Slide 1

Bovine Brucellosis:
Brucella abortus

Undulant Fever,
Contagious Abortion,
Bang's Disease

Bovine brucellosis, caused by the bacterium *Brucella abortus*, is an economically important cause of abortions in cattle. *B. abortus* also affects other species including bison, buffalo and elk; some species are maintenance hosts for this organism. Infections in wildlife can hinder eradication efforts in cattle. In addition, *B. abortus* is a human pathogen. In humans, brucellosis can be a serious, debilitating and sometimes chronic disease that may affect a variety of organs. Most cases are the result of occupational exposure to infected animals, but infections can also occur from ingesting contaminated dairy products. In addition, *B. abortus* could be used in a bioterrorist attack.

Slide 2

Overview

- Organism
- History
- Epidemiology
- Transmission
- Disease in Humans
- Disease in Animals
- Prevention and Control
- Actions to Take

In today's presentation we will cover information regarding the organism that causes bovine brucellosis and its epidemiology. We will also talk about the history of the disease, how it is transmitted, species that it affects (including humans), and clinical and necropsy signs observed. Finally, we will address prevention and control measures, as well as actions to take if bovine brucellosis is suspected.

[Photo: Cow and calf. Source: Dr. Beth Carlson/North Dakota State Board of Animal Health/CFSPH]

Slide 3

THE ORGANISM

Slide 4

The Organism

- *Brucella abortus*
  - Gram negative coccobacillus
  - Facultative intracellular pathogen
  - Nine biovars
- Additional Brucellae that affect cattle
  - *B. melitensis* and *B. suis*
- Can persist in the environment

In cattle, bison and buffalo, brucellosis is mainly caused by *Brucella abortus*, a Gram-negative coccobacillus or short rod. This organism is a facultative intracellular pathogen. Up to nine *B. abortus* biovars (1-9) have been reported, but some of these biovars differ only slightly and their status is unresolved. Other *Brucella* species uncommonly associated with disease in cattle include *Brucella melitensis* and *B. suis*. Genetic and immunological evidence suggests that all members of the genus *Brucella* are closely related, and some microbiologists have proposed that this genus be reclassified into a single species (*B. melitensis*), which contains many biovars. This proposal is controversial, and both taxonomic systems are currently in use. *Brucella* species can persist in the environment invariably depending on temperature, pH, and humidity.

Slide 5

HISTORY

Slide 6

The Many Names of Brucellosis

Human Disease	Animal Disease
• Malta Fever	• Bang's Disease
• Undulant Fever	• Enzootic Abortion
• Mediterranean Fever	• Epizootic Abortion
• Rock Fever of Gibraltar	• Slinking of Calves
• Gastric Fever	• Ram Epididymitis
	• Contagious Abortion

Due to its illustrious history, brucellosis has many different names. The disease is commonly known as undulant or Malta fever in humans and Bang's disease in animals.

Slide 7

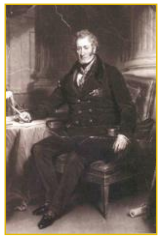
History of Brucellosis

- 450 BC: Described by Hippocrates
- 1905: Introduced to the U.S.
- 1914: *B. suis*
  - Indiana, United States
- 1953: *B. ovis*
  - New Zealand, Australia
- 1966: *B. canis*
  - Dogs, caribou, and reindeer

In his book Epidemics, Hippocrates first described a condition of recurring fever and death with a duration of 4 months in 450 B.C. Undulant fever did not enter into the United States until 1905 through the shipping of 65 Maltese goats on the *S.S. Joshua Nicholson. B. suis* was isolated in 1914 by Traum in the U.S. from aborting swine in Indiana. *B. ovis* was isolated in 1953 from sheep with ram epididymitis in New Zealand and Australia. *B. canis* was discovered in 1966 from dogs, caribou, and reindeer.

Slide 8

History of Brucellosis

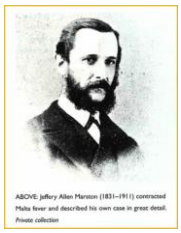


- Sir William Burnett (1779-1861)
  - Physician General to the British Navy
  - Differentiated among the various fevers affecting soldiers

The island of Malta was given to the Knights of the Order of St. John in 1530, and contagious fevers were noted from that time well into the 19th century. During the 17th and 18th centuries there were numerous reports of undulant fevers from all over the Mediterranean and most were given local names (Mediterranean fever, Rock fever of Gibraltar, Cyprus fever, Danube fever). Sir William Burnett was a physician to the British Navy in 1810 and was the first person to differentiate between the various fevers affecting seamen in the Mediterranean. It is thought that Malta became such an important center for the study of undulant fever because many British troops were sent there to recuperate following the Crimean War (1853-1856), along with skillful medical doctors utilizing clinical thermometers to monitor the disease progression.

