The Impact of Disease Nutrition and Management on the Beef Production Chain

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Animal health and nutrition can have significant impacts on beef cattle herds. If the nutrition, health or husbandry of the herd is compromised there will be adverse consequences with accompanying economic losses. The number one health concern in beef cattle production is respiratory disease commonly referred to as BRD or Bovine respiratory disease. The number one production concern for cow calf herds is reproductive efficiency. The beef industry has come a long way in understanding the various pathogens, nutritional, environmental, husbandry and genetic factors associated with disease and production loss. This knowledge is utilized in developing improved vaccines, treatments, nutrition programs and management options. However, the reality is that the incidence of BRD and other diseases within the cattle industry has not changed or has changed only slightly. The explanations for lack of improvement are not entirely clear but probably include, intense production, lack of efficient methods for disease prevention, animal movement and transport, genetic susceptibility, selection for production traits with less concern for health traits, a market system for beef cattle which combines enhanced pathogen exposure with collateral stress and production cost constraints. While new approaches hold promise, the beef industry could reduce losses associated with disease and improper nutrition by applying current knowledge regarding; adequate nutrition for the entire herd, management of dams during parturition, optimum heifer development, low stress handling, weaning, transport, preconditioning programs, ranch biosecurity and comprehensive herd health programs. With beef producers working with their herd's veterinarian, nutritionist and other industry professionals as a team utilizing the expertise within that team toward management of the herd. While it is beyond the scope of this paper to address all of the health management and nutrition programs which have an impact on beef production, selected health concerns and associated production losses will be discussed for cow-calf production, backgrounding and the fed cattle phase.

Cow Calf Production
In beef cattle production, animal health and life time performance enhancements begin at the cow calf level. It is at the cow calf level that perhaps the greatest impact can be attained in improving health and production of the beef herd. The 2007 USDA national animal health survey, (NAHMS) for cow calf producers indicated that the major cause of sickness and death for calves less than three weeks of age were birth related and weather. For calves older than three weeks of age the major cause for sickness and death was associated with respiratory disease and digestive disorders.

Adequate prepartum nutrition is important in ensuring; normal fetal growth, calf survivability and growth, postpartum breeding efficiency and a short calving interval. Dietary restrictions to the cow during pregnancy and post calving can have a negative impact on the health and performance of her progeny in both the short term and in total life time performance. Feed costs typically represent the single largest cost for cow calf producers. Based on data from cow calf operations located in the mid-west, total feed cost which included pasture and non-pasture were 48% of total costs in 2014 and 49% of total costs for the time period of 2009-2013 average. During this three-year period total annual feed cost averaged $491 per head, with a range from $209 to $793 per head.[12]

Calf health begins at conception and is affected during embryo and fetal development. In utero infections may result in failure of conception, early embryonic death, abortion, stillbirths, or the birth of weak calves

that often die. The proportion of abortions caused by infections is not known, but approximately 90% of abortions in which the cause is determined are due to infection. Cows can contract infectious agents by many routes; through the respiratory tract, mouth, vagina, or from insect bites. Some infectious agents may be carried into the reproductive tract with semen or embryo transfer fluids.[8] Most of the organisms known to cause placental and fetal disease may also cause disease or infection of the newborn. However, infections of the new born contracted in utero are uncommon compared with infections contracted after parturition. In cattle, these infectious agents include but are not limited to, *Brucella abortus*, *Leptospira*, E*. coli, Streptococci, Aspergillus, Campylobacter, Trichomonas foetus* and IBR and BVD viruses.[8]

 There are several infectious diseases which can cause abortion and impaired fertility in the cow and may be associated with disease in the calf. The most common reproductive diseases of beef cattle in the U.S are, Bovine herpes virus-1 (BHV-1), Bovine virus diarrhea (BVDV), *Campylobacteriosis*, *Leptospirosis* and *Trichomoniasis*.

