Swine Brucellosis

USDA APHIS VS Career Services Program
Program Diseases Training Module

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This course is designed to provide updated information on the major domestic diseases for which Veterinary Services (VS) has program responsibility. It will provide information on surveillance, disease control and eradication for these diseases. It will also give an overview of the duties of a field Veterinary Medical Officer (VMO) as a support worker of VS animal disease programs and how they interact with other units in APHIS.

1. **Disease information** .................................................................3
   a. Agent
   b. Transmission
   c. Clinical signs
   d. Epidemiology
   e. Diagnosis
   f. Prevention and control
   g. Public health consequences
   h. Economic impact

2. **History of the disease and control programs**.................................7

3. **Current control program** .............................................................9
   a. The swine brucellosis eradication program
      1) Stage I
      2) Stage II
      3) Stage III (Accredited Free)

4. **Role of the VMO in the swine brucellosis eradication program** ........11
   a. Testing and diagnosis
   b. Collection and submission of samples
   c. Traceback of MST reactors
   d. Managing an infected herd
   e. Surveillance
   f. Validated brucellosis free herds

5. **Role of other agencies, states and industry** ..................................14

6. **References** ...............................................................................15
1. DISEASE INFORMATION

a. Agent

Brucellosis is a contagious disease caused by various species of *Brucella*, a Gram negative rod in the family Brucellaceae. Brucellae are facultative intracellular pathogens, mainly proliferating inside cells of the macrophage lineage. Each species of *Brucella* is typically associated with a limited number of hosts but occasionally infects other species, particularly those in close contact. Swine brucellosis, seen in domestic and wild pigs, is caused by *Brucella suis*. Pigs can be experimentally infected with *Brucella abortus* and *B. melitensis*, but reports of natural infections with these species are rare.

Five biovars of *B. suis* have been identified. Only biovars 1, 2 and 3 infect swine and cause swine brucellosis. *B. suis* biovars 1 and 3 can be found worldwide, but the infection rate is high only in parts of South America and Southeast Asia, and in feral pigs in Australia and the southeastern United States. *B. suis* biovar 2 differs from biovars 1 and 3 in its decreased zoonotic potential, its pathology in pigs, and its limited geographic region. Biovar 2 is currently found in domestic swine, wild pigs and the European brown hare (*Lepus capensis*) in Scandinavia, most of Europe, and the Balkan Peninsula. Although this biovar is not thought to be present in the United States, outbreaks could occur as a foreign animal disease.

*B. suis* biovars 1 and 3 are highly pathogenic for humans, but infections with biovar 2 are rare. Some biovars of *B. suis* can also infect reindeer, caribou, hares, mice, Arctic foxes, wolves, rodents and occasionally cattle and dogs. Unusual host species are usually infected when they ingest contaminated material or come in close contact with the natural host.

The optimal conditions for the survival of this organism are high humidity, low temperatures and no sunlight. *Brucella* can be found for as long as six weeks in feces, urine, and water. Live bacteria have also been found on paper for up to 32 days, in soil for up to 125 days, in carcasses and organs for up to 135 days, and in blood stored at 4 °C (39.2 °F) for 180 days.

b. Transmission

After an initial bacteremia, *B. suis* localizes in the reproductive tract of both sexes. Bacteria are shed in birth and abortion products, uterine discharges, semen, and the urine of boars. Pigs usually become infected when they ingest birth or abortion products or uterine discharges, often in contaminated feed. Venereal spread is also common and semen used in artificial insemination can transmit brucellosis. If *B. suis* contaminates the hands of farm workers, it can also colonize the mammary gland of cattle; such infections have resulted in human epidemics when large numbers of bacteria were subsequently excreted in the milk.

Humans become infected by ingestion, inhalation, or direct contact through the mucous membranes or breaks in the skin. Aerosol transmission has been documented in laboratories and slaughterhouses. With the exception of rare cases when *B. suis* colonizes the udder of cows, most human infections with occur in people who handle domestic pigs on farms or who slaughter and process pigs, including hunters. Laboratory workers are also at a high risk of infection.
c. Clinical signs
Swine brucellosis is characterized mainly by reproductive symptoms and occasionally by locomotor signs. After the initial bacteremia, *B. suis* localizes in the placenta and the fetuses of sows, and the testis, epididymis, seminal vesicles, and/or bulbourethral glands of boars.2

