MANAGEMENT CONSIDERATIONS TO MINIMIZE REPRODUCTIVE DISEASE IN THE BEEF HERD

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Many conditions affect the reproductive performance of the beef herd, including nutrition, bull fertility, and environmental stresses. Perhaps none have the potential to create more significant losses than infectious diseases. Infectious diseases affecting reproduction can create losses throughout the entire reproductive cycle by decreasing ovulation rates, fertilization rates, embryonic survival rates, or fetal survival rates.

Infectious disease manifestation in an animal population results from the interaction of three different factors: 1) the host; 2) the infectious agent; and 3) the environment. This is referred to as the "epidemiologic triad" (Figure 1). Management practices influence all three of these factors. A common mistake of many disease investigators is to focus on only one part of the triad. For example, trying to boost the host's resistance to a disease by vaccination without paying attention to the sources of and exposure to the agent or the environment in which the host and agent coexist, will result in less than effective suppression of the effects of the disease. Attention must be paid to all three aspects of the condition in order to maintain herd health. Reproductive diseases are no different than others in this regard.
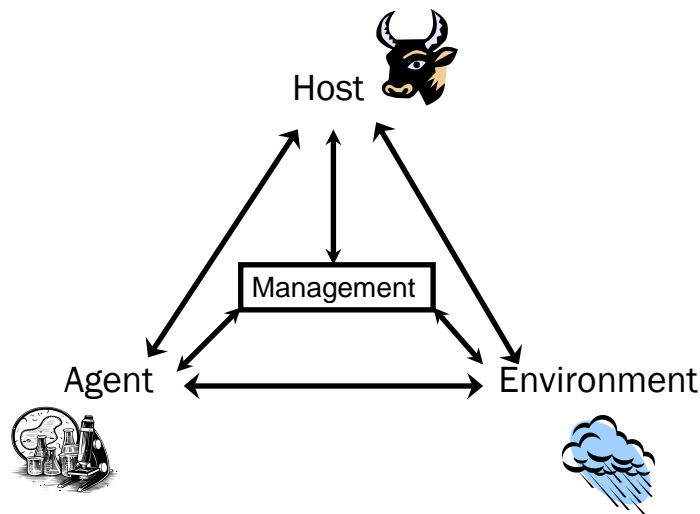

Figure 1. The Epidemiologic Triad

This paper will discuss important management considerations to reduce infectious reproductive diseases in beef cattle, including biosecurity, group composition, separation from high risk animals and group size. Subsequently, important reproductive diseases of beef cattle (bovine viral diarrhea (BVD), trichomoniasis, infectious bovine rhinotracheitis (IBR), leptospirosis, vibriosis, and neosporosis) will be discussed individually in terms of these management practices.

Management Concepts for Reducing Reproductive Disease

Biosecurity. Biosecurity may be defined as procedures implemented to keep novel infectious agents out of a population (for example, a cow herd).

Infectious reproductive diseases pose special challenges. Identifying specific reproductive pathogens is usually difficult. Causes of abortion, in particular, are very difficult to consistently diagnose. Roughly only a third of abortions submitted to diagnostic laboratories are diagnosed as due to a specific cause, not all of which are infectious. Infertility through decreased conception rates or early embryonic death is similarly difficult to diagnose, in part because effects of infectious reproductive disease are not always readily apparent. In most cases, a problem is not identified until pregnancy-check time, well after the inciting agent has left the reproductive tract. Sub-fertile bulls may recover enough by the time an investigatory breeding soundness examination is performed.

For all of these reasons, it is much more economical and sensible to institute biosecurity procedures in order to keep out infectious disease, rather than try to diagnose and then deal with a problem after the agents have entered the herd.

Biosecurity programs have four major components:

1. Diligent homework about the source of the animals. Before animals enter the farm or are purchased, information about the source herd should be obtained. Data regarding source herd testing procedures, health programs, and biosecurity programs are valuable pieces of information. Granted, there are many situations in which this information is not available (purchases at livestock markets, etc.).