Bovine herpes virus-1 (BHV-1), may terminate pregnancy at any stage of gestation and may contribute to neonatal losses in calves from susceptible dams. The use of intramuscular modified live vaccine at the correct time of the production cycle provides protection against respiratory signs and abortion in cattle. It does not prevent latent infections. Achieving successful immunization against IBR while avoiding complications requires proper timing of administration and handling of vaccine. Vaccination at the time of breeding with intramuscular modified live IBR vaccine may significantly decrease the conception rate in susceptible cattle.   Failure of a single injection of a modified live IBR agent to immunize may be due to improper handling, storage or administration. Declining immunity against IBR may be stimulated by natural infection, reactivation of latent virus, or the administration of a modified-live vaccine.   The annual use of intramuscular modified live IBR products may be unnecessary to attain herd immunity and protection from abortion.[9,10]   Because modified live products must replicate (cause infection) to stimulate immunity, caution should always be used in planning the herd vaccination program to avoid exposure of susceptible non-vaccinated animals. The use of killed IBR vaccines has increased because of safety concerns that may be related to modified live vaccines. However, modified live vaccines invoke a longer and often greater degree of immune response than killed viral vaccines.[16] There is some concern about the use of modified live BHV-1 vaccines in pregnant cattle. Sprott evaluated the use of a MLV BHV-1 vaccine in pregnant cattle previously immunized with chemically altered vaccines prior to breeding. There were no differences in the pregnancy rate or abortion rate between MLV and killed vaccine vaccinated animals. The conclusion was that under field conditions one injection of either chemically altered BHV-1, or modified live BHV-1 virus vaccine given to previously vaccinated beef replacement heifers did not increase the incidence of fetal loss above expected spontaneous rates.[17]

Bovine virus diarrhea (BVDV) is distributed worldwide. The main concern for the beef breeding herd regarding BVDV is fetal infection resulting in abortion, the development of congenital defects or the development of persistently infected animals that are a constant source of infective virus. The virus has the ability to cross the placenta in susceptible pregnant cattle and infect the fetus. If this occurs before the sixth month of pregnancy, fetal losses or immunotolerance may result. Fetal infection during the last month of pregnancy usually results in the birth of an immune seropositive health calf. It is believed that optimum protection of the breeding herd depends on active immunization with a modified live BVD virus vaccine prior to breeding.[11] For replacement heifers, in order to insure a response the vaccine should be administered two or more times between weaning and breeding with the final injection given no sooner than thirty days prior to breeding. The long duration of immunity and the cross protection between BVDV serotypes following the use of modified live vaccines makes them ideal for use in breeding herds. Vaccination of cows against BVDV is usually performed in combination with BHV-1 virus vaccine.

Campylobacteriosis, (Vibriosis), is a venereal disease of cattle characterized by temporary infertility and sometimes abortion. Immunization provides protection for a high reproductive rate. Effective

immunization using an oil adjuvanted vaccine requires a sensitizing dose followed by a second dose one month prior to breeding followed with annual boosters approximately one month prior to breeding.[9] Immunization of bulls has been shown to be of value in preventing the carrier state.[9] Vaccination of beef cows and heifers against campylobacteriosis is commonly performed in combination with a five-way leptospirosis vaccine. Both should be administered pre-breeding which can be a logistical concern for cow calf producers.

Leptospirosis has been reported to be the most commonly reported disease causing abortion in beef cattle. Vaccination every twelve months in closed herds and every six months in endemic areas is protective. Vaccination of bulls with booster injections prior to breeding season is important due to the ability of bulls to venerally transmit the disease. Vaccination may also aid in reducing the incidence of shedding the organism through the urine. A five-way Leptospirosis vaccine is often utilized in combination with campylobacter. Both should be administered prior to the onset of breeding.

Reproductive losses due to *Tritrichomonas foetus* results primarily in delayed fertility but may also be associated with abortion, pyometra and reduced calving rates. Infected animals gradually develop an immune response that allows them to remain pregnant and eventually eliminate the infection in four to seven months. Bulls are the primary source for the disease and once infected are considered to be permanently infected. A licensed vaccine is available which is reported to help the vaccinated female eliminate the organism and infection in a more rapid manner. Vaccination of bulls appears to have no application in the control of the disease. Vaccination against Trichomoniasis has been recommended by some for controlling the disease in infected or high-risk herds.

Because infectious disease processes can have an effect on bovine pregnancy, the status of the immune response of a pregnant cow and infectious diseases that cause abortion or infertility are important. The successful outcome of pregnancy requires the dam to have and the fetus to develop a functional immune system and each must tolerate the other. During pregnancy the dam must protect the fetus from maternal infections and not reject the fetus. The fetus must develop the ability to recognize self from non-self and not respond to antigens from the dam. The dam must develop and provide high quality colostrum. The calf must consume colostrum in sufficient quantity soon after birth to enhance survival and optimize life time performance. It has been well established that there is a nonspecific immunosuppression of the dam and an increased susceptibility to infection during pregnancy.[8] The mechanism that accounts for this immunosuppression involves both T and B cells. Antibody production by B cells is active against infectious agents in pregnant animals. The T cells function of phagocytosis of virus infected cells appears to be the immune compartment most affected during pregnancy.[8] During pregnancy there is an increase in suppressor T cells which results in a decreased response to T-cell dependent antigens (viruses). Also endotoxins, excreted by bacteria, may cause an endotoxemia which can stimulate prostaglandin synthesis in a variety of tissues. Prostaglandins are leutolytic, cause regression of the corpus luteum and a decrease in progesterone which can lead to fetal loss or an abortion.[8] The immune depression in the cow is controlled by progesterone, the hormone of pregnancy. The suppressed immune response in pregnant cows can be partially controlled with proper nutrition and appropriately timed vaccination programs.

