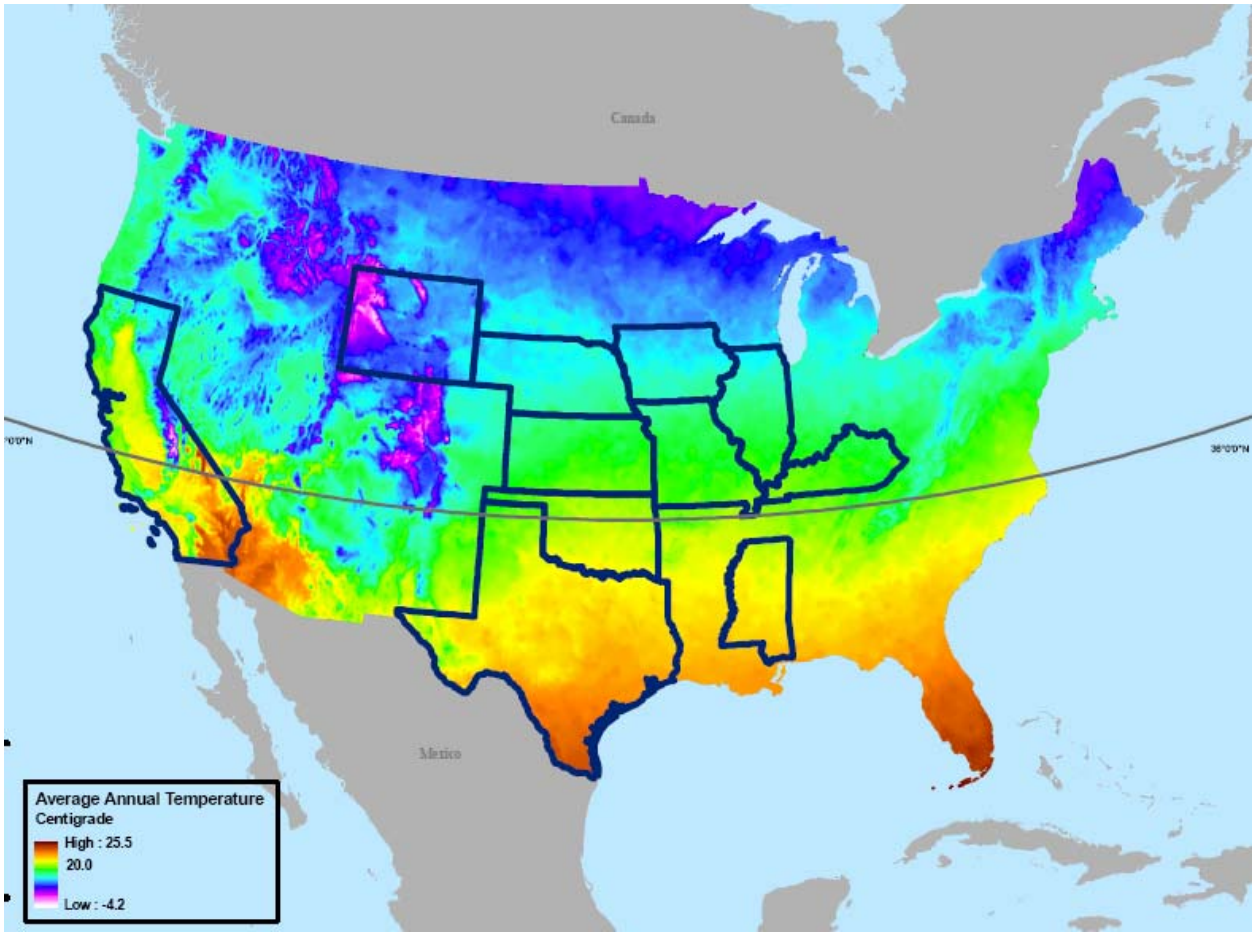
A review of tick submissions to the USDA-APHIS National Veterinary Services Laboratory, Ames, IA, during the period 1990-2005 yielded *R. microplus* positive samples originating from Texas.[d] *Rhipicephalus (Boophilus) annulatus and microplus* ticks were also removed from trophy hides shipped to GA from Africa in 1997.