Perhaps one of the best indicators of lack of infectious reproductive disease in a source herd would be that of a history of consistent excellent reproductive performance (pregnancy rates, calving rates). Demonstrable evidence of vaccination and biosecurity procedures would also be pieces of evidence that would be favorable to the health potential of the source herd's animals.

Herd-level testing for an infectious disease is not necessarily a guarantee that the specific animals purchased will be disease-free; however, it creates a higher level of assuredness compared to a similar herd without disease surveillance in place. In some instances in which individual animal tests lack sensitivity, whole-herd tests may be of more value than tests on the individually purchased animal.

Reputable producers will be straightforward and open about the health status of their herd and animals. Some may agree to pre-purchase diagnostic testing; some may provide the name of their veterinarian so that the receiving herd's veterinarian can communicate with them regarding herd health and proper methods of introducing the new animals.

2. <u>Isolation/Quarantine and Testing</u>. The most common way that new infectious agents enter a herd is through introduction of infected animals. By preventing immediate contact between affected and non-affected animals, we allow entering animals an opportunity to recover from any transient illnesses that they may be incubating on or shortly after arrival. For many conditions, this helps to ensure that new animals do not shed these infectious agents to animals in the existing herd. This is especially important in the case of animals stressed by shipping, which have a greater likelihood of succumbing to conditions such as bovine respiratory disease complex (BRDC) due to the immunosuppressive effects of stress. Likewise, this isolation allows the incoming animals to be protected from sudden exposure to agents from the existing herd at a time when stress makes them more susceptible.

It is important to realize that for certain conditions, any length of isolation period will not be sufficient for animals to stop shedding the infectious agents. For example, cattle persistently infected with BVD will shed virus throughout their lifetime. Cows infected with host-adapted strains of *Leptospira* also will shed organisms persistently.

In general terms, for transient diseases such as many of the BRDC agents and infectious bovine keratoconjunctivitis (IBK, or "pinkeye"), a 30-60 day isolation period is considered sufficient.

Characteristics of an effective isolation program include:

a) **Physical separation** <u>from existing herd members</u>. At best, the isolation facility would be located as far from the existing herd as possible, ideally at another farm site. At a minimum, the isolation site should not allow nose-to-nose contact from new to existing animals. Most BRDC pathogens such as IBR, BRSV, *Haemophilus somnus*, and *Mycoplasma bovis*, among others, do not survive for more than several days outside the host, and require close contact for transmission to occur. However, providing maximal physical separation will best ensure that aerosol transmission of pathogens does not occur. Alternatively, solid barriers between pens of animals may also help decrease aerosol transmission of pathogens.

b) **Separate runoff** <u>and drainage patterns</u>. Pathogens transmitted through feces (Bovine Viral Diarrhea Virus [BVDV], *Salmonella*) or urine (*Leptospira*) could potentially infect either the new arrivals or the existing herd if manure runoff or drainage enters the other site, despite a producer's best efforts to provide nose-to-nose separation between the groups.

c) Management such that **equipment and instruments are not shared** between groups. Any equipment that enters a lot such as tractors, trucks, or skid-steer loaders used to feed or move manure, should only be used in either the isolation facility or the existing herd – not both. Alternatively, equipment tires and loader buckets, etc. could be thoroughly cleaned and disinfected between groups. Equipment such as stomach tubes, oral bolus guns, tube feeders, etc. should be restricted to either the isolation site or the existing herd and not shared between groups. Boots and coveralls used by personnel entering the lots or contacting the animals should be changed between groups.

d) **Testing** of new arrivals. The isolation period is the time in which incoming animals should undergo testing for certain diseases, depending on the disease and the producer's goals. Specific recommendations for testing will be discussed later in this paper. For some diseases, limitations in diagnostic test sensitivity exist. For example, for Johne's disease (an important non-reproductive disease which will not be discussed in this paper), the commonly used serum ELISA test has a sensitivity of only about 15% in non-clinical cases. For this disease, therefore, herd-level testing of the source herd is more valuable than individual blood tests for detecting potentially infected animals.