Slide 9

History of Brucellosis



ABOVE: Jeffery Allen Marston (1831–1911) contracted Malta fever and described his own case in great detail. Private collection

- Jeffery Allen Marston
  - British Army surgeon
  - Contracted Malta fever
  - Described his own case in great detail

J.A. Marston was an army surgeon (British) who, after contracting the Malta fever, wrote the first detailed account of the disease (his own illness). He was afflicted with an irregular fever for 30 to 90 days, gastrointestinal symptoms, and muscle and joint pains.

Slide 10

History of Brucellosis

- Sir David Bruce (1855-1931)
  - British Army physician and microbiologist
  - Discovered *Micrococcus melitensis*

The microorganism responsible for Malta fever was discovered by a British Army physician, Sir David Bruce, on July 9, 1887, which he called *Micrococcus melitensis*. It was isolated from the spleen of a British soldier who had died of the disease. He also identified that the organism grew best at higher temperatures and speculated that this accounted for the increased frequency of cases in hot summer months. He later established goats as the main reservoir for infection by identifying the organism in their blood, urine, and milk. This discovery helped explain the epidemiology of the disease. For example, officers were three times more likely to become ill because they drank more milk than private soldiers, and large numbers of cases were found in hospitals where milk was widely distributed.

Slide 11

History of Brucellosis

- Bernhard Bang (1848-1932)
  - Danish physician and veterinarian
  - Discovered *Bacterium abortus* could infect cattle, horses, sheep, and goats

A Danish physician and veterinarian, Bernhard Bang discovered *Bacterium abortus* in 1897 while investigating contagious abortion that had been affecting cattle in Denmark for over a century. He also discovered the organism affected horses, sheep, and goats. Thus the disease became known as "Bang's disease".

Slide 12

History of Brucellosis

- Alice Evans
  - American bacteriologist credited with linking the organisms in the 1920s
  - Discovered similar morphology and pathology between:
    - Bang's *Bacterium abortus*
    - Bruce's *Micrococcus melitensis*
- *Brucella* nomenclature
  - Credited to Sir David Bruce

The connection between animals and humans was discovered by Alice Evans, an American bacteriologist in the 1920s. The morphology and pathology of the organism was very similar between Bang's *Bacterium abortus* and Bruce's *Micrococcus melitensis*. The name of Sir David Bruce has been carried on in today's nomenclature of the organisms.

Slide 13

EPIDEMIOLOGY

Slide 14

Populations at Risk

- Occupational disease
  - Cattle ranchers/ dairy farmers
  - Veterinarians
  - Abattoir workers
  - Meat inspectors
  - Lab workers
- Hunters
- Travelers
- Consumers
  - Unpasteurized dairy products

Brucellosis is predominantly an occupational disease of those working with infected animals or their tissues, but can also infect consumers of unpasteurized dairy products, and hunters who unknowingly handle infected animals. Illness in people can be very protracted and painful, and can result in an inability to work and loss of income. Travelers to areas with enzootic disease who consume local delicacies, such as goat, sheep, or camel milks or cheeses, may become infected.

[Photo: Bottles of raw milk. Source: Kyle McDaniel/Wisconsin State Journal]

Slide 15

Geographic Distribution

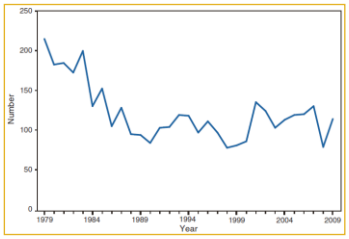
- Distribution
  - Worldwide
  - Eradicated in some countries
- Notifiable disease in many countries
  - World Organization for Animal Health (OIE)
    - Poor surveillance and reporting due to lack of recognition
    - Fever of unknown origin (FUO)

B. abortus is found worldwide in cattle-raising regions, except in Japan, Canada, some European countries, Australia, New Zealand, and Israel, where it has been eradicated. Eradication from domesticated herds is nearly complete in the U.S. *B. abortus* persists in wildlife hosts in some regions, including the Greater Yellowstone Area of North America. The actual incidence of infection may be 10-25% higher than recognized because cases may not be properly diagnosed (i.e., fevers of unknown origin).