Reproductive efficiency is a major determinant of profit in beef cattle enterprise. Reproductive efficiency is affected by numerous factors. An Australian study evaluated calf death losses in tropically adapted beef cattle. Some of the significant findings were, heifer calves were half as likely to die Odds Ratio, (OR .57) as bull calves during the first week of life. Twins, which are associated with lighter birth weights and increased incidence of dystocia were ~ 7 to 10 time more likely to die than were single-born calves. The rate of twinning was <1% of all calves born.[36] Culling of twin calving cows was considered unlikely to be beneficial for improving herd reproductive performance because of the very low incidence of twinning cows with repeating twin pregnancies. Low birth weight calves, which are often associated with reduced vigor and reduced colostrum intake when compared to calves weighing 85 pounds or greater

were strongly associated with an increased mortality rate (OR range depending upon birth wt. 1.56-2.12). Calves with birth weights less than 70 lbs. had a significantly increased risk of death, OR~5-9 within the first month of life. It was noted that the heaviest calves also had an increased risk for mortality compared to lighter calves. The increased risk of death for heavier calves was associated with calves which were assisted at birth. Young cows ≤ 4 yrs. had a higher percentage of low birth weight calves. These light weight calves had an increased risk for mortality 2 to 6 times greater than calves born to mature 5-7 year-old cows which had weaned a calf the previous year. Generally, the increased risk of calf mortality associated with younger cows was highest for maiden cows or young cows that had calved but had not successfully reared a calf (2.3-2.3). For all older cow-aged groups, cows that failed to rear a calf the previous year also tended to have an elevated risk for calf mortality relative to older cows that had successfully reared a calf previously, ranging from 2.7 in < 4 year old cows, to 2.1 in 5-7 year old cows, to 1.49 in 7+ year old cows.

In the Australian study, the majority of calf mortalities occurred before calves were first gathered for branding and vaccinating. In calves surviving to first gather, calves identified with horn scurs and dehorned at first work had a significantly higher risk (0R 8) of mortality compared to polled calves. The Canadian Veterinary Medical association has recommended that when dehorning is required it should occur via disbudding at <1 week of age in dairy, or at < 8 weeks of age in beef cattle to reduce the incidence of serious infection. Guidelines from the American Association of Bovine Practioners recommends both castration and dehorning be done at the youngest age prudent. Both procedures may be performed as early as first 24 hours of life.[37] It is further recommended that horns should be removed before the horn base grows larger than 1 inch in diameter.[37] In the Australian study, death after dehorning, (2.1% of dehorned calves) was the second most common reason listed for death, the most frequent reason for death was listed as unknown.[36]

No bull calves were castrated during the study therefore the risk of mortality from castration could not be determined. The effects of calving difficulty on calf mortality could not be estimated accurately because actual calving was rarely observed or assisted. However, it was noted that the death loss for assisted calves was high supporting the objective of avoiding heavy-birthweight calves. In extensive Australian production systems, Brahmans are a preferred breed partially because of the maternal ability to produce smaller calves which reduces the likelihood of dystocia related deaths where there is limited calving supervision. However, one concern for Brahman cows is the incidence of bottle teats which was associated with increased calf mortality. Because of the climactic similarities between Florida and parts of Australia as well as the influence of Brahman genetics within the Florida herd, the Australian study is quite applicable to Florida beef production systems.