In sows, the most common symptom is abortion, which can occur at any time during gestation. Vaginal discharge is often minimal or absent and the abortions may be mistaken for infertility.2 Piglets born alive may be weak and die before weaning.4,6 Occasionally, sows develop metritis.2 Some sows may become permanently sterile but, in most cases, sterility is temporary.7

Orchitis, often unilateral, is usually the most apparent sign in boars.2,4 An initial fever may be followed by testicular pain and reluctance to mate. Abscesses and swelling can sometimes occur in the initial stages, and the testes may become sclerotic and atrophy during the final stages of disease. The interference with breeding may be temporary or permanent.2 Boars that remain asymptomatic can also excrete *B. suis* in the semen.2 Fertility seems to be decreased in affected boars.7

The joints, tendon sheaths, and bones can be affected in both sexes, resulting in lameness, incoordination, and sometimes posterior paralysis.2,4,6 Occasionally, animals develop abscesses in other parts of the body.2 However, some infected animals may be asymptomatic.4

d. Epidemiology
The reservoirs of *B. suis* are domestic and wild pigs. An additional reservoir for biovar 2 is the European brown hare (*Lepus capensis*).2 Brucellosis is most likely to be introduced into a herd by infected pigs or infected semen.4

In infected herds, 0 to 80% of the herd will abort.7 Deaths are not usually seen in adult pigs but weak piglets may die before weaning. Suckling pigs can become infected from their dams, but most piglets are still uninfected when they reach weaning age.7 Some affected pigs may recover, often within six months, but many others remain permanently infected.2

Natural resistance to *Brucella suis* exists among swine, and pigs can be bred to increase their resistance to infection.8 In one study, only nine percent of unselected pigs were originally resistant to infection but, after selective breeding, 73-77% of the pigs became resistant to challenge. In a single generation of mass selection, brucellosis susceptibility could be decreased in the herd by 54%. Increased resistance to infection has also been seen in the offspring of pigs during a natural outbreak.8 These studies suggest that resistance to *B. suis* in pigs is controlled by a small number of genes.8

Currently, one of the major challenges to brucellosis eradication is its presence in wild and feral swine. There are thought to be more than two million wild and feral swine in the U.S., spread throughout 23 states.9 Brucellosis has been confirmed in these animals in at least 9 states, including California, Texas, Oklahoma, Louisiana, Florida, Alabama, South Carolina, Georgia, and Hawaii, and serologic evidence of infection has been found in wild pigs in Arkansas.10,11,12 In various studies conducted in South Carolina, the prevalence of infection ranged from 14% to 44%; in one case, the percentage of infected pigs in one location also varied over time, from 28% in 1976 to 18% in 1992 and 44% in 1999.9,13 In another study, six percent of the wild and feral pigs sampled in 11 southeastern states and Hawaii were seropositive.11 Most producers
have completely isolated their herds from wild and feral pigs to prevent disease transmission; however, brucellosis could still infect swine owned by backyard swine producers and other small farmers who may use old-fashioned husbandry techniques. These farms could, in turn, reintroduce brucellosis into the domestic swine industry. A further complication is added when hunt clubs and shooting preserve owners, who may not have a good understanding of swine diseases, relocate feral pigs. The Uniform Methods and Rules (UM&R) for swine brucellosis currently contains regulations for the movement of wild and feral swine.

e. Diagnosis
Swine brucellosis can be difficult to diagnose and is usually recognized as a herd problem rather than a disease of individual swine. In a herd where brucellosis has become endemic, the signs can be subtle and typically include non-specific infertility, a slightly lowered farrowing rate, and irregular estrous cycles in sows. In cases where the disease has recently entered the herd, the signs will probably be more dramatic and can include abortions and stillbirths, the birth of weak piglets, an increase in the pre-weaning mortality rate and in the number of returns to service. In most cases, brucellosis is recognized when it causes reproductive failure in sows; however, boars may develop genital lesions, particularly orchitis, as well as musculoskeletal signs (i.e., lameness, incoordination). Common non-reproductive signs in newly infected herds include posterior paralysis, lameness resulting from arthritis, and abscesses in the subcutaneous tissues, kidneys and muscles.

At necropsy, abscesses, other purulent or inflammatory lesions, or calcified foci may be seen in the testes and male accessory sex organs, particularly the epididymis and seminal vesicles. Sows may have catarrhal metritis, and nodules and abscesses may be found in both the gravid and non-gravid uterus. At times, abscesses or other purulent lesions can also be found in non-reproductive organs, particularly the lymph nodes, spleen, liver, kidneys, joint capsules, tendon sheaths, bones, mammary gland, bladder and occasionally the brain. Nodular splenitis is suggestive of brucellosis, and arthritis and osteomyelitis may be seen in the lumbar and sacral vertebral bodies. After an abortion, the placenta may be edematous and hyperemic, and the fetuses may have hemorrhagic subcutaneous and peritoneal fluid.