Diagnostic testing of incoming animals should not be performed indiscriminately. There should be a prior understanding of the limitations of testing and of what interventions will be employed if unexpected test results occur. If animals are kept and allowed to enter the herd despite positive test results, diagnostic testing is a waste of time and resources. No animals should be allowed to enter a herd from isolation until they are confirmed negative to a disease of interest, as determined by the producer and his or her veterinarian.

e) **Antibiotic** Treatments. For certain diseases, antibiotic treatments are indicated when animals enter isolation. For example, injections of long-acting tetracycline are used to clear cows or heifers of the carrier state of leptospirosis. Otherwise, blanket antibiotic treatment without an underlying reason is probably unnecessary for healthy incoming cattle. Treatment decisions should be made with input from the herd veterinarian.

f) **Vaccination**/Acclimation of the new animals. The isolation period should also be used to coordinate the immune status (through use of vaccination) of the newly arrived animals with that of the existing herd. The timing of vaccine administration to these animals should be carefully considered in light of: confirmed previous vaccinations before arrival, stress level of the new arrivals, and possible interference with diagnostic testing (diagnostic tests based on blood antibody levels will likely be affected by vaccination, creating potential for false positive test results).

A practice commonly employed is that of vaccinating incoming cattle with an intranasal MLV (modified live virus) IBR-PI3 or IBR-PI3-BRSVvaccine on arrival or before they leave isolation. This vaccine can be administered safely to stressed or pregnant animals and is considered by some to provide rapid mucosal immunity (resistance centered on the lining of the nasal passages and upper respiratory tract) to the animal.

There appears to be a great opportunity for improvement in cow-calf herds regarding isolation/quarantine of new arrivals. The most recent NAHMS study revealed that, of bred cows or open cows brought into cow-calf operations, 69.1% and 68.3%, respectively, were not segregated for any length of time upon their arrival.

3. Vaccination. Another component of biosecurity involves increasing the herd's level of resistance through proper vaccination. It is important to realize that vaccination of all individuals within a population does not mean that each individual becomes immune to the agent in question. Individual animal responses to vaccine are subject to biological variation, in which a few animals respond extremely well to the vaccine, a few respond poorly to the vaccine, and most animals respond in an intermediate fashion. Therefore, the goal of a vaccination program is not to render each individual immune to disease; rather it is to stimulate sufficient immunity in a sufficient number of animals such that an epidemic, or widespread outbreak, does not occur.

Herd vaccination programs should be considered a form of risk management rather than a means to completely prevent disease. Differences between vaccine strains and wild virus strains, or overwhelming exposures to pathogens are both reasons why even a well-vaccinated herd could express significant clinical disease. All vaccine programs should be designed with appropriate guidance from a veterinarian.

4. Environmental Control. Control of environmental factors is important in controlling transmission of certain diseases. Environmental factors may influence the relative ease with which disease agents are transmitted and may influence the resistance of the animals to clinical disease. Other disease agents (IBR, *Campylobacter*, and *Tritrichomonas*) do not survive outside the host animal for long periods of time, and environmental control is not an issue in prevention of these diseases.

Group Composition. Except for strictly closed herds, a typical cow-calf herd is an amalgamation of animals from several different sources combined over a period of time. The probability of introduction of infectious agents such as BVDV increases with the number of new animals brought into the herd and with the number of different sources for those animals.

Co-mingling newly-acquired animals (e.g., replacement heifers or cows) that have originated from many different sources is a risk factor for introduction of many diseases, whether they affect reproduction or not. Social stresses and varying degrees of immune system competence among animals result in conditions conducive to transmission of infectious agents and the emergence of clinical signs of illness. Following isolation/quarantine recommendations as outlined above will help mitigate these potential problems, as will procurement of animals from a single source when possible.