The period of time around parturition has a significant impact on reproductive efficiency. The process of parturition can be a traumatic and hazardous event in the life of a calf. Parturition is initiated by a rise in fetal cortisol followed by a course of endocrine events in the dam that lead to; uterine contraction, dilation of the cervix, delivery of the fetus and finally expulsion of the placenta. Many different factors can disrupt the fetal or maternal systems involved with parturition and result in dystocia. Dystocia is one of the major causes for calf death and a loss of reproductive efficiency in the herd. Factors causing dystocia may include pelvic dimension of the dam, calf size, calf presentation and maternal factors such as weak labor, insufficient dilation of the cervix and uterine torsion. The most common cause of dystocia is feto-pelvic disproportion which is a mismatch in dam pelvic size and calf weight.[33]

Once a calf is born, one of the most important determinants of its survivability and immunocompetence is the timely consumption of high quality colostrum.[9,13] A calf's initially acquired immunity relies upon absorbing immunoglobulins found in the colostrum with its ability to absorb these macromolecules declining rapidly during the first 12 hr. after birth.[31]

Providing milk to the calf is perhaps the most important and obvious maternal behavior. Cows will typically suckle their calf within the first few hours after birth, this latency to nurse is longer in dairy cows after birth than it is in beef cows.[31] Latency is usually longer in primiparous than multiparous, likely because of the difficulties that some primiparous animals have in accepting their calves.[32] This latency period to first nurse is an important issue in cattle management. Dystocia resulting in poor newborn calf vitality and an increase in the time period before nursing may be a major cause of failure of passive transfer (FPT). Dystocia can lead to a cascade of behavioral and physiological responses which may have implications for calf vitality as well as long term health and productivity. Consumption of colostrum in calves with fetal distress can be reduced by up to 74% during the first 12 hours of life. Severe acidosis in calves which have experienced a difficult birth has been found to reduce colostrum intake by 52% and serum IgG concentration by 35%. Acidosis in the newborn calf can occur due to premature rupture of the umbilical vessels due to prolonged labor or forced extraction.

Following a normal delivery, a calf will be standing within 32 ± 20 minutes and will be nursing within 60 ± 27 minutes. A calf which is assisted during deliver will often be, anorexic, weak and slow. Calves born with assisted deliveries will generally be standing within 90 ± 78 minutes and be nursing within 138 ± 100 minutes. Intervention strategies should be in place to mitigate the effects of pain and trauma on the health and survival of the newborn calf. Ninety percent of calf losses are attributed to a delay in the dam receiving assistance or to the difficulty and time required to remove the calf. Knowing when intervention is required and when to call for professional veterinary assistance can greatly increase the calf's chance of survival.[30] Signs of reduced viability of the neonate, including peripheral edema, scleral hemorrhages, cyanosis of the mucous membranes or reduced responsiveness to stimulation are indications that intervention is required.[35] Monitoring calving cows and assisting their calves at deliver and after deliver are important considerations for a producer.

After a calf has suckled and absorbed colostrum, the half-life of IgG received through the colostrum is approximately twenty days. By one hundred days of age, 97% of the maternal antibody received by the calf through colostrum is gone. Colostral leukocytes are also absorbed from colostrum and are also able to affect immune function.[14] Other important components of colostrum include growth factors, hormones, cytokines and non-specific antimicrobial factors.[13] Adequate colostrum consumption by a calf has a significant impact on the future health and performance of that calf. Calves identified as having failure of passive transfer were at greater risk (OR 3.2) of mortality from birth to weaning and were also at greater risk for feedlot respiratory morbidity (OR 3.1). Lower calf weaning weights are also observed in calves identified as having failure of passive transfer due to higher morbidity during the first 28 days of life which resulted in weaning weights being 35 pounds lower than expected.[20]

The response to vaccination by a young calf is affected by both its passive immune status i.e. absorbed maternal antibody and by the specific antigens in question.[9] The two key components required for successful immunization are efficacious vaccines and immunocompetent animals. Both killed and live vaccines are in use and the advantages of one are usually the disadvantages of the other. Modified live vaccine attributes are, strong, long lasting antibody response achieved with fewer doses, less reliance on adjuvants, stimulation of interferon production and stimulation of the cell mediated immune responses. Some advantages of the killed vaccines are, they are more stable in storage and are unlikely to cause disease due to residual virulence or reversion. It is generally recommended that calves receive at least one, preferably two modified live four way viral vaccines against the four common viral components associated with BRD prior to weaning. Studies have shown that a single dose of a MLV virus vaccine containing BVDV, BHV-1, and BRSV administered to calves at 3.5 to 4 months of age induced humoral and cellular immune responses against the vaccine viruses and protected those calves from a BHV-1 challenge for 6 months after vaccination.[21] If a killed vaccine is utilized, a calf should receive two doses of that vaccine within the labeled time interval prior to weaning. The ability of residual maternal antibodies to influence the immune response in young calves remains controversial and requires

continuing research. Immunological dogma that passively acquired maternal antibodies can inhibit the immune responses in calves appears to be somewhat true for the humoral immune response but not true for cell mediated immunity.[21,22,23]