[Photo: Cow and calf. Source: Bob Nichols/USDA]

Slide 16

Brucellosis: Reported cases, by year
United States, 1979 – 2009



Because the U.S. control and eradication program for brucellosis has nearly eliminated *B. abortus* infections among U.S. herds, the risk of a human acquiring the infection, either from occupational exposure to domestic livestock or from consuming contaminated food products, is small. A summary of cases is published each year in the Morbidity and Mortality Weekly Report from the CDC. Today in the United States, most cases come from consuming contaminated imported unpasteurized milk products; there were 115 human cases reported to the CDC in 2009.

[Graph: Brucellosis: Reported cases, by year in the United States, 1979-2009. Source: Summary of Notifiable Diseases 2009. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5853a1.htm]

Slide 17

Brucellosis: U.S. Incidence

- About 100 human cases/yr
  - Less than 0.5 cases/100,000 people
  - Most cases occur in California, Florida, Texas, Virginia
- Most associated with consumption of unpasteurized foreign cheeses

Incidence in the United States is less 0.5 cases per 100,000 people. Most cases are reported from California, Florida, Texas, and Virginia. There have been about 100 cases reported each year for the last 10 years.

Slide 18

TRANSMISSION

Slide 19

Transmission in Humans

- Ingestion
  - Raw milk, unpasteurized dairy products
  - Rarely through undercooked meat
- Mucous membrane or abraded skin contact with infected tissues
  - Animal abortion products
    - Vaginal discharge, aborted fetuses, placentas

Humans usually become infected with *Brucella* species by ingesting organisms or by the contamination of mucous membranes and abraded skin. Common sources of infection for people include: animal abortion products, ingestion of unpasteurized dairy products, ingestion of uncooked meat uncooked or undercooked meat or meat products, contact with laboratory cultures or tissue samples and accidental injection of live brucellosis vaccines.

Slide 20

Transmission in Cattle

- Ingestion of/contact with:
  - Reproductive tissues and/or fluids
  - Milk, urine, semen, feces, hygroma fluids
- *In utero*
- Venereal (uncommon)
  - Artificial insemination
- Fomites

In animals, *B. abortus* is usually transmitted by contact with the placenta, fetus, fetal fluids and vaginal discharges from infected animals. Animals are infectious after either abortion or full-term parturition. *B. abortus* may also be found in the milk, urine, semen, feces and hygroma fluids. Shedding in milk can be prolonged or lifelong, and may be intermittent. Many infected cattle become chronic carriers. Infection usually occurs by ingestion and through mucous membranes, but *B. abortus* can be transmitted through broken skin. Although the mammary gland is usually colonized during the course of an infection, it can also be infected by direct contact, with subsequent shedding of the organisms in the milk. *In utero* infections also occur. Venereal transmission seems to be uncommon.

Transmission by artificial insemination is reported to occur when contaminated semen is deposited in the uterus but not in the midcervix. *B. abortus* can be spread on fomites including feed and water.

Slide 21

Transmission in Other Animals

- Contact with infected cattle
- Carnivores
  - Can be infected
  - Not a source of infection for others under natural conditions

Other species can be infected with *B. abortus* after contact with infected cattle or other maintenance hosts. Carnivores do not seem to be a significant source of infection for other animals. Dogs and coyotes can be infected with *B. abortus*, shed bacteria in reproductive discharges, and can infect cattle if these species are kept in close confinement under experimental conditions. However, no confirmed cases of transmission from dogs to cattle have been reported under natural conditions, and there is no epidemiological evidence that carnivores act as a source of infection for ruminants in *B. abortus* eradication programs. Experimentally infected wolves excrete few organisms in the feces, and the number of organisms is much lower than the reported infective dose for cattle.

[Photo: Wolf. Source: USDA APHIS]

Slide 22

DISEASE IN HUMANS

Slide 23

Disease in Humans

- Incubation period
  - Variable; 5 days to three months
- Multisystemic
  - Any organ or organ system
  - Cyclical fever
- Flu-like illness
  - May wax and wane
  - Chronic illness possible

Brucellosis in humans can involve any organ or organ system, and have an insidious onset with varying clinical signs. The incubation period in humans is variable and can range from 5 to 21 days up to three months. The one common sign in all patients is an intermittent/irregular fever of variable duration, thus the term *undulant fever*. The acute form (<8 weeks from illness onset) is characterized by symptomatic, nonspecific, or flu-like symptoms, including fever, malaise, anorexia, headache, myalgia, and back pain. Drenching sweats can occur, particularly at night. Splenomegaly, hepatomegaly, coughing, and pleuritic chest pain are sometimes seen. Gastrointestinal signs, including anorexia, nausea, vomiting, diarrhea, and constipation, occur frequently in adults but less often in children. In many patients, the symptoms last for two to four weeks and are followed by spontaneous recovery. Others develop an intermittent fever and other persistent symptoms that typically wax and wane at 2 to 14 day intervals. Most people with this undulant form recover completely in three to 12 months. A few patients become chronically ill. Relapses can occur months after the initial symptoms, even in successfully treated cases.