Segregation from High-Risk Groups. Non-venereal reproductive disease agents such as BVDV, IBR and leptospirosis may be harbored and shed in greater numbers by younger animals, namely weaned calves in the feeding phase or grass/stocker calves. Because of this, the reproductive herd should ideally be segregated from these younger animals. Steps should be taken to eliminate fenceline contact and sharing of equipment between these groups.

Unweaned "foster" calves should be avoided for the same reasons. If introduction of foster calves is deemed necessary, isolation/quarantine and testing procedures should be employed as outlined above.

Group Size Considerations. Group sizes within cow-calf operations are normally set as a result of numerous factors, most of which have little to do with infectious disease considerations. Pasture size, age of animals, cow-bull ratio, productivity of pastures, labor, feed and water availability all enter into decisions about how many animals will comprise a management group.

Group size influences the speed with which an infectious agent is able to infect members of the group. For any given transmissible infectious agent, smaller group sizes (assuming a susceptible population) often result in a shorter timeframe for a group to become infected. This may manifest itself as a more rapid progression of clinical signs, and depending on the agent, possibly a more rapid recovery and immunity of the group to future infections. For example, one model of BVDV spread indicated that cow herds of 50 and 100 head eventually cleared BVDV infection (albeit over several years), however a herd of 400 did not.

Segregation of cows into smaller management groups may serve to confine effects of reproductive disease to a single group. True segregation may be difficult to accomplish if groups share fenceline contact or if shared equipment and vehicles are used between groups. In one case study, *Salmonella* infection was thought to have spread between separate cow management groups through the use of a common tractor and bale feeder.

Infectious Diseases Affecting Reproduction: Specific Biosecurity Aspects

Bovine Viral Diarrhea virus (BVDV). Evidence of exposure to BVDV is widespread throughout cattle herds throughout the world. The reproductive effects of BVDV possibly surpass its other effects in economic importance, when the occurrence of persistently infected animals is factored in. Reproductive effects of BVDV in the cow herd depend on the stage of gestation in which the cow or heifer is infected. Early gestation infection results in low conception rates due to early embryonic death. Infection in mid-gestation may result in the formation of persistently infected (PI) calves, which occurs as a result of infection during a period of fetal development (roughly between 40 and 120 days of gestation) in which the fetus is differentiating its own cells from foreign materials. The result is a calf that has incorporated the virus into its own body and sheds high levels of virus persistently throughout its lifetime. Later infections may result in congenital defects, late-term abortions, or the birth of congenitally infected calves, which are weaker and more prone to illness than normal calves.

BVDV is spread through many body fluids including saliva, respiratory secretions, and feces. The virus does not persist in the environment but can survive long enough to be transmitted via infected equipment, needles, and palpation sleeves.

Persistently infected animals are especially efficient at transmitting virus, since they shed a tremendous number of viral particles. These animals can effectively infect susceptible animals through brief (as short as one hour) nose-to-nose or fenceline contact, and can shed enough virus to overwhelm a proper vaccination protocol. When on pasture during the breeding season, they can efficiently cause the creation of more PI calves by infecting cows during the susceptible stage of gestation.

Identification of persistently infected calves can be accomplished with various diagnostic techniques. Perhaps the most effective is that of using an ear-notch from the calf in an ELISA or pooled PCR test. These are yes-or-no tests and are generally extremely reliable in identifying persistently infected calves.

- Isolation/Quarantine and Testing. As previously mentioned, if an animal is persistently infected with BVDV, no length of isolation period will be long enough. A 30-60 day isolation period will, however, allow any transiently infected animals to clear their infections before contacting the existing herd.

  Some seedstock producers are now marketing animals as "PI-test negative." As the term implies, this is not 100% proof that an animal is not PI (since no diagnostic test is 100% sensitive), but is as good an assurance as can be made. If not previously performed, proper testing for BVDV PI animals is critical during the isolation period. All incoming animals should be ear-notched upon arrival and the samples tested for BVDV PI. This includes not only purchased females and bulls, but also offspring of purchased bred animals, since only rarely is the dam herself persistently infected. Also, any purchased foster calves should be tested before leaving isolation.