BRD is an infectious respiratory disease of cattle with a multitude of causes including stress and possible viral or parasitic infections that suppress the host immune system, allowing bacteria to rapidly reproduce in the upper respiratory tract. Bacteria identified in calves suffering from BRD include *Mannheimia haemolytica, Pasteurella multocida, Histophilus somnus* and *Mycoplasma bovis. Mannheimia haemolytica* is considered to be the predominant bacterial pathogen associated with BRD.[18] For cow calf producers BRD is a calf health problem. Two of the viruses that are associated with reproductive failure in beef cows, BHV-1 and BVDV are also associated with respiratory disease. Two other common respiratory viruses, Parainfluenza-3 virus PI3) and Bovine Respiratory Syncytial Virus (BRSV) have been isolated in pneumonic calves and are not considered to be associated with reproductive failure but are associated with respiratory disease in young calves. All four viruses, BHV-1, BVDV, PI-3, and BRSV, are immunosuppressive and create damage to the respiratory tract epithelium allowing commensal bacteria access to the lower respiratory tract and the potential to create active infection. The leading causes of death for beef calves greater than 3 weeks of ages is respiratory disease.[30] Woolums reported on the incidence of BRD in cow calf operations in the Plains and Eastern states. Bovine respiratory disease had been detected in ≥1 calf in 21% of operations; ≥1 calf was treated for BRD and ≥ 1 calf died because of BRD in 89.2% of the plains states and 46.6% of Eastern states operations in which calf BRD was detected. Detection of BRD in calves was significantly associated with larger herd size, detection of BRD in cows and diarrhea in calves. Calving season length was associated with BRD in calves in Plains states but not Eastern states. Cumulative incidence of BRD treatment was negatively associated with large herd size and examination of cows to detect pregnancy. Incidence of BRD was positively associated with calving during the winter, introduction of calves from an outside source, offering a supplemental feed to calves and use of an estrous cycle synchronization program for cows.[7] Bovine respiratory disease is the most important and costly disease condition encountered by stocker and feeder operations accounting for over 50% of the deaths.[41] The highest incidence of death associated with BRD occurs in recently weaned calves that have recently arrived at a feedlot.[40] Seventy five percent of calves that die from BRD are sick with 2 weeks of feedlot arrival.[40] The relative risk that cattle entering a feedlot would die of a respiratory tract disorder increased significantly from 1 in 1994 to 1.46 in 1999.[41] The highest incidence of death associated with BRD occurs in recently weaned calves that have arrived in feedlots. In one study 75% of calves that died of BRD were sick within two weeks of feedlot arrival.[30] The U.S. feedlot industry estimates an annual loss as high as one billion dollars due to loss of production, increased labor expenses, drug costs and death because of bovine respiratory disease. Fulton and colleagues estimated that producers lose $41.00 per head for 1 treatment, $58 per calf for 2 treatments and $291 per calf for 3 or more treatments for BRD.[19]

It is a common recommendation by veterinarians to vaccinate calves against respiratory pathogens. Vaccinating calves while on the cow and/or at weaning are important management considerations for the beef herd. In order to help minimize the effects of respiratory disease within the beef production chain, preconditioning programs should be instituted at the earliest point of intervention, the breeding cow herd. Preconditioning programs generally prepare the weaned calf to meet the health challenges occurring when; the calf comes in contact with other cattle, the calf is placed in an environment facilitating transmission such as trucking over long distances and or overcrowding in the markets, the calf is exposed to environmental conditions such as dust, humidity, environmental temperature extremes, nutrition changes, all singularly or combined predispose the calf to increased BRD risk.[45]

Currently in the U.S. there are licensed and commercially available viral vaccines for BHV-1, BVDV, Pi-3 and BRVS. The bacterial pathogens associated with commercial vaccines include *Mannheimia haemolytica, Pasteurella multocida, Histophilus somni,* and *Mycoplasma bovis.* Proper immunity to the