Between 2000-2005, 5,117,814 head of cattle passed through ports designated to handle cattle that originate from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist.[b] Over 3,421,305 head (66.9%) were consigned to Texas. None were to have a final destination within the eight counties comprising the permanent tick quarantine zone. The remaining 1,696,509 head of cattle were dispersed to 11 other States (AK, CA, IA, IL, KS, KY, MO, MS, NE, OK, and WY).

Figure 2 shows a map of the continental US which displays the variation in mean annual temperature of States and the borders of those States (CA, IA, IL, KS, KY, MO, MS, NE, OK, TX, and WY) that received cattle during 2000-2005 from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist. The solid horizontal line follows latitude 36° N. It would appear that MS and portions of CA, TX, OK, and possibly MO are most at risk over the long-term to experience an outbreak of babesiosis in their indigenous cattle, provided these animals come into contact simultaneously with Mexican-origin *babesia annulatus and microplus* carrier cattle and a population of *R. microplus* or *R. annulatus* ticks.

Figure 2. Map of US displaying variation in mean annual temperature of States in continental US (CA, IA, IL, KS, KY, MO, MS, NE, OK, TX, WY) that received cattle between years 2000-2005 from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist. Solid horizontal line passing through the US is latitude 36° N.

[d] Personal communication. Angela M. James, Ph.D., Entomologist/Invasive Species Specialist and Project Leader, national tick survey, USDA, APHIS, VS, CEAH, Fort Collins, CO.



4.3. Conclusions

4.3.1. Legal importation of Mexican-origin cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present and the cattle ARE NOT INFESTED with *Rhipicephalus (Boophilus) annulatus and microplus* ticks but the cattle ARE INFECTED with (carriers of) *Babesia bovis* or *Babesia bigemina*

4.3.1.1. Entry into permanent tick quarantine zone in Texas

In the absence of *Rhipicephalus (Boophilus) annulatus and microplus* vector ticks living within the permanent quarantine zone, ordinarily any *B. bigemina*- and/or *B. bovis*-infected (carrier) Mexican-origin cattle that enter this area will not create a long-term (endemic) animal health problem for susceptible US cattle because the disease would eventually die out. However, this situation is not present currently. *Rhipicephalus (Boophilus) annulatus and microplus* vector ticks are currently present in the permanent tick quarantine zone in Texas. Cattle and free-ranging wild ruminants (e.g. white-tailed deer) serve as a host for these vector ticks within the quarantine zone.

Given that cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present have been heretofore prevented from entering and remaining within

the permanent tick quarantine zone, reversal of this movement restriction automatically increases the risk of exposure of US cattle to babesia organisms. *Rhipicephalus (Boophilus) annulatus and microplus* ticks that currently inhabit the permanent tick quarantine zone will probably find and feed on some of these babesia carriers, become infected with the pathogen, and then transmit it to susceptible US cattle directly through secondary feedings or indirectly through infected (vertically) larvae or nymphs hatched from eggs produced by these ticks that subsequently feed on susceptible cattle.

4.3.1.2. Movement through port of entry at San Luis, Arizona

Opening this port of entry (POE) to Mexican-origin cattle that may be infected with (carriers of) *B. bigemina*- and/or *B. bovis* would not create a 'new' risk of exposure of US cattle to these blood-borne pathogens over the risk already present. The number of cattle slated for export from Mexico to the US is not expected to increase above current levels. Thus, the number of cattle that will pass through this proposed POE are expected to come from those that would ordinarily have used other POEs.