Brucellosis must be differentiated from other diseases that can cause abortion in sows. Other causes of posterior paralysis and lameness or incoordination may also have to be ruled out. Although brucellosis is the only disease where reproductive failure in sows is accompanied by orchitis in boars and lameness or paralysis, many herds have few symptoms and this classical presentation may not be seen.

A tentative diagnosis of brucellosis must be confirmed with laboratory tests, including either isolation of B. suis or serology. Allergic (hypersensitivity) tests (skin tests) have been developed and are widely used as a herd test in some countries but not in the U.S.

Samples for culture can be collected from aborted fetuses, placentas, vaginal swabs, semen, joint exudates, and the material from abscesses. At necropsy, most infected animals can be identified by collecting a limited number of lymph nodes, such as the mandibular, retropharyngeal and iliac nodes, as well as the material from any suspicious lesion. Semen can be cultured before use in artificial insemination. Brucella suis is a human pathogen and culture must be done in laboratories that are equipped to work safely with this organism.
A variety of serologic tests are available for screening and as herd tests. The buffered Brucella antigen tests (BBAT) are the tests prescribed by the World Organization for Animal Health (OIE) for international trade. These tests include the card test, the rose bengal plate agglutination test (RBT) and the buffered plate agglutination test (BPAT). Other serologic tests are the indirect and competitive enzyme-linked immunosorbent assays (ELISAs), complement fixation, and the fluorescence polarization assay (FPA). The FPA is also known as the particle concentration fluorescence immunoassay (PCFIA) test. Unlike some other tests, cross-reactivity with *Yersinia enterocolitica* is not seen in the PCFIA test.

Conventional serological herd tests are not reliable for diagnosis in individual pigs. One significant problem is that swine younger than three months do not always develop significant titers of agglutinating antibodies. In addition, swine serum can contain nonspecific antibodies that can decrease the specificity of conventional serologic tests and cross-reactions may occur with antibodies to *Yersinia enterocolitica* serotype 0.9 in many tests. For these reasons, many herds have low agglutinin titers, even if they are not infected and some infected pigs may be seronegative. Swine serum also contains a pro-complementary activity that reduces the sensitivity of the complement fixation (CF) test.

**f. Prevention and control**

Brucellosis infected swine herds are identified by first-point testing, testing high-risk swine, and epidemiologic investigations. A Market Swine Test (MST) is done on all boars and sows sent to slaughter (first-point) and on breeding animals (high-risk) subject to testing because they are being moved or sold. Pigs that test positive in an official confirmatory test (reactors) are traced back to their herd of origin. These herds are quarantined and tested for brucellosis (epidemiological). An infected herd is typically depopulated. Since *B. suis* can be difficult to detect in seronegative swine, test and removal programs are rarely used (Dr. John Korslund, personal communication). Reactors are tagged and slaughtered and the infected or exposed premises, equipment, and vehicles are decontaminated, under official state or federal supervision, using approved methods.

*Brucella suis* is susceptible to numerous disinfectants, including most commercial disinfectants, 1% sodium hypochlorite, 70% ethanol, iodine/alcohol solutions, glutaraldehyde and formaldehyde. It can also be inactivated by moist heat [121 °C (250 °F) for a minimum of 15 minutes] or dry heat [160-170 °C (320-338 °F) for at least one hour]. To prevent the re-introduction of brucellosis into domestic herds, producers must be particularly vigilant in preventing any contact with wild and feral swine.

As almost all human cases of brucellosis are zoonotic, the eradication of brucellosis in animals can greatly reduce the threat to humans. When handling swine, the risk of infection can also be decreased to some extent with good hygiene and protective clothing including gloves, rubber boots, a face mask, and impermeable clothing. Pasteurization can eliminate *Brucella* species from milk and milk products. Potentially infected material should be treated with caution and disposed of properly to prevent human infections. Particular care should be taken in the laboratory during culture and other procedures that amplify the number of organisms. The OIE and Centers for Disease Control and Prevention (CDC) recommend biosecurity containment level 3 conditions during laboratory culture.
g. Public health consequences