viral and bacterial pathogens is important because they have been identified by isolation and serology in commingled post-weaned calves purchased at auction markets. Many respiratory viral vaccines are available for the prevention of bovine respiratory disease. Each vaccine has unique characteristic such as antigen content, virus strains(s) and presence or absence of adjuvant. Vaccination against common respiratory tract pathogens has been the primary emphasis of BRD prevention. Recommendations regarding what age of calf to vaccinate, with what vaccines, with which type of vaccine varies greatly. Vaccination strategies that require the primary vaccination to be given at approximately 60 days of age, may have to contend with the effects of maternally derived antibody on vaccine response. There is mounting evidence that an immune response to viral antigens can be stimulated in calves with detectable antigen specific maternally derived antibodies.[39],[43,44] Studies have revealed a more rapid anamnestic response to revaccination with an MLV BHV-1 vaccine when the initial vaccination was administered to calves that had detectable virus specific maternally derived antibodies. Calves vaccinated prior to weaning against IBR, BVD, BRSV, PI-3 and two bacterial pathogens *Mannheimia* and *Pasteurella* were compared to control or non-vaccinated calves. Vaccinated calves seroconverted with an active immune response regardless of the age they were vaccinated prior to weaning when compared to controls.[39] Treatment costs were lower for vaccinates vs controls.[39] The mean mortality rate was higher in control non vaccinated calves than calves vaccinated at 2 and 6 months of age. However, there was no difference in feedlot performance and carcass value between the vaccinated and control groups.[39] In another study, calves inoculated with viral and bacterial antigens associated with BRD were only 0.68 times as likely to be treated for BRD as were unvaccinated controls.[38] Calves vaccinated and conditioned on the farm for 30 days after weaning were only 0.22 times as likely to be treated for BRD as were control calves.[39] Fulton evaluated pre- arrival vaccination programs and feed lot performance for retained ownership calves, and re-affirmed that post weaning calves with increased immunity to viral and bacterial pathogens measured by antibody titer after vaccination perform better in the feedlot and have less clinical disease caused by the BRD pathogens and provide greater economic return to the owner.

The most obvious economic losses resulting from BRD are medicine costs and death loss. In the Texas A&M ranch to rail summary reports for the years 1992 through 2000, medical costs for calves becoming sick ranged from $20.76 to $37.00 per head. The economic losses due to an animal dying can be significant. The cost associated with an animal dying is calculated by multiplying the purchase price per head by the percentage death loss. For a set of calves experiencing a 5% death loss, the economic value in calves dying from a load calves weighing 550 lbs. could amount to approximately $5,600, before freight, medicine, opportunity cost, and lost performance of other pen mates is determined.

The more challenging loss to determine financially is the loss in production due to sick calves. The difference in average daily gain (ADG) between calves that remain healthy and those that suffered from BRD can be quite significant. In receiving studies ranging from 28-42 days in length, differences in ADG of 0.31 to 0.50 lb. per day have been reported.[46,47] Calves requiring two or more courses of therapy experienced even greater losses in daily gain as compared to calves requiring only one treatment. In a study conducted by Van Donkersgoed et al. calves which were never sick gained 2.75 lbs. per day, while those treated once for BRD gained 2.62 lbs. per day and those treated with two or more courses of therapy gained 1.54 lbs. per head per day.[49] In an Oklahoma receiving study, calves that did not become ill gained 2.32 lbs. per day during a 42-day trial, while those treated once or more than once gained 2.17 and 1.83 lbs. per day. A 90-day Canadian trial showed that calves experiencing an episode of BRD gained 0.39 lb. per day less than those remaining healthy, while those treated two or more times gained 0.73 lbs. less per day. In a 150-day feedlot finishing study, researchers found that steers never treated for BRD, gained 0.09 to 0.4 lbs. more per day than steers treated once or more than once respectively. Differences in ADG between treated and untreated cattle may persist until close out, however the difference in ADG tends to narrow as days on feed increases.

Clinical illness is clearly associated with increased production costs and has been estimated to cost the beef industry $500 million dollars per year. However subclinical illness also leads to increased costs of production while simultaneously causing reduced performance and carcass value. With current technology it is not possible to identify all sick calves. It has been estimated that for every calf pulled from its pen for treatment there are likely two calves that experience subclinical illness. In a Nebraska report, lungs were examined at slaughter for the presence or absence of pulmonary lesions. Average daily of gain of calves with pulmonary lesions at slaughter was reduced by 0.17 lbs. per day during the 273-day feeding period.[49] They found that 78% of calves that had been treated had pulmonary lesions at slaughter, while 68% of those untreated were also found to have lung lesions. Bryant reported that the presence of lung lesions at slaughter was associated with decreases in ADG ranging from 0.073 to 0.65 lbs per day. Researchers at Oklahoma State University reported that steers without pulmonary lesions at slaughter gained 3.48 lbs per day during a 150 day feeding period. Steers with inactive pulmonary lesions gained 3.15 lbs per day, while those with active pulmonary lesions gained only 2.57 lbs per day. Among the steers never diagnosed as sick, 37% had respiratory tract lesions at slaughter. Of those diagnosed as sick 48% had lung lesions. In a study following heifers from backgrounding thru full feeding and then slaughtered, 66% of heifers never treated for BRD graded choice, 59% treated once graded choice, and 41% of those treated more than once graded choice.