  This testing should be performed as soon as possible, and animals identified as PI should be removed from the herd as soon as possible. Depending on the animals left in isolation after PI calf removal, a producer or veterinarian may consider starting the isolation "clock" again to ensure that any transiently infected animals have a chance to clear their infections after the source of their infection is removed.

  It is usually recommended that a positive ear-notch test be re-confirmed with another diagnostic method 2-4 weeks following the initial test. This is due to the fact that transient infections may give positive results on the ear notch ELISA. This is an especially important distinction to make with valuable animals. Depending on timing and the number of calves involved, a producer may alternatively opt to dispose of all calves testing positive to the first test.

- Vaccination. Vaccination is an important tool in the overall herd biosecurity plan, but, as previously mentioned, even a proper vaccination program can be insufficient if exposure is overwhelming.

  While in isolation, incoming animals should be vaccinated to coordinate with the existing herds' program, if possible. Common recommendations are for MLV vaccines to be administered 30 days pre-breeding.

- Environmental Control. Proper cleaning and disinfection of potentially contaminated equipment should be practiced, and sources of runoff between animal groups should be managed. Researchers have identified deer persistently infected with BVDV, but their significance in the transmission of BVDV to cattle is still uncharacterized.

Trichomoniasis. Trichomoniasis is a venereal disease caused by a single-celled protozoon, *Tritrichomonas foetus*. This agent causes inflammation of the inner lining of the uterus and of the developing fetus. Infertility results from early embryonic loss, which shows up as returns to estrus (both regular and prolonged) and rarely, abortions.

Bulls, especially older bulls, are the reservoir and carrier of *T. foetus* in the herd and transmit it to cows when they breed them. The organisms are harbored in the lining of the sheath and penis. Once infected, a bull is considered infected for life.   Cows generally clear the infection after several months but serve as a source of infection for bulls that breed them.

- Isolation/Quarantine and Testing. Many states, including South Dakota, have regulations that require non-virgin bulls to test negative for trichomoniasis before they can be sold to herds within their states. In addition, many states regulate the sale of open cows to breeding herds. Infected cows may be carriers of trichomoniasis for a significant period of time (one to two months), and a small percentage may be long-term carriers that have the potential to stay infected even after they calve and potentially serve as a source of infection for a new breeding season. Purchasing virgin bulls ensures that trichomoniasis and vibriosis will not enter the herd, as these are strictly venereal diseases.

  Non-virgin bulls should undergo testing while they are in isolation if this has not been performed prior to purchase. Approved testing regimens vary among states, but PCR testing of a single sample of preputial scrapings is considered sensitive enough by many. Alternatively, taking three sequential samples and incubating them in special culture pouches is also an accepted testing strategy.

  Since bulls are lifelong carriers, and cows may carry the agent for a prolonged period of time, the length of the isolation period is immaterial.

- Vaccination. A vaccine is available for trichomoniasis, but it does not prevent infection in cows nor does it affect the status of the infected bull. Its main use is for those herds already infected that are not able to employ the right management tools to eliminate the disease from the herd. In infected herds, vaccine has been shown to improve pregnancy rates and decrease the duration that a cow is infected. Routine use in non-infected herds is not advocated.

Infectious Bovine Rhinotracheitis (IBR, "Red-nose"). IBR virus is also termed BHV-1, or "bovine herpesvirus 1." Being a herpes virus (in the same family as viruses causing cold sores in people), it has a propensity to become "latent" or dormant in nerve clusters in the throat area or lower spine, and can re-activate during times of stress. Because of this, any animal exposed to

IBR in the past could potentially shed the virus to susceptible animals. IBR is shed and transmitted in nasal secretions and aerosols from infected animals.

In addition to its effects on the respiratory tract, IBR virus affects reproduction by its effects on the ovaries, uterus, and developing embryo or fetus. The result can be infertility or early embryonic death, but notably, IBR is one of the most frequently diagnosed viral causes of late-term (5th to 9th month of gestation) abortions.

