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Perspective on BVDV control programs

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Abstract

Programs for control and eradication of bovine viral diarrhea virus (BVDV) are often considered prudent when the expense of a control program within a specified time frame effectively prevents loss due to disease and the expense of control does not exceed the costs associated with infection. In some geographic areas, concerns about animal welfare or desires to reduce antibiotic usage may motivate BVDV control even when control programs are associated with a lack of financial return on investment. In other geographic areas, concerns about financial return on investment may be the key motivating factor in considering implementation of BVDV control programs. Past experiences indicate that systematic, well-coordinated control programs have a clear potential for success, while voluntary control programs in cultures of distributed decision-making often result in notable initial progress that ultimately ends in dissolution of efforts. Segmentation of the cattle industry into cow–calf producers, stocker/backgrounders, and feedlot operators amplifies the distribution of decision-making regarding control programs and may result in control measures for one industry segment that are associated with significant costs and limited rewards. Though the host range of BVDV extends well beyond cattle, multiple eradication programs that focus only on testing and removal of persistently infected (PI) cattle have proven to be effective in various countries. While some individuals consider education of producers to be sufficient to stimulate eradication of BVDV, research surrounding the adoption of innovative health care procedures suggests that the process of adopting BVDV control programs has a social element. Collegial interactions and discussions may be crucial in facilitating the systematic implementation necessary to optimize the long-term success of control programs. Compulsory control programs may be considered efficient and effective in some regions; however, in a nation where individual identification of cattle remains voluntary, the likelihood of effective compulsion to control BVDV within a farm or ranch appears to be very unlikely. While currently available diagnostic tests are sufficient to support BVDV eradication via systematic, well-coordinated programs, the development of a diagnostic procedure to safely and consistently detect the gestation of a PI fetus after 5 months of gestation would be a valuable research breakthrough. This desired testing modality would allow diagnosis of PI calves, while the dam continues to provide biocontainment of the infected fetus. This development could speed the progress of control programs in achieving the goal of BVDV control and eventual eradication.

Keywords: Bovine viral diarrhea virus, disease control, epidemiology, pestivirus

Introduction

The United States beef supply chain consists of approximately 95 million head of cattle and calves (National Agricultural Statistics Service, 2014) which includes approximately 30.9 million beef cows (Galyean *et al*., 2011). Concentration of larger numbers of cattle on fewer production units progresses at each level of this rather segmented industry. This beef industry consists of approximately 765,000 cow–calf farms, many preconditioners or backgrounders that prepare young, lightweight cattle for feedlot finishing, and a much smaller number of feedlots to finish cattle prior to humane euthanasia and slaughter (McBride and Mathews, 2011). The average beef cow–calf herd in the USA contains 40 head. Although operations with 100 or more cows constitute only 9% of all cow–calf operations, they comprise 51% of the beef cow inventory. Feedlots with a capacity of less than 1000 head compose the vast majority of

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US feedlots, but market a very small share of fed cattle. Conversely, the five largest cattle feeding operations in the USA comprise approximately 20% of the industry capacity to finish cattle. The slaughter and packing industry is even more consolidated. Approximately 70% of the daily slaughter capacity is controlled by the top five beef packing companies (Galyean *et al.*, 2011). Cow–calf producers with herds of more than 250 head have realistic options of retaining ownership throughout feeding. However, retaining ownership of weaned calves is a high risk activity which must be prudently supported through detailed evaluation and mitigation of risk using cattle futures markets to achieve consistent success (McGrann, 2010). Consequently, transfer of ownership of growing cattle occurs consistently in the industry and commonly involves over 1000 weekly livestock auctions throughout the nation.

In the context of this segmented industry of the USA which involves many producers, each producer plays a critical role in the decision-making process to enact and maintain a voluntary (or even a compulsory) program to control bovine viral diarrhea virus (BVDV). With a spirit of rugged individualism prevalent in American agriculture, this distribution of decision-making creates notable challenges to the development and implementation of systematic, well-coordinated programs to control BVDV in the cattle population. Systematic, well-coordinated programs for BVDV control have exhibited the greatest success, while less coordinated voluntary programs generate initial progress that ultimately ends in dissolution of the efforts (Barrett *et al.*, 2012). The details of such programs may vary depending on the structure of the cattle population in a given geographical area but at a minimum, should address the identification and elimination of persistently infected (PI) animals and the implementation of biosecurity measures to prevent infection of naïve cattle with BVDV. The use of vaccines to boost immunity to the virus should also be given full consideration.

In a survey of United States beef cow–calf operations in 2007, 66.7% of producers believed that BVDV was a significant problem for the US beef industry (United States Department of Agriculture, 2010). Producers were generally aware of BVDV but only 4.2% had done any testing of calves for persistent infection with the virus in the past 3 years. In that survey, 46.6% of cow–calf operations did not know if removing calves that were PI would affect the value of the remaining calves in the herd. Overall, 33.1% of operations vaccinated calves against BVDV; 25.1% vaccinated weaned replacement heifers; and 28.1% vaccinated cows. Consequently, additional opportunities exist within the US beef industry to strengthen current BVDV control programs and institute control measures where they are currently lacking. For producers vaccinating weaned replacement heifers before breeding, 51.5% used killed BVDV vaccine and 48.5% used modified live BVDV vaccine.