Identifying cattle suffering from BRD and applying appropriate treatment(s) in order to minimize the effects of BRD on fed cattle is challenging. The use of clinical signs or treatment records for classifying BRD may have limitations. Sub clinically infected cattle are often not identified as suffering from BRD. At slaughter the presence of lung lesions is a common method of determining current or previous respiratory lung infections. Not all cattle with lung lesions associated with BRD will have clinical symptoms and not all cattle with BRD will have detectable lung lesions at slaughter.[5,6] Subclinical respiratory tract infections may produce permanent lung damage and have associated negative effects on growth and carcass traits. An integrated approach involving a continuation and expansion of preventive health-care measures in the cow-calf segment of the beef industry is advocated to improve health and economic outcomes for the cow-calf, feedlot and packer segments of the industry.[39]

Stocker and Fed Cattle
The fed cattle industry continues to evolve due to the economic risks associated with feeding cattle. Ownership of fed cattle is changing, partially due to economic constraints and historical returns associated with different sections of beef production. In 2011, yards with less than 8,000 head on feed sourced a majority of their animals from sale barns while yards with a capacity over 8,000 sourced their cattle from cattle buyers and backgrounders. There is an increasing percentage in the overall number of cattle on feed owned by the feedlot rather than by individual cattlemen. Nearly 60% of cattle on feed were owned by the feedlot in 2011, compared with about 25% of cattle in 1994.[24]

In order to mitigate some of the economic risk of fed cattle, feedyard operators are increasingly concerned with the health and health programs for new arrivals. Bovine respiratory disease (BRD) is the costliest feedlot disease in the United States. Incidence rates have been reported to average 14% for fed cattle.[1] Estimates of losses associated with BRD have been placed at over one billion dollars annually while prevention and treatment costs are estimated at over three billion dollars annually.[2]

The percentage of feedlot operators that considered pre-arrival processing practices to be either extremely or very effective has increased.[24] There is an increased emphasis on the timing of vaccination on new arrivals and the use of metaphylaxsis on incoming cattle. The procedures that cattle feeders felt were important or very important for cattle prior to arrival at the yard are; introduction to a feed bunk, respiratory vaccines administered at least 2 weeks prior to weaning and at weaning, calves weaned at least 4 weeks prior to shipping, castrated and dehorned prior to arrival and treated for internal parasites prior to arrival.[24] The average death loss for fed cattle in 2011 was 1.4% of all cattle placed on feed.[24]

Vaccinating calves against the viral respiratory pathogens prior to weaning has an impact on the health and performance of those animal's post weaning.[24]

Feedlot veterinarians whom represented 11,295,000 cattle on feed in the U.S. and Canada participated in a beef cattle health and well-being survey. All participants recommended IBR and BVDV for high risk cattle at processing while 65%, 15 of 23 recommended an additional vaccination against BRSV and 14 against PI-3 virus.[25] Clostridial vaccinations were recommended by 14 (60.87%), 17 (74%) recommended *Mannheimia haemolytica*, and 8 (35%) recommended *Pasteurella multocida* and 5 (22%) recommended *Histophilus somni* vaccinations. Autogenous bacterins were recommended by 39% of participants for high risk cattle. Metaphylaxsis and feed grade antibiotics were recommended by 95% and 52% of respondents for high risk cattle on arrival. For low risk cattle, 4 veterinarians recommended feed grade antibiotics and 16 did not. Past research has shown a decrease in treatment rates for BRD in high risk cattle using various protocols for metaphylaxsis and or use of feed grade antibiotics.[25,26] High risk cattle would include weaned or recently weaned light weight calves, particularly if the incoming calves had not been vaccinated, castrated or dehorned prior to arrival into the yard.