Human brucellosis is almost always zoonotic and person-to-person transmission is extremely rare.\textsuperscript{1,3,5} Infections with \textit{B. suis} are usually occupational diseases seen in farmers, meatpackers, veterinarians, laboratory workers, hunters, and others who are exposed to domestic or wild pigs or their tissues.\textsuperscript{1,2,3,5} Biovars 1 and 3 of \textit{B. suis} are highly pathogenic for humans, but infections with biovar 2 seem to be relatively rare.\textsuperscript{2}

In humans, brucellosis can be either an acute febrile disease or a chronic infection with variable clinical signs.\textsuperscript{1,17} The incubation period for human brucellosis is usually 5 days to 2 months, but is occasionally longer. Subclinical and unrecognized infections occur frequently. The symptoms of brucellosis appear either insidiously or abruptly.\textsuperscript{1} Some infections resemble influenza, with fever, anorexia, myalgia, severe limb and back pain, and marked sweating and fatigue.\textsuperscript{1,17} In humans, unlike domestic animals, abortion is not a feature.\textsuperscript{1}

Many untreated human brucellosis cases resolve spontaneously after 2 to 4 weeks.\textsuperscript{1} Other patients develop undulant fever, with the fever and clinical signs recurring and receding at approximately 10 day intervals.\textsuperscript{1} Most people with this undulant form recover completely in 3 to 12 months, but some can develop complications including arthritis, spondylitis, anemia, leukopenia, thrombocytopenia, uveitis, optic neuritis, epididymo-orchitis, endocarditis, granulomatous hepatitis, and neurologic signs.\textsuperscript{1,17} A chronic form, in which the symptoms continue for more than a year, is also seen.\textsuperscript{1,17} The symptoms of the chronic form are poorly understood, but may include chronic fatigue, depressive episodes and arthritis. Hypersensitivity reactions can also mimic the symptoms of brucellosis.\textsuperscript{1} By some estimates, fewer than 10\% of human brucellosis cases are recognized and reported because the clinical course is so variable.\textsuperscript{5}

In humans, brucellosis is treated with antibiotics. Relapses can occur months after the initial symptoms, even in successfully treated cases.\textsuperscript{1} The mortality rate is low, even when the disease is not treated; in untreated persons, the case fatality rate is less than 2\%.\textsuperscript{3}

h. Economic impact

In 1952, the annual losses due to brucellosis (swine and bovine), including decreased milk production in cattle, abortions of piglets and calves, and losses from decreased breeding efficiency were estimated at $400 million.\textsuperscript{18} Currently, brucellosis costs farmers and producers less than $1 million.\textsuperscript{18} In 2002, the cost to depopulate infected swine herds was $197,000.\textsuperscript{14}

2. HISTORY OF SWINE BRUCELLOSIS AND ITS CONTROL PROGRAMS

Brucellosis or “contagious abortion” has been recorded as a serious animal problem since the 1840s.\textsuperscript{19} In 1897, the Danish veterinarian Bernhard Bang isolated the causative organism, \textit{Bacillus abortus} (which later became \textit{Brucella abortus}), from cattle; for many years, this disease was known as “Bang’s disease.” A British army surgeon, Sir David Bruce, first found the organism in human patients on the island of Malta, prompting two of the names for this disease in humans - brucellosis and Malta fever. The third term, undulant fever, comes from the waxing and waning nature of many human infections.
Brucellosis was the most significant livestock disease of the early 20th century. Although *Brucella* caused only sporadic abortions in some herds, its first appearance in a newly infected herd was often heralded by abortion storms, a severe drop in milk production and, occasionally, sterility in some animals. Humans became infected when they drank unpasteurized milk or were exposed to infected animals. In 1938, more than 4,000 human cases of brucellosis were reported in the U.S., many of them in slaughterhouse workers. By 1947, that number had risen to over 6,000 cases (4.4 cases/100,000 population).

During the 1930s, with the Great Depression and severe droughts causing hardship for farmers, the government established an emergency program to reduce cattle numbers and stimulate economic recovery. To some states, this seemed to be a golden opportunity to reduce the level of brucellosis. In 1934, a cooperative state-federal brucellosis eradication program was established as part of the emergency program. At the time, the incidence of brucellosis was 11.5%. At first, the program concentrated on brucellosis in cattle. It offered herd testing and slaughter of reactors, with indemnity payments to their owners. Many states began to require that breeding and dairy cattle originate in brucellosis-free accredited herds or test negative before they entered the state and some states established area testing programs.