Slide 24

Human Disease

- 20 to 60% of cases
  - Osteoarticular complications
    - Arthritis, spondylitis, osteomyelitis
- Hepatomegaly may occur
- Gastrointestinal complications
- 2 to 20% of cases
  - Genitourinary involvement
    - Orchitis and epididymitis most common

Complications are seen occasionally, particularly in the undulant and chronic forms. The most frequent complication of brucellosis appears to be involvement of the bones and joints. Arthritis of the hips, knees, and ankles also occurs with spondylitis being the primary complaint. Complications involving the bones and joints are reported in 20-60% of patients with clinical brucellosis. The liver is generally involved in most cases of brucellosis as it is an organ involved in the reticulo-endothelial system (RES), much like the skeletal system. When foodborne exposure occurs, the gastrointestinal complications are no worse than the systemic signs of any other route of infection, including nausea, vomiting, anorexia, weight loss, and abdominal discomfort. Genitourinary complications can occur with the testicles being most frequently involved. Evidence of orchitis, or epididymo-orchitis can occur in association with systemic infection. Renal involvement is rare. To date there is no convincing evidence that pregnant women with brucellosis have more abortions than do those with other bacteremic infections if the disease is identified and treated promptly. While venereal transmission has not been proven, *Brucella* organisms have been identified in banked human sperm.

Slide 25

Complications of Brucellosis

- Most common
  - Arthritis, spondylitis, epididymo-orchitis, chronic fatigue
- Neurological
  - 5% of cases
- Other
  - Ocular, cardiovascular, additional organs and tissues

Complications are seen occasionally, particularly in the undulant and chronic forms. The most common complications are arthritis, spondylitis, epididymo-orchitis and chronic fatigue. Neurological signs occur in up to 5% of cases. They may include personality changes, meningitis, encephalitis and peripheral neuropathy. Uveitis, optic neuritis and papilledema have been reported. Endocarditis is one of the most serious complications, and is often the cause of death in fatal cases. Many other organs and tissues can also be affected, resulting in a wide variety of syndromes including nephritis, dermatitis, vasculitis, lymphadenopathy, deep vein thrombosis, granulomatous hepatitis, cholecystitis, osteomyelitis, anemia, leukopenia and thrombocytopenia. Abscesses can occur in internal organs.

Slide 26

Treatment and Prognosis

- Rarely fatal if treated
  - Case-fatality rate <2% (untreated)
  - Antibiotics necessary
  - Death usually caused by endocarditis, meningitis
- About 5% of treated cases relapse
  - Failure to complete treatment
  - Infections requiring surgical intervention

Brucellosis is rarely fatal if treated; in untreated persons, estimates of the case fatality rate vary from less than 2% to 5%. Antibiotics are usually the mainstay of treatment; long-term treatment may be required. Some forms of localized disease, such as endocarditis, may require surgery. Deaths are usually caused by endocarditis or meningitis. Although recovery is common, disability is often pronounced depending on the localization of infection and response to treatment. Approximately 5% of treated cases will relapse weeks to months after therapy has ended due to the failure to complete the treatment regimen or infection that requires surgical drainage. Antibiotic resistant strains of *Brucella* have been reported, but the clinical importance of that fact is not well understood.

Slide 27

DISEASE IN ANIMALS

Slide 28

Disease in Cattle

- Cows
  - Abortion, stillbirth
  - Weak calves
  - Retained placenta
  - Decreased lactation
- Bulls
  - Epididymitis, orchitis
- Infertility, arthritis

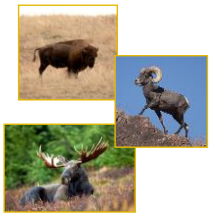
In cattle, *B. abortus* causes abortions and stillbirths; abortions usually occur during the second half of gestation. Some calves are born alive but weak, and may die soon after birth. The placenta may be retained and secondary metritis can occur. Lactation may be decreased. After the first abortion, subsequent pregnancies are generally normal; however, cows may shed the organism in milk and uterine discharges. Epididymitis, seminal vesiculitis, orchitis or testicular abscesses are sometimes seen in bulls. Infertility occurs occasionally in both sexes, due to metritis or orchitis/epididymitis. Hygromas, particularly on the leg joints, are a common symptom in some tropical countries. Arthritis can develop in some long-term infections. Systemic signs do not usually occur in uncomplicated infections, and deaths are rare except in the fetus or newborn. Infections in nonpregnant females are usually asymptomatic.