- Isolation/Quarantine and Testing. An isolation period for incoming animals would be considered prudent despite the possibility that animals may be latently infected with IBR for long periods of time. Any episode of acute shedding of virus or clinical signs brought on by the stress of transport would diminish during a 30-60 day isolation period. Because, like BVD, evidence of exposure to IBR virus is widespread in North American cattle, testing for IBR while in isolation would be considered of little use.

- Vaccination. Vaccination for IBR is widely practiced and many products are available, either killed or modified live, most often in conjunction with other viral antigens. They are used in pre-weaning and weaning vaccination programs in calves, and also in pre-breeding programs for breeding animals, reflecting its potential to cause both respiratory and reproductive problems. Vaccine has been effective in preventing outbreaks of clinical disease, but does not necessarily prevent infection or eliminate latency.

  Modified live IBR vaccines should be administered to herds only after sufficient input from a veterinarian. Adverse reproductive effects may occur after IBR use in naïve heifers and in pregnant cows.

  During the isolation period, depending on the animals in question, it is usually advisable to vaccinate animals in isolation to coordinate with the rest of the herd. MLV vaccines should not be given to pregnant animals. Producers may consider administering intranasal MLV IBR-PI3 or IBR-PI3-BRSV vaccine to animals before they leave isolation. These intranasal vaccines are considered safe for pregnant or stressed animals.

Leptospirosis. Leptospirosis has long been recognized as a cause of infertility in cattle. Symptoms of *Leptospira* infection include early embryonic death (manifested as repeat breeders and reduced pregnancy rates), late-term (7th to 9th month of gestation) abortions, weak liveborn calves, and low-grade uterine infections.

Traditional "5-way lepto" vaccines include *Leptospira pomona*, *hardjo*, *canicola*, *icterohemorrhagica*, and *grippotyphosa* strains. The emergence of *Leptospira* infertility cases due to *Leptospira hardjo-bovis* has resulted in the inclusion of that strain in many leptospirosis vaccines.

Leptospira hardjo-bovis is referred to as a "host-adapted" strain of *Leptospira* in cattle. This means it can evade with relative ease the host's immune system to create a persistent carrier state in the body. In contrast, cattle are considered "incidental hosts" for the other strains of *Leptospira*. This means that those strains are persistently carried in other species (such as dogs,

rodents, and raccoons, for example), and cattle become infected when exposed to strains shed by these animals.

Leptospira strains colonize the kidney and reproductive tracts of cattle. The organisms are shed in the urine, and susceptible animals become infected through contact of their mucous membranes (eyes, nose, and mouth) with infected urine. These organisms are hardy in the environment and can be found in contaminated standing water.

- Isolation/Quarantine and Testing. Host-adapted strains of *Leptospira* colonize susceptible animals such that extremely long-term shedding will result. Therefore, an isolation period of any length will <u>not</u> be sufficient for these animals to stop shedding the bacteria.

  Testing individual animals for *Leptospira* infection is problematic at best. Testing serum for antibodies or culturing urine for the bacteria is quite insensitive. Negative results do not mean the animal is not shedding. Polymerase Chain Reaction (PCR) examination of urine samples is an extremely sensitive, if expensive, method of diagnosis, but runs the risk of false positive tests if even a minute amount of urine from a positive animal contacts the sample.

- Vaccination/Treatment. Incoming animals should be given a vaccine with proven efficacy against *L. hardjo-bovis* and the non-host adapted, incidental strains. Producers should follow label directions and give the appropriate boosters when indicated. Vaccines specifically containing *L. hardjo-bovis* are available, however some 5-way lepto vaccines have demonstrated efficacy against *L. hardjo-bovis* too. It is important that the vaccine has the ability to protect animals from kidney colonization. There is also evidence that certain vaccines may eliminate the carrier state in infected animals.