4.3.1.3. Entry into States outside permanent tick quarantine zone in Texas

In the past five years, Texas and 11 other States (AK, CA, IA, IL, KS, KY, MO, MS, NE, OK, and WY) have received cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist. If this same mix of States continue to receive these cattle following implementation of the proposed amendments, then the presence of *B. bigemina*- and/or *B. bovis*-infected (carrier) Mexican-origin cattle within States located outside the permanent tick quarantine zone of Texas would not create a 'new' risk of exposure to these blood-borne pathogens over the risk already present.

4.3.2. Legal importation of Mexican-origin cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks are present and the cattle ARE NOT INFECTED with (carriers of) *Babesia bovis* or *Babesia bigemina*, but the cattle ARE INFESTED with *Rhipicephalus (Boophilus) annulatus and microplus* ticks which are infected with *Babesia bovis* or *Babesia bigemina*

4.3.2.1. Entry into permanent tick quarantine zone in Texas

As a requirement for entry into the US, current Customs procedures require that all cattle originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist must be physically inspected for and found free of live ticks and must be dipped with an acaricide. Unfortunately, follow-up quality assurance data is lacking that documents the efficacy of these procedures in eliminating 100% of *Rhipicephalus (Boophilus) annulatus and microplus* ticks carried on these animals.

Consequently, in the absence of quality assurance data to the contrary, it is presumed that a small number of cattle will harbor live *Rhipicephalus (Boophilus) annulatus and microplus* ticks despite the defined mitigations. Therefore, reversal of this movement restriction automatically

increases the risk of exposure of US cattle to babesia organisms through their intermediate host, *Rhipicephalus (Boophilus) annulatus and microplus* ticks.

4.3.2.2. Movement through port of entry at San Luis, Arizona

As the result of amendment to 9 CFR 93.427(b)(2), it is anticipated that this port of entry will not receive an entirely new population of Mexican-origin cattle, but will receive some of the cattle ordinarily destined for ports in Texas and New Mexico.[a] Upon leaving the proposed port of entry of San Luis, Arizona, these cattle are also expected to follow historical destination patterns.[a]

Two issues are important to consider regarding opening the port at San Luis, Arizona to the entry of Mexican-origin cattle: (1) whether the port and surrounding area in Arizona provide suitable habitat for the establishment of populations of *R. microplus* and *R. annulatus* ticks and (2) the final destination of cattle within the US that originate from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks presently exist.

Rhipicephalus (Boophilus) annulatus and microplus ticks appear not to survive long-term in geographic regions above latitude 36° N in the US (Estrada-Pena 2005). Geographic regions above this latitude generally have mean average temperature below 20° C which is a prime determinant for successful reproductive function of female *Rhipicephalus (Boophilus) annulatus and microplus* ticks (Mahoney et al 1972, Friedhoff et al 1981).

A recent simulation based on historical monthly temperature, relative humidity, and rainfall data has provided a geographical estimation of the changes in habitat suitability (HS) for the development and survival of *R. microplus* ticks from latitude 36° N in the US to the most southern parts of South America (Estrada-Pena 2005). The port of entry at San Luis, Arizona is located at latitude 32.49245° N (U.S. Census Bureau 2006). The results of this simulation seem to indicate that the entire state of Arizona presents a hostile environment for survival of *R. microplus* ticks. *R. annulatus* ticks are predicted to face a similar hostile environment for survival.[e] Whereas the range of environmental temperatures present in this area are favorable for tick survival, precipitation levels are probably not. For example, the average monthly temperatures range from 67 degrees F in January to 102, 105, 104, and 100 degrees F in June, July, August, and September, respectively to 67 degrees F in December (Weather per Hour 2006a). These temperatures are slightly warmer in the months of June, July, August and September when compared to counties (e.g. Val Verde County) within the permanent tick quarantine area of Texas that have recently experienced infestations of *Rhipicephalus (Boophilus) microplus* ticks.[d] The difference between Val Verde County, Texas and the city of San Luis, Arizona is the amount of precipitation present in each area on a monthly basis. San Luis, Arizona experiences 0.03 to 0.7 inches per month of precipitation (Weather per Hour 2006a) whereas Val Verde County, Texas witnesses 0.57 to 2.0 inches of monthly precipitation (Weather per Hour 2006b).