At the same time, attempts were being made to develop a vaccine for cattle. Some of these early vaccines contained live organisms that persistently infected cows, a misfortune that helped prompt the federal licensing of vaccines. However in 1936, the 19th strain of *Brucella abortus* isolated from the milk of a Jersey cow protected calves from infection during a field trial, did not cause persistent infections, and did not spread to other calves. Trials with strain 19 were so successful that this vaccine became established as the vaccine for cattle worldwide. By 1941, as a result of the test and slaughter program, as well as vaccination, the incidence of brucellosis had been reduced to 2.4%.

Although World War II slowed the progress of eradication, the program was rejuvenated after the war. In 1947, the first uniform methods and rules (UM&R) were established and a market cattle testing program was set up to find infected herds. The eradication efforts were aided by the development of new tests including the ring test and complement fixation. As a result of the brucellosis eradication program and the widespread pasteurization of milk, the number of human cases of brucellosis began to drop.

For many years, experts had debated whether to control brucellosis by vaccination alone or to eradicate the disease. In 1954, the brucellosis program became an accelerated eradication program. With at least 124,000 infected cattle herds still existing nationwide, a target date of 1975 was set for complete eradication. At this time, swine brucellosis eradication still lagged far behind bovine brucellosis. However, the changing pattern of human infections soon focused attention on pigs. Before 1960, most human cases of brucellosis had been caused by *Brucella abortus*. As the number of infections in cattle declined, brucellosis increasingly became an occupational disease related to pigs; from the mid-1960s to the early 1970s, most human infections were caused by *B. suis*. In the 1960’s, alarmed at the high incidence of brucellosis among abattoir workers, California officials threatened to accept slaughter hogs only from states that were brucellosis-free. This threat worried pork producers of the Midwest and, in 1961, the swine brucellosis eradication program was established. Still hoping to eradicate brucellosis by 1975, the brucellosis committee also became concerned about infections in domestic bison, as well as the wild bison in Yellowstone National Park.
However, the target date of 1975 passed and in 1976, brucellosis was not only still present in the U.S., but was spreading faster than the program could clean up infected herds.\textsuperscript{19} One problem was that some federal funds had been diverted to other animal health programs.\textsuperscript{19} In 1978, a brucellosis technical commission reported that "control leading to eradication is biologically feasible" and recommended changes in the program, including increased testing.\textsuperscript{19} At the time, 7,483 infected herds still existed – undoubtedly an underestimate, as some areas still had no real surveillance to find infected herds.\textsuperscript{19} In 1986, a five-year swine brucellosis eradication plan was approved and in 1989, APHIS began another program, the Rapid Completion Plan (RCP), to accelerate the eradication efforts.\textsuperscript{18,19} 1990 marked a major milestone in the bovine brucellosis program; the number of infected cattle herds fell below 1,000 and surveillance programs existed in all states.\textsuperscript{19}

In the last 10 years, the eradication program has come close to success.\textsuperscript{20} Currently, the domestic cattle and pig herds of most states are free of brucellosis. Only Texas, Arkansas, Florida, and Louisiana still contain brucellosis-infected domestic pig herds and only Missouri and Texas have infected cattle herds.\textsuperscript{14,15} Cases of human brucellosis are now rare in the U.S.; fewer than 0.5 cases per 100,000 are seen each year.\textsuperscript{17} Occupationally related infections have decreased since the early 1970s.\textsuperscript{5} In 1997, APHIS began the Brucellosis Emergency Action Plan (EAP), as a supplement to the RCP.\textsuperscript{18} As a result of the EAP, all brucellosis surveillance and management of new cases are now conducted as emergencies.

In the U.S., brucellosis is now found mainly in wild animals. As the last infections in domestic animals are eliminated, APHIS will shift its attention to surveillance efforts and attempt to eradicate brucellosis from bison and elk in Yellowstone National Park, other wildlife, and exotic livestock.\textsuperscript{20,21} Methods to control brucellosis in wild and feral swine are also being studied.\textsuperscript{21} Research is continuing on the RB51 vaccine, which APHIS expects to use in Yellowstone bison as part of the management plan.\textsuperscript{21}

### 3. CURRENT CONTROL PROGRAM

APHIS expects to eradicate brucellosis from domestic pigs during the next five years (by 2006).\textsuperscript{21} In 2003, four states – Texas, Arkansas, Florida and Louisiana – were in stage II of the swine brucellosis eradication program.\textsuperscript{14} No infected herds remained in the U.S. by Oct 2003.\textsuperscript{14} By July 2004, Louisiana and Arkansas were granted Free Status (John Korslund, DVM, personal communication). It is the policy of USDA-APHIS to immediately depopulate any swine herds currently found infected with swine brucellosis.