  In addition, animals entering isolation should receive a dose of antibiotic to eliminate any potential carrier states. Long-acting tetracyclines such as LA-200 or Bio-Mycin 200 are commonly used. Because of the limitations of diagnostic testing, antibiotic treatment and vaccination are usually considered the main points of leptospirosis biosecurity.

- Environmental Control. Since *Leptospira* can survive for extended periods of time in standing water and runoff, these sources of infection should be managed as best as possible. Because rodents and wildlife species can carry *Leptospira*, efforts to control these animals' access to livestock in isolation are important.

Campylobacter fetus **subsp.** *venerealis* **("Vibrio") infection.** Vibriosis is a bacterial disease that affects the reproductive tract of male and female cattle in much the same manner as trichomoniasis. Clinical signs of vibriosis manifest themselves as infertility (decreased pregnancy rates and prolonged returns to estrus). Late term abortions are rare. Effects of these bacteria are a result of the inflammation they cause in the inner lining of the uterus (endometritis).

As in trichomoniasis, the causative bacteria is maintained in a group of cattle by persistently infected bulls which carry the agent in the lining of the sheath and penis. The infected bull

passes the bacteria to cows or heifers during the act of breeding, after which the organism colonizes the reproductive tract and causes inflammation. In contrast to trichomoniasis, it is possible for a bull to clear himself of vibriosis. Cows generally clear the infection after several months but serve as a source of infection for bulls that breed them.

Vibriosis is an infrequently diagnosed cause of reproductive failure in northern plains beef herds today. Pockets of infection still exist, however, and producers should not "let their guard down" against this disease.

- Isolation/Quarantine and Testing. Older (three or more years of age) bulls that carry vibriosis are likely to carry the organism for life, while younger bulls (2-3 years of age) have the ability to clear themselves of the infection. As a result, an isolation period of 30-60 days may be useful for younger, but not older bulls.

  Specialized transport media is necessary to successfully culture *Campylobacter*. Current recommendations are for three tests to be performed at one-week intervals. Currently, bulls entering bull studs are commonly cultured for *Campylobacter* but not often in commercial conditions. Use of vaccination and of virgin bulls seem to preclude testing of bulls for *Campylobacter* at this time.

- Vaccination and Treatment. Vaccination has proven quite effective for control of vibriosis. There are differences among *Campylobacter* vaccines in regard to duration of immunity and whether boosters are required for initial vaccination. Oil-based vaccines are labeled for one-dose protection and generally result in a longer duration of immunity than other products. Vaccine should be administered relatively close to breeding to maximize its effectiveness. Label directions should be adhered to. In general, bulls and breeding females should receive one dose of the oil-based vaccine one month prior to breeding, or two doses of other vibrio vaccines (this includes lepto-vibrio combinations) two to four weeks apart one month before breeding the first year and annually thereafter. There is evidence that vaccination will enable infected bulls to clear themselves of infection.

Neospora caninum **infection.** Infection with the protozoa *Neospora caninum* has recently become recognized as a not-infrequent cause of abortion in dairy and beef cattle. Surveys of dairy and beef herds indicate that exposure to this agent is relatively widespread, as measured by serum antibody responses.

Abortions due to *Neospora* may occur at any stage of gestation, but are most common between five and six months of gestation. In addition, stillborn calves or infected liveborn calves may result from this infection.

Neospora is considered to have "definitive hosts" and "intermediate hosts." Cattle are the intermediate hosts for *Neospora* and dogs, foxes, coyotes, and other wild canines are the definitive hosts, or reservoirs, in which the organism is maintained.

Initially, a canine will encounter the protozoa when it feeds on a dead calf or placental tissue that was infected with *N. caninum*. The organism forms cysts in the body of the canine, which are passed out of the body through its feces. If these animals defecate into a feed source, or in the environment of a cow, the cow may ingest the protozoa. The protozoa then travel through the cow's body to the pregnant uterus and infect the developing calf. This infection, if severe enough, will kill the fetus, causing it to be aborted. The cycle then starts over when canines have access to the newly aborted fetus and tissues.