[e] Personal communication. Prof. Agustín Estrada-Peña, Department of Parasitology, Veterinary Faculty, Miguel Servet, Zaragoza, Spain.

However, only considering general precipitation levels probably underestimates the likelihood of *Rhipicephalus (Boophilus) annulatus and microplus* ticks surviving because micro-habitats may exist in the area surrounding San Luis, Arizona which offer a favorable range of moisture (and humidity) levels. In fact, favorable micro-habitats probably exist. San Luis, Arizona is located in Yuma County in southwestern Arizona (Yuma County Arizona 2006). Yuma County encompasses approximately 5,561 square miles of desert interspersed with mountains and valleys, but with ample surface water. Thus it maintains a thriving agricultural business. There are approximately 238, 900 acres of farm land within Yuma County. The Colorado River and private wells are a source of irrigation water for this farm land.

If current trends remain the same regarding the US destination for cattle that originate from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus*ticks exist, no cattle should remain in Arizona. However, should some of these Mexican-origin cattle reside in Arizona in the future and carry *Rhipicephalus (Boophilus) annulatus and microplus* ticks with them, it can not be ruled out that micro-habitats (e.g. along rivers, irrigated pasture land maintained by ranchers) exist in this area which will support establishment of viable populations of these vector ticks.

As mentioned previously, environmental temperature constraints (< 20° C) appear to be the single biggest deterrent to successful establishment of viable populations of *Rhipicephalus (Boophilus) annulatus and microplus* ticks with which to transmit *B. bigemina*- and/or *B. bovis* hemoparasites. Thus, States located below latitude 36° N (which have mean annual temperatures > 20° C), particularly MS and portions of CA, TX, OK, and possibly MO, should be considered high risk States for experiencing an outbreak of babesiosis in their indigenous cattle, provided these naïve cattle come into contact simultaneously with Mexican-origin *Babesia annulatus and microplus* carrier cattle and a population of *R. microplus* or *R. annulatus* ticks. Conversely, States located above latitude 36° N (which have mean annual temperatures < 20° C) should face lower risk for experiencing an outbreak of babesiosis in indigenous cattle.

4.3.2.3. Entry into States outside permanent tick quarantine zone in Texas

Environmental temperature constraints (< 20° C) appear to be the single biggest deterrent to successful establishment of viable populations of *Rhipicephalus (Boophilus) annulatus and microplus*ticks with which to transmit *B. bigemina*- and/or *B. bovis* hemoparasites. Thus, States located below latitude 36° N (which have mean annual temperatures > 20° C), particularly MS and portions of CA, TX, OK, and possibly MO, should be considered high risk States for experiencing an outbreak of babesiosis in their indigenous cattle, provided these naïve cattle come into contact simultaneously with Mexican-origin *Babesia annulatus and microplus* carrier cattle and a population of *R. microplus* or *R. annulatus* ticks. Conversely, States located above latitude 36° N (which have mean annual temperatures < 20° C) should face lower risk for experiencing an outbreak of babesiosis in indigenous cattle.

Section 5: Consequence Assessment

A consequence assessment describes the potential consequences of a given exposure and estimates the probability of them occurring (World Organization for Animal Health (OIE) 2005). This estimate may be either qualitative or quantitative. The OIE Code also States that, if the release assessment or exposure assessment demonstrates no significant risk, a consequence assessment is not required.

5.1. Biological Consequences

Due to a general lack of immunity to *B. bigemina* and/or *B. bovis* in US cattle, should a herd be exposed to these hemoparasites over a period of several months, within herd morbidity is likely to be high (greater than 50%). Clinically affected animals are more likely to be older animals than calves. Case fatality rate (mortality of clinically affected animals) will likely be 50% or greater, depending upon the level of stressors placed upon sick animals. A portion of the animals that survive clinical infection will remain persistently infected and serve as a source of infective material for new susceptible cattle that they come in contact with, provided *Rhipicephalus (Boophilus) annulatus and microplus*vector ticks are also present to transmit the pathogen.