As eradication is completed in domestic swine herds, APHIS will place increased emphasis on the surveillance and testing of adjacent and contact herds to find the last infected herds.\textsuperscript{21} The presence of brucellosis in wild and feral pigs also remains a concern. States with feral swine populations are currently encouraged to sample these animals for brucellosis and report these cases separately from brucellosis in domestic swine.\textsuperscript{14} In 2002, the swine brucellosis committee recommended that such reports not interfere with state advancement to free status.\textsuperscript{14} Feral pig management plans will be developed for each state to control disease transmission from wild pigs and research is also continuing on this goal.\textsuperscript{14,21}
a. The Swine Brucellosis Eradication Program

Infected swine herds are identified by first-point testing, testing of high-risk swine, and epidemiologic investigations.\(^{14}\) The swine brucellosis program is a three-stage program, which begins with the establishment of a swine brucellosis testing and control program in stage I, and culminates in eradication and surveillance in stage III. All states with swine brucellosis eradication programs submit reports to the APHIS Veterinary Services swine health staff quarterly.

**1) Stage I.** To qualify for stage I, a state must establish the legal and regulatory authority to test and quarantine swine for brucellosis, perform epidemiologic investigations, and regulate the movement of infected or exposed pigs.\(^{16}\) The state must establish a validated swine brucellosis-free herd program and set up a swine brucellosis eradication committee or swine disease committee.\(^{16}\) The state is also responsible for distributing information on the swine brucellosis eradication program to the swine industry.

In stage I states, feeder and slaughter swine can be imported without restrictions if they have no contact with breeder pigs.\(^{16}\) Swine imported for breeding must have a negative presumptive test or come from a validated swine brucellosis-free herd or brucellosis-free state.\(^{16}\) Breeding pigs that are sold or transferred must also come from validated swine brucellosis-free herds or test negative on an official test 30 days before the ownership is transferred.\(^{16}\) All breeding pigs that pass through markets are subject to first-point testing.\(^{16}\) Breeding animals sold for slaughter are also tested. Only validated swine-brucellosis-free herds are allowed to sell semen.\(^{16}\)

Record-keeping requirements help trace slaughtered sows and boars back to their farm of origin. Within a state, sows and boars sent to slaughter must be identified by their herd of origin.\(^{16}\) The method of identification should be consistent with the identification methods approved for swine moved interstate and must be externally visible.

The herd of origin of all Market Swine Test (MST) reactors is traced, quarantined, and tested for brucellosis with a Complete Herd Test (CHT). Reactors are tagged and slaughtered and an infected herd is either depopulated within 30 days or a herd cleanup plan is established.\(^{16}\) Infected and exposed premises, equipment, and vehicles must be decontaminated. A designated brucellosis epidemiologist decides whether to investigate MST suspects, as well as the extent of testing, on a case-by-case basis.

A state must also control the intrastate movement and importation of wild and feral swine.\(^{16}\) Wild and feral pigs must be kept separate from domestic swine. They may be sent to immediate slaughter without screening, but pigs moved to hunting preserves, game farms, or feeding areas must come from monitored brucellosis-free populations or test negative before shipment. Feral pigs moved for breeding must test negative on two official tests at least 60 days apart. Any domestic pigs that have been exposed to wild or feral pigs must also be quarantined until they have tested negative on two official tests at least 60 days apart. Hunting preserves and game farms that have feral swine must be kept under surveillance by state animal health officials.
To maintain its stage I status, a state must be re-certified at 36 to 40 month intervals or certify that it meets the requirements for state II status.\textsuperscript{16} States that do not re-certify automatically lose their stage I status.

\textbf{2) Stage II.} In stage II, a state continues to meet all stage I requirements and must also have established a surveillance program to locate and eliminate infected pigs.\textsuperscript{16} One method of surveillance is complete herd testing; a state can enter Stage II if, during the previous two years, a state tested all six-month old and older breeding pigs for brucellosis. Alternatively, 10\% of a state's breeding pigs must have been tested during each of the two previous years, and at least 80\% of all MST reactors must have been successfully traced back to their farm of origin.\textsuperscript{16} Blood samples can be collected at markets or slaughter sites. All MST reactor herds are subject to a CHT within 30 days.

A state may also enter stage II if its brucellosis testing methods during the prior two years are analyzed and found to be equivalent to the two surveillance programs described above.

To maintain its stage II status, a state must be re-certified at 36 to 40 month intervals or certify that it meets the requirements for state III status.\textsuperscript{16} States that do not re-certify automatically lose their stage II status.