Vaccine recommendations for low risk cattle included all respondents (100%) recommending IBR and 22 (95%) recommending BVDV, while 12 recommended additional vaccinations for BRSV and PI-3. Approximately half (56%) recommended the use of clostridial bacterins in low risk cattle. For the route of administration of parasiticides, 16 (70%) recommended injectable forms only, none preferred oral only, 9% preferred pour on and 22% recommended a combination of administrations.[25] Six veterinarians recommended generic vs. trade-name parasiticides. Feedlot veterinarians recommended starting high risk calves in smaller pens and allowing 13 inches per head of bunk space. Ancillary therapy for treating respiratory disease was recommended by 47% of those surveyed. Vitamin C was recommended (30.4%) twice as often as any other ancillary therapy. Cattle health risk on arrival was influenced by weather patterns, and labor availability. These two influencers were the most important factors identified for predicting feedlot morbidity while the metaphylactic antibiotic, antibiotic therapy, and brand of vaccine were least important. Training of feedlot employees by veterinarians can be critical for the implementation of management recommendations for health and well-being of feeder cattle. All respondents indicated they spent time training feedlot employees on cattle handling, 12 (52%) conducted animal welfare audits at their client's feedlots while 47% did not. Rest after arrival is an important consideration for stressed calves and their response to vaccine. After receiving short hauled cattle defined as less than 8 hours in transit, 52% of survey veterinarians did not require a rest period before processing, 22% required a 6-hour rest period, three a 12-hour rest and four required a 24-hour rest. After receiving long haul cattle, defined as greater than 8 hrs. travel, one veterinarian did not require a rest period, one required 6 hrs. rest, 6 required 12 hrs. rest, and 15 required 24 hours of rest.[25]

Castration and pregnancy management are important health considerations for fed cattle. Surgical castration was recommended more frequently for light weight cattle while banding was recommended for frequently for heavier cattle.[25] For cattle weighing less than 300 lbs. on arrival, surgical castration was recommended by 63% of veterinarians. For cattle weighing between 300 to 500 lbs. on arrival, 43% recommended surgical castration, 13% recommended banding and 43% recommended either banding or surgical castration. For cattle weighing over 500 lbs. on arrival, surgical castration was recommended by 22% and banding was recommended by 56% of respondents and 22% recommended either method.[25] For animals weighing greater than 800 lbs. a majority of the veterinarians recommended castration utilizing the banding technique. Some research has not indicated a significant difference in average daily gain between banding and surgical castration, but regardless of the method the degree of weight loss post castration increases significantly as the age of castration increases and cattle castrated with a band have greater average daily gain on a carcass weight basis compared to surgically castration.[27,28] When castrating bulls using a band, it was recommended by 96% of the survey participants to administer concurrent tetanus antitoxin

To manage pregnancy in newly arrived heifers, 18 (78.26%) of 23 feedlot veterinarians recommended that a producer should pregnancy-check heifers while five did not. Respondents additionally emphasized checking heifers of unknown origin or no management history. Mass abortion protocols were recommended by 8 (35%) veterinarians while 15 (65%) did not recommend mass abortion. Open feedlot heifers returned $40.00 more per head than aborted heifers and $66 more per head than pregnant heifers.

Testing animals for persistent BVDV viral infection (PI) was recommended by 39% of surveyed feedlot veterinarians.[25] The issue that comes about from testing animals for PI is what to do with the animals that test positive. Should these animals be euthanized, sold, fed in quarantine or remain with their pen mates? The feedlot survey respondents indicated that cattle testing positive are either held and fed in quarantine or sold for salvage slaughter.[25] PI positive animals should not be placed back onto the market.

Railed cattle are unthrifty and non-producing animals sold prior to pen mates in order to salvage some monetary value. Slightly less than 4 percent of all cattle placed on feed left the feedlot for non-harvest reasons.[24] Ninety six percent of feedlots sold railers for salvage value, with the most common reason for cattle to be railed was chronic BRD (44%), lameness (48%), and chronic non-performance issues (8%).[25]

Euthanasia is occasionally necessary as part of animal care and husbandry. Feedlot veterinarians use gunshot in a majority of feedlots (87%) with only 13% using a captive bolt. All respondents indicated they had a program in place for the care and handling of non-ambulatory cattle before. The time to wait for clinical improvement before recommending euthanasia in non-ambulatory cattle ranged; 21% recommended euthanasia in less than 24 hours for non-responders, 52% waited from 24 to 48 hours with no improvement before animal euthanasia and 27% would wait 49 to 72 hours with no clinical improvement before animal euthanasia, none waiting longer than 72 hours for signs of clinical improvement before performing euthanasia.[25]

Seven factors related to prediction of morbidity and mortality of feeder cattle were ranked by feedlot veterinarians. The ranking were in order of importance, cattle heath risk, weather patterns, amount and quality or labor, receiving nutrition program, class of antibiotic for metaphylaxsis, class of antibiotic for treatment and the least important being brand of vaccine.[25]

The production system for beef cattle can be associated with numerous stressful events. Understanding these events and how to minimize their impact on beef cattle is important. Beef producers who understand the production chain from conception to consumption understand the importance of herd management, nutrition and timely applications of health protocols. Applying the principles of, animal science, animal care, animal welfare and herd health management with the application of production technologies when appropriate will enhance food production, animal well-being and the safety of beef as a nutritious high quality food.

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