If babesiosis becomes endemic, morbidity and mortality rates will subsequently drop to negligible levels in indigenous animals. Although indigenous animals will likely not routinely show clinical symptoms, introduced naïve cattle will be very susceptible to disease.

5.2. Economic Consequences

5.2.1. International Trade

Bovine babesiosis is a reportable disease to OIE (World Organization for Animal Health (OIE) 2006b). If clinical babesiosis in US cattle is a result of cattle that have been imported from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist, the index case will most likely be detected in one of the 12 States (AK, CA, IA, IL, KS, KY, MO, MS, NE, OK, TX, and WY) that are currently receiving these animals. Upon reporting this index case to the OIE, it is presumed that one or more international trading partners will curtail, at least temporarily, importation of live cattle from the US regardless of the bovine babesiosis status of the importing country.

Between 2000 and 2005, these 12 States exported $214,683,120 worth of live cattle (e.g. slaughter, breeding, feeding) to 30 countries. Most of this international trade ($213,385,671) occurred during 2000-2003. International trade with these 12 States has fallen dramatically during 2004 and 2005. In 2004, Brazil and Mexico imported live cattle worth $591,953 and in 2005, seven countries (Canada, India, Israel, Japan, Mexico, Suriname, and Venezuela) imported $705,493 worth of cattle.

5.2.2. Domestic Trade

Data were not available, in terms of numbers of cattle or dollar amount, to summarize the extent of interstate trade occurring between these 12 States and the remaining United States.

5.2.3. Eradication Costs

In the absence of a tick vector to serve as an intermediate host, babesiosis will not sustain itself (remain endemic) in a cattle herd. Consequently, efforts to eradicate babesisosis in a cowherd are usually focused on vector ticks rather than *B. bigemina* and/or *B. bovis.*

Fiscal Year 2005 data for the Cattle Fever Tick Eradication Program Expenses in Texas were used as guidance to estimate per animal eradication costs (APHIS-VS 2006). Based upon total expenses ($6,152,933), the estimated cost on a per head basis to eradicate *Rhipicephalus (Boophilus) annulatus and microplus* ticks from Texas beef cow-calf herds is $649.59. This cost does not include the replacement cost of an animal.

Section 6: Risk Estimation

Risk estimation consists of integrating the results from the release assessment, exposure assessment, and consequence assessment to produce overall measures of risk associated with the hazards identified at the outset (OIE 2005a). Thus, risk estimation takes into account the whole risk pathway from hazard identified to the unwanted event.

Important data deficiencies (see section 7: Data Limitations) precluded being able to complete a quantitative risk assessment whereby the output for risk estimation is expressed numerically. Instead, preparation of this document was qualitative in nature whereby the outputs for the likelihood of the outcomes, including overall risk estimation, are expressed in qualitative terms such as 'high'or 'low'. Overall, the paucity of available data creates uncertainty surrounding the conclusions presented in this section of the document.

Based upon present information, the overall risks associated with babesiosis occurring in indigenous US cattle as a result of the following proposed amendments to 9 CFR 93.427(b)(2) are:

6.1. Importation of Cattle from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* Ticks Exist into the Permanent Tick Quarantine Zone in Texas and to Other States

The risk is high that indigenous cattle within the permanent tick quarantine zone in Texas will likely experience an outbreak of babesiosis if cattle originating from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* ticks exist are allowed to co-mingle over several months duration.

This conclusion is based upon (1) documented current presence of *Rhipicephalus (Boophilus) annulatus and microplus* vector ticks in the designated permanent tick quarantine zone of Texas and (2) seroprevalence data from Mexico that shows high exposure rate of cattle to *B. bigemina* and/or *B. bovis* in areas that also harbor *R. annulatus* and *R. microplus* ticks. Undoubtedly, a portion of the animals from any consignment of cattle originating from these States in Mexico will be persistently infected with *B. bigemina* and/or *B. bovis* and serve as the source of infection for susceptible US-origin cattle, provided *Rhipicephalus (Boophilus) annulatus and microplus* vector ticks effectively transmit the pathogen to naïve cattle.