Cattle can either become infected by ingesting contaminated feces or, in the case of a liveborn calf, become infected in utero. These infected calves, if raised to breeding age, have a higher likelihood of aborting their first and second calves also.

- Isolation/Quarantine and Testing. When considering isolation of newly-purchased animals, it is important to realize that infected animals will only transmit disease to others when they calve (or abort). Probably of more importance than an isolation period is the practice of performing diagnostic blood testing during the isolation period to identify females that should not enter the breeding herd.

  Intense control measures would entail testing the entire breeding female herd and either: 1) identifying positive animals and not keeping their offspring as replacements (as there is a high likelihood they will be infected and perpetuate the disease); or 2) culling all positive females and replacing them with test-negative animals. Considering these options should be done primarily in the face of significant problems with *Neospora* and with a close accounting of the economic costs and benefits.

- Vaccination. A vaccine for *Neospora* is commercially available, although not widely evaluated in the field. There is published evidence that use of the vaccine has reduced prevalence of abortion in significantly affected herds. The vaccine is designed to be given to the pregnant animal in the first trimester of pregnancy, with a booster three to four weeks later, and annual (subsequent pregnancies) boosters thereafter.

  Use of vaccine will result in antibody titers to *Neospora* in vaccinated animals. Therefore, implementing a vaccine program before any herd testing will prevent a producer from accurately identifying carrier cows in a test-and-cull program. Any consideration of vaccination should be discussed with a veterinarian before implementation.

- Environmental Control. Of all the reproductive diseases discussed, neosporosis is the condition for which environmental control is the most important. As outlined by the protozoa's life cycle, risks of transmission to unaffected females lie in either: 1) the contamination of feedstuffs by wild or domestic canines; or 2) the exposure of canines to infected fetal tissues.

  Therefore, control measures should also emphasize: 1) the protection of feed and water sources from contamination by dogs, foxes, and coyotes; 2) prompt disposal of dead fetuses, dead calves, and placenta; and 3) steps to eradicate dogs or wild canines from the premises or prevent their contact with the female herd during calving. One interesting observation that

has been reported is that beef herds with cattle dogs were less at risk of finding neosporosis. It is postulated that the farm dogs played a role in keeping coyotes and foxes away from the cow herd. In contrast, several studies with dairy herds link higher numbers of dogs on the farm with a higher risk of neosporosis.

Conclusion

Because differences exist among reproductive diseases based on transmission, duration of shedding, persistence in the environment and other factors, it is difficult to design a one-size-fits-all-diseases management program. However, the following guidelines should be considered as a base from which the producer and veterinarian can design an effective biosecurity and management plan. The following guidelines are based on incoming breeding stock, but they should be applied to all animals entering a cattle operation.

1. Purchase animals from reputable sources with reliable information about the animals' health and management.

2. Buy animals from single sources whenever possible.

3. Isolation facilities should:
   - be sited at least as far away from the existing herd so as to not allow nose-to-nose contact between new and existing groups.
   - not have manure runoff or drainage to or from the existing herd.
   - be planned so that equipment and personnel do not have to be shared between sites. Alternatively, cleaning and disinfection, changes of clothes and boots should be employed, and chores done on the isolation animals after the existing herd.

4. Hold animals in isolation for 30-60 days.

5. Treat incoming females with a long-acting tetracycline to assist in clearing the carrier sate of *L. hardjo-bovis*.

6. Test incoming animals for BVD PI with an ear-notch test. Promptly remove positive animals.

7. Perform other diagnostic tests as outlined by the herd veterinarian early on during the isolation period.

8. Employ appropriate vaccines (generally MLV 4-way virals plus Vibrio-Lepto, depending on the age and reproductive stage of incoming animals.

Because most infectious disease, including reproductive disease, enters the herd via incoming animals, a management and biosecurity plan for these new arrivals is the best defense against potentially devastating diseases and reproductive loss.

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