\textbf{3) Stage III (Accredited Free).} For a state to be accredited free of swine brucellosis (stage III), stage II requirements must have been met and no more than one infected herd must have been identified during the prior two years. This herd must either be depopulated or tested and found to be free of swine brucellosis. To maintain its Stage III status, a state must conduct random surveys of at least 5\% of its breeding swine each year, and trace back at least 80\% of its MST reactors to their herd of origin.\textsuperscript{16} States must re-certify at 36-40 month intervals or lose their stage III status.

A state may lose its Stage III status if brucellosis is identified in the state, with evidence of spread. Stage III status may also be terminated if the state does not maintain adequate surveillance or fails to comply with quarantine requirements, testing schedules, or the disposal of reactors.

\textbf{4. ROLE OF THE VMO IN THE SWINE BRUCELLOSIS ERADICATION PROGRAM}

\textbf{a. Testing and diagnosis}
Seropositive swine are identified by presumptive tests, followed by confirmatory tests.\textsuperscript{16} Presumptive tests include the buffered acidified plate antigen (BAPA) test, which identifies sera that should be re-tested with the standard card test (SCT). All sera that are positive in the SCT are then tested with a confirmatory test.

The official confirmatory tests include the standard tube test (STT) and the particle concentration fluorescence immunoassay (PCFIA) test.\textsuperscript{16} Other confirmatory tests that are not official or standardized include the Rivanol test, the complement fixation test, the standard plate test, and the semen plasma test. These tests can be used if their results are evaluated by the designated brucellosis epidemiologist.\textsuperscript{16} The semen plasma test is considered to be an official
test in boars used for artificial insemination, if the card test and/or the standard tube test are done at the same time.16

Pigs that test positive on a confirmatory test or on the card test (when a confirmatory test is not done), are classified as **brucellosis reactors**. Pigs that are positive on a presumptive test, but negative on a confirmatory test, are classified as **brucellosis suspects**.

Within three days after being notified of the test results, a herd owner or designated brucellosis epidemiologist may request that brucellosis reactors be retested.16 The designated brucellosis epidemiologist can also reclassify pigs that have been classified as reactors or suspects, if there is bacteriologic, serologic, and/or epidemiologic justification. Herds that contain a brucellosis reactor are kept under quarantine until the designated brucellosis epidemiologist makes a final decision.

**b. Collection and submission of samples**

All pigs tested for brucellosis must be identified by externally visible, permanent identification such as ear notches recorded at a pureblood registry association, an official eartag, or tattoo.16 Collected blood samples must be submitted to a designated laboratory within 24 hours.16

Before reactors are slaughtered, tissues should be collected for culture, frozen, and sent to a state-approved diagnostic laboratory or the National Veterinary Services Laboratories (NVSL). The preferred tissues (in the order of preference) are the mandibular, gastrohepatic, internal iliac, suprapharyngeal, and superficial inguinal lymph nodes. Any tissues with inflammatory lesions such as abscesses should also be cultured. Brucellosis lesions are most likely to be found in the reproductive organs, including the testes, epididymis, and seminal vesicles in boars, and the ovaries and uterus in sows. Lesions may also be found in the bones and joints of either sex.

**c. Traceback of MST reactors**

A traceback is successful if the farm of origin is identified and a CHT is done or if after investigation, a designated brucellosis epidemiologist decides that a CHT is not necessary. The designated brucellosis epidemiologist may recommend an alternative testing plan. A traceback is also considered to be successful if all of the swine on the farm of origin have been sold for slaughter.

A traceback is unsuccessful if a MST reactor cannot be traced back to its farm of origin or can only be traced to a dealer.

Records that must be kept for all MST reactors include:

1. Identification of the MST reactor, including sex, breed, and identification numbers
2. The consignor’s name and address
3. Date and location blood sample collected
4. The results of the presumptive and confirmatory tests
5. Epidemiologic data, including the results of the farm-of-origin CHT.

Tracebacks are generally recommended for MST suspects but may be waived at the discretion of the designated brucellosis epidemiologist.
Pigs that have been sold from infected herds should also be traced. All herds that have been exposed to brucellosis should be identified as soon as possible and a CHT of these herds done within 30 days of locating the index herd. Even if all of the pigs in the herd of origin were slaughtered, the source of infection should, if possible, be found and any exposed herds identified.

d. Managing an infected herd
An infected herd must be managed under quarantine until all of the pigs are sold for slaughter under permit, or brucellosis has been eliminated from the herd. Reactors must be identified with an approved tag in the left ear and sent to slaughter within 15 days after the owner has been notified of the test results. Reactor and exposed pigs can be moved only to slaughter and must not be allowed to mingle with any breeding animals. The infected premises must be cleaned and disinfected, under official state or federal supervision, within 15 days after the reactors have been removed. This period may be extended, with federal and state approval, by another 15 days.