[Photo: Cow and calf. Source: wikimedia.commons]

Slide 29

Disease in Other Ruminants

- Camels, bison, water buffalo, bighorn sheep, other ruminants
  - Signs similar to cattle
- Moose
  - May die rapidly



In camels, bison, water buffalo, bighorn sheep and other ruminants, the symptoms are similar to cattle. Abortions have also been reported in experimentally infected llamas. Other herbivores may develop more serious disease. Moose die rapidly in experimental infections. Two bighorn sheep rams with no apparent disease other than testicular lesions also died inexplicably, giving rise to speculation that *B. abortus* infections might sometimes be lethal in this species.

[Photo: (Top) Bison. Source: USDA APHIS Image Gallery; (Middle) Bighorn Sheep. Source: Magnus Kjaergaard/Wikimedia Commons; (Bottom) Moose. Source: Ryan Hagerty/U.S. Fish and Wildlife Service via Wikimedia Commons]

Slide 30

Disease in Other Animals

- Carnivores
  - Abortion, epididymitis, polyarthritis
  - May be asymptomatic
- Horses
  - Inflammation of bursae
    - Supraspinous (fistulous withers)
    - Supra-atlantal (poll evil)
  - Abortion rare

Symptomatic infections have been reported in some species of carnivores. Abortions, epididymitis, polyarthritis and other symptoms occur in some *B. abortus*-infected dogs. Experimentally infected wolves remained asymptomatic, although the organism could be recovered from lymphoreticular tissues for at least one year. Infected coyotes and foxes are also reported to be asymptomatic. In horses, *B. abortus* can cause inflammation of the supraspinous or supra-atlantal bursa; these syndromes are known, respectively, as fistulous withers and poll evil. The bursal sac becomes distended by a clear, viscous, straw-colored exudate and develops a thickened wall. It can rupture, leading to secondary inflammation. In chronic cases, nearby ligaments and the dorsal vertebral spines may become necrotic. *Brucella*-associated abortions are rare in horses.

Slide 31

Post Mortem Lesions

- Granulomatous inflammatory lesions
  - Reproductive tract
  - Udder
  - Lymph nodes
  - Joints
- Abnormal placenta
- Enlarged liver
- Bulls: swollen scrotum

At necropsy, granulomatous inflammatory lesions may be present in the reproductive tract, udder, supramammary lymph nodes, other lymphoid tissues, and sometimes in the joints and synovial membranes. Mild to severe endometritis may be seen after an abortion. The placenta is usually thickened and edematous, and may have exudate on its surface. The intercotyledonary region is typically leathery, with a wet appearance and focal thickening. The regional lymph nodes can be enlarged, and the mammary gland may contain lesions. Some aborted fetuses appear normal; others are autolyzed or have variable amounts of subcutaneous edema and bloodstained fluid in the body cavities. The liver may be enlarged and discolored, and the lungs may exhibit fibrous pleuritis and pneumonia. In bulls, one or both sacs of the scrotum may be swollen due to orchitis, epididymitis or abscesses. The tunica vaginalis may be thickened and fibrous, and adhesions may be present. Hygromas may be found at slaughter in both sexes on the knees, stifles, hock, angle of the haunch, and between the nuchal ligament and the primary thoracic spines. These lesions are not pathognomonic for brucellosis.

[Photo: Bovine, placenta. The placenta contains numerous hemorrhagic cotyledons. Source: Armed Forces Institute of Pathology/CFSPH]

Slide 32

Morbidity and Mortality

- Naïve cattle
  - *B. abortus* spreads rapidly
  - Abortion storms common
- Endemic herds
  - Sporadic symptoms
- Death rare in adult animals
  - Exceptions: moose, bighorn sheep

In previously unexposed and unvaccinated cattle, *B. abortus* spreads rapidly and abortion storms are common. The abortion rate varies from 30% to 80%. In herds where this organism has become endemic, only sporadic symptoms occur and cows may abort their first pregnancies. Abortions are less common in water buffalo cows than cattle. Genetic resistance to brucellosis has been reported in both cattle and water buffalo. Deaths are rare in adult animals of most species; however, *B. abortus* can be lethal in experimentally infected moose, and possibly in bighorn sheep.