If *B. bigemina*- and/or *B. bovis*-infected Mexican-origin cattle are allowed to flow into States within the US located below latitude 36° N. (i.e. States with mean annual temperatures > 20° C), the risk of exposure of indigenous cattle in these States to babesiosis is high (provided that the tick vector and babesia-carrier Mexican-origin cattle are also present and in contact with naïve US cattle).

6.2. Importation of Cattle through Port of San Luis, Arizona from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus* Ticks Exist

If current trends prevail regarding the US destination for cattle that originate from States in Mexico where *Rhipicephalus (Boophilus) annulatus and microplus*ticks exist, no cattle should remain in Arizona. However, should this trend change and some of these Mexican-origin cattle eventually reside in Arizona and carry live *Rhipicephalus (Boophilus) annulatus and microplus* ticks with them, it cannot be ruled out that micro-habitats (e.g. along rivers, irrigated pasture land maintained by ranchers) will exist in this area which will support establishment of viable populations of these vector ticks.

Section 7: Data Limitations

The value of any risk assessment is only as good as the timeliness and quality of data that it is built upon. This risk assessment is no exception. Many gaps in data existed. Overall, the paucity of available data creates a high level of uncertainty surrounding the conclusions presented in this document. Furthermore, the lack of data precluded being able to complete a quantitative risk assessment whereby the outputs of risk are expressed numerically. Instead, preparation of this document was qualitative in nature whereby the outputs for the likelihood of the outcomes are expressed in qualitative terms such as 'high'or 'low'.

In order to facilitate a more confident estimation of the risk of exposure of indigenous US cattle to *Babesia* organisms and their tick vectors, the following additional data are needed:

1. Across-herd and within-herd prevalence of babesiosis for all cattle-raising States in Mexico that export cattle to the US.
2. The number (proportion) of Mexican-origin cattle imported into the US that are persistently infected with *B. bigemina* and/or *B. bovis.*
3. Rate of failure of import health mitigations (serial acaricide treatments and physical inspection of cattle at port of entry) to prevent live *R. annulatus* and *R. microplus* ticks from remaining on Mexican-origin animals following their entry into the US.
4. The number of *B. bigemina*- or *B. bovis*-infected *R. annulatus* or *R. microplus* ticks (larvae, nymph, or adult) necessary to transmit babesiosis to naïve US cattle.
5. The duration of feeding (days) needed for *B. bigemina*- or *B. bovis*-infected *R. annulatus* or *R. microplus* ticks (larvae, nymph, or adult) to transmit babesiosis to naïve US cattle.

6. The natural history of disease and its persistence in naïve cattle placed in a drylot environment on a continuous basis where babesiosis is endemic
7. The geographical location of origin of cattle from Mexico that will be imported through the Texas, NM, and proposed Arizona port of entry.
8. Destination of Mexican-origin cattle in the US that flow through the San Luis, Arizona port of entry and the production system (e.g. feedlot, backgrounding, pasture, and/or drylot environment) that these cattle will be entering and their length of stay.
9. Destination of Mexican-origin cattle in the US that flow through the port of entry in Texas and NM and the production system (e.g. feedlot, backgrounding, pasture, and/or drylot environment) that these cattle will be entering and their length of stay.
10. Records of *Rhipicephalus (Boophilus) annulatus and microplus* tick populations within Mexico

Finally, the development of an ecological model would facilitate a better understanding of the various factors needed for the successful establishment of *Rhipicephalus (Boophilus) annulatus and microplus* tick populations in Texas and Arizona and in those States that historically supported populations of these ticks prior to the beginning of the fever tick eradication efforts.

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