If the herd is sold for slaughter, the premises are disinfected and can then be restocked with pigs from validated swine brucellosis-free herds. The new herd must be placed on ground that has been free of pigs for at least 30 days.

Alternatively, if the herd owner wishes to preserve the genetic characteristics of the stock, the herd may be cleaned by segregation of offspring. Gilt pigs are separated from their dams before they are 28 days old, or sooner, and kept isolated from other pigs. The gilts are tested approximately 30 days before breeding, bred to negative boars, and retested after farrowing but before removal from individual farrowing crates or pens. Gilts that test positive at any time during this process are sent to slaughter. If reactors are found at farrowing, the process is begun again. All infected breeding stock from the original herd are also isolated and sent to slaughter as soon as possible.

A test-and-slaughter procedure may also be tried. This procedure is sometimes effective in herds that have no symptoms of brucellosis and only contain a few reactors, but is not generally recommended. Brucellosis reactors are sent to slaughter and the entire breeding herd is retested at 30-day intervals until no reactors remain. If this procedure does not seem to be working, either slaughter of the herd or segregation of offspring should be tried instead.

If brucellosis is eliminated by segregation of offspring, three negative CHT must be completed before the quarantine is released. Four CHT are required if a simple test-and-slaughter procedure is used. In both cases, the first CHT must be no sooner than 30 days after all reactors have been set to slaughter. The second, third, and, if necessary, fourth CHT are at 60-90 day intervals after the first test.

Within 15 days of the quarantine date, state or federal program officials must notify all swine owners within a 1.5 mile (2.4 km) radius of the infected herd. An information letter is sent to these owners within 30 days after the quarantine is released.
**e. Surveillance**

In all Stage I and Stage II states, breeding swine are tested when they are sold or transferred to a new owner and are also tested by first point testing at markets. Pigs can be transferred between validated brucellosis-free herds without a test.

**f. Validated brucellosis-free herds**

A herd can be validated as brucellosis-free if a CHT is negative. A herd may also be tested by examining 25% of the pigs that are at least 6 months old, every 80-105 days, or 10% of these animals every 25-35 days; all breeding animals must be found to be negative. A herd can be validated as negative for brucellosis while it is being established as a Qualified Pseudorabies-Negative (QN) or Qualified Gene-Altered Vaccinated (QVN) breeding herd. Pigs that are positive on a presumptive test and negative on a confirmatory test are evaluated by a designated brucellosis epidemiologist.

Validated brucellosis-free herds must be revalidated every 12 months with a CHT. Alternatively, validation can be maintained by continuing to retest the pigs on the schedules specified for validation.

Semen used for artificial insemination in a validated brucellosis-free herd must come from a validated brucellosis-free herd. Breeding animals can be added from another validated brucellosis-free herd without testing. Breeding animals from a nonvalidated herd must have one negative presumptive test 30 days before they are transferred, and must be isolated and retested 30-60 days after they arrive. Breeding swine cannot come from feedlots or slaughter consignments.

If, during testing, a reactor is found on the brucellosis card test, its infection status and that of the herd is determined by a designated brucellosis epidemiologist. If the herd is infected, it is quarantined until brucellosis is eliminated. If the designated brucellosis epidemiologist classifies the reactor as non-infected, it is retested every 30–60 days or slaughtered and its tissues cultured for *B. suis*.

**5. ROLE OF OTHER AGENCIES, STATES AND INDUSTRY**

State governments provide personnel to carry out inspections and detection and eradication activities. State funds are also used for vaccination, sample collection, indemnities, supplies, and other direct program costs.

Industry encourages producers to participate in the brucellosis eradication program, provides information in industry journals, and consults with the Department and professional societies.

Individual producers are responsible for the cost of making their herds available for inspection, testing and vaccination.

Other agencies involved in the brucellosis eradication program include the National Park Service, the U.S. Fish and Wildlife Service (FWS), the Center for Disease Control and Prevention (CDC), Packers and Stockyards, Forest Service (FS), Bureau of Land Management (BLM), Food Safety and Inspection Service (FSIS), and Agriculture Research Service (ARS).
6. REFERENCES