Slide 33

Differential Diagnosis

- Trichomoniasis
- Vibriosis
- Leptospirosis
- Listeriosis
- Infectious bovine rhinotracheitis
- Various mycoses

Brucellosis should be considered in all abortions, particularly when there are multiple late-term abortions in the herd. Other diseases causing abortion or epididymitis and orchitis should be considered. In cattle, the differential diagnosis includes trichomoniasis, vibriosis, leptospirosis, listeriosis, infectious bovine rhinotracheitis and various mycoses.

Slide 34

Laboratory Diagnosis

- Direct examination
- Serology
  - *Brucella* antigen tests, complement fixation, ELISA, others
- Milk testing
- Culture and identification
  - Phage, biochemical typing
- PCR

Microscopic examination of smears stained with the Stamp's modification of the Ziehl-Neelsen method can be useful for a presumptive diagnosis, particularly if the direct examination is supported by serology. Serological tests used to test individual cattle and herds include the buffered *Brucella* antigen tests (rose bengal test and buffered plate agglutination test), complement fixation, indirect or competitive enzyme-linked immunosorbent assays (ELISAs) or the fluorescence polarization assay. ELISAs or the *Brucella* milk ring test (BRT) can be used to screen herds by detecting antibodies in milk. In vaccinated cattle, the native hapten-based gel precipitation tests (gel diffusion or radial immunodiffusion tests) are sometimes used to distinguish vaccination from infection. A brucellin allergic skin test can be used to test unvaccinated cattle for *B. abortus*.

This test is performed by injecting the allergen intradermally into the caudal fold, the skin of the flank, or the side of the neck. A definitive diagnosis can be made if *B. abortus* is cultured from an animal. *Brucella* spp. can be isolated on a variety of plain media, or selective media such as Farrell's medium or Thayer-Martin's modified medium. *B. abortus* can be identified to the species and biovar level by phage typing and cultural, biochemical and serological characteristics. Genetic techniques can also be used for biotyping. The vaccine strains (*B. abortus* strains S19 and RB51) can be distinguished from field strains by their growth characteristics and sensitivity to antibiotics and other additives. Polymerase chain reaction (PCR) techniques and other genetic techniques (restriction fragment length polymorphism or Southern blotting) are available in some laboratories.

Slide 35

Brucellosis in Yellowstone National Park

Although Brucellosis is not a prevalent disease in the United States, certain wildlife species can serve as a source of infection to domesticated animals, especially cattle. This is especially a concern in the Yellowstone area where cattle can come into contact with roaming bison or *Brucella* contaminated soils and fetal tissues. *B. abortus* was first detected in bison in 1917 in Yellowstone National Park.

[Photo: Waterfall at Yellowstone National Park in Wyoming, United States. Source: Erik Marr/wikimedia-creative commons.org]

Slide 36

Brucellosis in Yellowstone

- Bison
  - Up to 50% seropositive
- Bison Management Plan
  - Maintain a wild, free-ranging bison population
  - Minimize risk of transmission to domestic cattle
- Disease transmission
  - Contaminated birthing fluids, soil

Up to 50% of bison in Yellowstone test positive for brucellosis. Concern exists that bison leaving the park will transmit the disease to cattle in surrounding states. Currently, a bison management plan is in place; it's goals are to maintain a wild, free ranging bison population while minimizing the risk of transmitting brucellosis from bison to domestic cattle on public and private lands adjacent to Yellowstone. The bison management plan is not considered to be a brucellosis eradiation plan. Bison are likely to spread disease to herdmates by direct contact with birthing fluids and contaminated soil and vegetation during calving.

[Photo: Bison. Source: Scott Bauer/USDA]

Slide 37

Brucellosis in Yellowstone

- Usually less disease transmission between herdmates
  - Solitary birthing
- Elk feeding grounds result in congregation
  - Increased likelihood of disease transmission
- Disease control strategies
  - Vaccination, habitat improvement

Elk are less likely to spread brucellosis than bison; they prefer to calve separately from other animals. However, elk feeding grounds cause congregation and may lead to increased disease transmission. Vaccination of elk in feeding grounds and habitat improvement (to keep elk away from cattle) have been used to combat brucellosis in elk.

Source: Elk feeding ground. Source: U.S. Fish and Wildlife Service]

Slide 38

PREVENTION AND CONTROL

Slide 39

Recommended Actions

- Notification of authorities
  - Federal
    - Area Veterinarian in Charge (AVIC) http://www.aphis.usda.gov/animal_health/area_offices/
  - State
    - State Animal Health Officials (SAHO) www.usaha.org/Portals/6/StateAnimalHealthOfficials.pdf

Brucellosis is a reportable disease. State and/or federal authorities should be consulted for specific guidelines.

Slide 40

Prevention and Control

- Herd additions
  - Vaccinated calves
  - Nonpregnant heifers
  - Pregnant or fresh cows from brucellosis-free areas or herds
  - Isolate and test before adding to herd

Bovine brucellosis is usually introduced into a herd in an infected animal, but it can also enter in semen from infected bulls and on fomites. In endemic areas, vaccinated calves or nonpregnant heifers are the best herd additions in uninfected herds. Any pregnant or fresh cows should come from brucellosis-free areas or herds, and should be seronegative. Herd additions should be isolated for approximately a month and retested for *B. abortus* before they are added to the herd. Selective breeding for disease-resistant genotypes may also be feasible as a control strategy in water buffalo. *B. abortus* can be eradicated from a herd by test and removal procedures, or by depopulation.

[Photo: Cow and calf. Source: Beth Carlson/North Dakota State Board of Animal Health/CFSPH]

Slide 41

U.S. Eradication Program

- U.S. Department of Agriculture
  - 1934: Cooperative State-Federal Brucellosis Eradication Program
    - Removal of diseased cattle due to drought
- 1951: APHIS became involved
- 1957: 124,000 positive herds
- Approach
  - Test, slaughter, trace back, investigate, and vaccinate

The USDA started the Cooperative State-Federal Brucellosis Eradication Program in 1934. An increasing public health concern and drought conditions made it necessary to reduce cattle herds, so the diseased were the first eliminated. The Program also implemented testing, quarantine, and elimination standards that are still followed today. In 1951, the National Brucellosis Program was initiated by the Animal and Plant Health Inspection Service and made it mandatory that all states comply. In 1957, there were more than 124,000 cattle herds known to be infected. The approach was to test herds and remove positives, depopulate if necessary, vaccinate new animals, and trace back reactors through the market identification program to the herds of origin.

Slide 42

U.S. Eradication Program

- Surveillance
  - Brucellosis ring test
    - Pooled milk
  - Market cattle identification
    - Blood test, individual
- Indemnity: whole herd depopulation
  - $250 nonregistered cattle/bison
  - $750 or 95% of value minus salvage value for registered cattle

There are two primary surveillance procedures to locate infection without having to test each animal in every herd. Milk from dairy herds is checked two to four times a year by testing a small sample obtained from creameries or farm milk tanks for evidence of brucellosis, also known as the brucellosis ring test. Bison herds and cattle herds that do not produce milk for sale are routinely checked for brucellosis by blood-testing animals sold from these herds at livestock markets or at slaughter. The blood agglutination test is used to pinpoint infection within a herd. USDA APHIS is moving towards reduced brucellosis surveillance in the coming years. Should a herd test positive, it must then be depopulated. Financial compensation to the producer varies by offering a fixed rate, which is $250 per animal for cattle or bison that are not registered, or $750 per head for registered cattle, minus their salvage value. The appraisal option has been introduced based on fair market value for registered cattle, and producers are then offered 95% of that value, again, minus the salvage value.

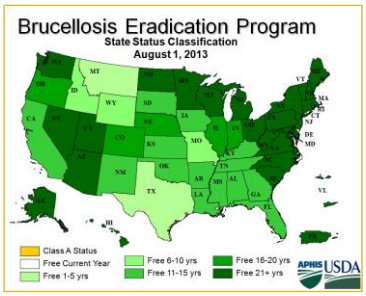
Slide 43

Brucellosis Classes

- Class Free
  - All U.S. states
- Class A
  - <0.25% infection rate
  - Cattle tested before export
- Class B
  - <1.5% infection rate
  - Cattle tested before interstate movement

For management purposes, three bovine brucellosis classes have been defined: Free, A, and B. Currently all 50 states, Puerto Rico, and the U.S. virgin Islands are officially designated as Brucellosis Class Free. However, occasional cases still occur, mostly in the Greater Yellowstone Area. [Graphic design by Clint May, Iowa State University/CFSPH]

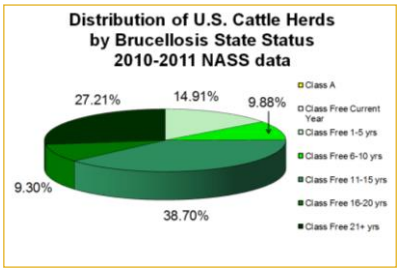
Slide 44



This map shows the status classification of each state for bovine brucellosis.

[Source: USDA APHIS. Bovine Brucellosis Monthly Report-Maps. http://www.aphis.usda.gov/animal_health/animal_diseases/brucellosis/downloads/monthly_rpt.pps]

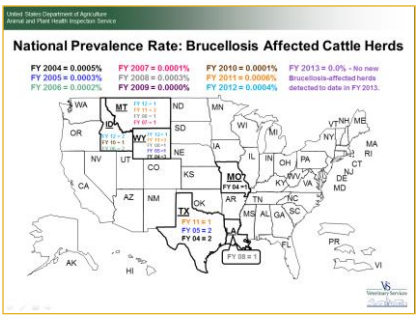
Slide 45



This chart shows the distribution of U.S. cattle herds by brucellosis state status.

[Source: USDA APHIS. Bovine Brucellosis Monthly Report-Maps. http://www.aphis.usda.gov/animal_health/animal_diseases/brucellosis/downloads/monthly_rpt.pps]

Slide 46



This map shows the national prevalence of brucellosis in U.S. cattle herds.

[Source: USDA APHIS. Bovine Brucellosis Monthly Report-Maps. http://www.aphis.usda.gov/animal_health/animal_diseases/brucellosis/downloads/monthly_rpt.pps]

Slide 47

Prevention and Control

- Readily killed by most disinfectants
  - Hypochlorite
  - 70% ethanol
  - Isopropanol
  - Iodophores
  - Phenolics
  - Formaldehyde/glutaraldehyde
- Quaternary ammonium compounds not recommended

Any area exposed to infected animals and their discharges should be thoroughly cleaned and disinfected. *Brucella* species are readily killed by most commonly available disinfectants including hypochlorite solutions, 70% ethanol, isopropanol, iodophores, phenolic disinfectants, formaldehyde, glutaraldehyde and xylene; however, organic matter and low temperatures decrease the efficacy of disinfectants. Alkyl quaternary ammonium compounds are not recommended. Autoclaving [moist heat of 121°C (250°F) for at least 15 minutes] can be used to destroy *Brucella* species on contaminated equipment.

[Photo: Disinfectant bottles. Source: Dani Ausen/CFSPH]

Slide 48

Vaccination: RB51

- Approved for use February 1996 for calves
- Able to differentiate "wild type" exposure from immunization
  - Lacks LPS-O antigen that causes antibody response on serologic or milk tests
- Infectious to humans
  - Serologically negative upon testing post-exposure
  - CDC registry of human exposures
  - 32 documented exposures as of 1998

Vaccination has become an important control measure for brucellosis in the United States. RB51 was approved for use by APHIS in February 1996 and for use in the eradication program in March. It was the first new vaccine for brucellosis in 50 years, and it is given only to calves 4-12 months old. This attenuated strain is less virulent in cattle so they will shed fewer organisms if they become infected via vaccination. There are two major advantages with RB51: one is the ability to protect via vaccination and the other is the ability to differentiate those animals infected with the wild type virus. However, because vaccination with RB51 does not induce an antibody response, assessment of human exposure is also difficult. RB51 is considered infectious for humans and only federally accredited veterinarians should administer the vaccine. The CDC keeps a registry of all human exposures, and they can be notified at (404) 639-3158. As of 1998 there have been 32 documented exposures. Of those, three reported inflammation at the inoculation site, and one had intermittent fever, chills, headache, and myalgia.

Slide 49

Prevention and Control

- Education about risk of transmission
  - Farmers, veterinarians, abattoir workers, butchers, consumers, hunters
- Wear proper attire if dealing with infected animals/tissues
  - Gloves, masks, goggles
- Avoid consumption of raw dairy products

Education for those at greatest risk about the routes of transmission of is an important prevention measure to reduce the occurrence of brucellosis in humans. Properly protecting yourself, if you are an "at risk" individual, by wearing gloves, masks, goggles, and coveralls to prevent exposure to tissues and body secretions of infected animals can help. Pasteurization or boiling milk and avoidance of eating unpasteurized dairy products will also help decrease human exposure to brucellosis.

Slide 50

Additional Resources

- USDA APHIS VS Brucellosis Disease Information
  - http://www.aphis.usda.gov/animal_health/animal_diseases/brucellosis/
- Center for Food Security and Public Health
  - www.cfsph.iastate.edu
- Centers for Disease Control and Prevention (CDC): Brucellosis
  - http://www.cdc.gov/ncidod/dbmd/diseaseinfo/brucellosis_g.htm

Slide 51

Acknowledgments

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