Considering studies that focused on random sampling of more than 1000 cattle, research indicates that the prevalence of PI cattle in the USA ranges from 0.12 to 0.6%, whereas the prevalence of herds that contain a PI animal ranges from 4 to 17.2% (Houe *et al.*, 1995; Loneragan *et al.*, 2000, 2005; Wittum *et al.*, 2001; Fulton *et al.*, 2006a, b; Stephenson, 2008; United States Department of Agriculture, 2010). In a large study focused on the prevalence of PI cattle by weight class, PI animals were prevalent at a rate of 0.7% in calves less than 300 lbs (136 kg) and diminished to 0.3% in calves more than 800 lbs (364 kg) (Lawrence and McClure, 2007).

Considerations

Motivation to control BVDV in the USA

Programs for control and eradication of BVDV may be considered prudent when the expense of a control program within a specified time frame effectively prevents loss due to disease and the expense of control does not exceed the costs associated with infection. In some geographic areas, concerns about animal welfare or desires to reduce antibiotic usage may motivate BVDV control even when control programs are associated with a lack of financial return on investment. In other geographic areas, concerns about financial return on investment may be the key motivating factor in considering implementation of BVDV control programs.

If the national beef cow population is multiplied by the per cow costs of BVDV in the USA as determined by computer simulation modeling, infections might cost the industry 460 to 767 million dollars per year. When considering the cattle population collectively as a single entity, a BVDV control or eradication program is clearly justified. However, as the collective impact of BVDV varies greatly for each industry segment, for each management system, and for each producer employing each management system, the impact of BVDV on each individual stakeholder involved in the collective industry varies tremendously. In the context of a distributed model of decision making, this variability of disease impact creates a cacophony of opinions regarding the validity of initiating a systematic BVDV control program in the USA.

The economic impact of BVDV on cow–calf operations is variable with key determinants being the timing of introduction of BVDV to a herd and management characteristics such as duration of the breeding season. In one recent randomized controlled clinical trial, introduction of PI animals to seronegative heifers at 50 days prior to a controlled breeding season with constant exposure until mid-gestation was associated with no negative impact on health or reproduction (Rodning *et al.*, 2012). In contrast, a recent report from the field indicated a negative health impact in 34% (46/136) of pregnancies associated with BVDV exposure of 3-year-old cows during gestation (Darweesh *et al.*, 2014). In that report, eight cows exhibited early embryonic death or abortion, 8-weak calves died during the first week of life, five PI calves died at weaning, and 25 PI calves died or were euthanized prior to 17 months of age. In computer simulation modeling of production scenarios in USA beef cow–calf operations in 2002, the economic advantage for herds without PI calves ranged from US$14.85 to 24.84 per cow (Larson *et al.*, 2002).

While research could not be found to quantify the impact of BVDV on backgrounders or stocker operations, much work has

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been done to define the impact of BVDV infections in feedlots. Unfortunately, research in North America has yielded conflicting results regarding the effect of constant exposure to PI cattle on the health and performance of feedlot cattle (Loneragan *et al.*, 2005; O'Connor *et al.*, 2005; Booker *et al.*, 2008; Elam *et al.*, 2008; Hessman *et al.*, 2009; Grooms *et al.*, 2014). This variation in the health of cattle constantly exposed to PI animals in the feedlot likely depends on multiple factors including the age, breed, nutritional status and immune status of individual calves; environmental factors such as prior exposure to BVDV, the duration of transport to the feedlot, the presence of other pathogens, stocking density and ventilation; and viral factors such as transmissibility and virulence of the strain of BVDV to which the calves are constantly exposed (Grooms *et al.*, 2014). In these studies, the economic impact of constant exposure to PI animals ranged from no significant impact (O'Connor *et al.*, 2005; Booker *et al.*, 2008; Elam *et al.*, 2008) to performance losses of $88.26 per animal and fatalities accounting for losses of US$5.26 per animal during the first 66 days of the feeding period (Hessman *et al.*, 2009).

Significant disease problems involving BVDV are often associated with herd expansion and the presence of a PI animal in purchased additions or the existing herd. The concentration of virus secreted by a PI animal normally exceeds an infective dose for contacted animals. In previous research, 1 h of direct contact with a PI animal was sufficient for consistent transmission of virus to seronegative cattle (Houe, 1999). In contrast, the inefficiency of transmission of virus from acutely infected animals is exemplified by lack of seroconversion of 14 calves following 2 days of close, nose-to-nose contact with acutely infected calves (Houe, 1999). Therefore, the most obvious and efficient method of introduction of virus into a susceptible herd is by purchase of a PI animal or pregnant animals carrying a PI fetus. The risk of introducing PI animals when buying from random sources without testing for virus can be calculated by [1-(the probability of buying a non-PI animal)^n], where n is the number of animals purchased. For example, if the prevalence of animals PI with BVDV in the population is 0.4% and 100 animals are introduced from random sources without any testing, the calculated risk is 33% ($1–0.996^{100} = 33\%$) (Houe, 1999). Alternatively, if purchased additions to the herd are immunologically naïve, PI cattle in the native herd may cause severe disease during the stress of herd expansion (Amiridis *et al.*, 2004).

In addition to financial or disease consequences, concerns regarding animal welfare or antibiotic usage may motivate programs to control or eradicate BVDV. Mucosal disease resulting from BVDV may cause acute deaths, the need for humane euthanasia of ill animals, and calves that exhibit developmental abnormalities (Darweesh *et al.*, 2014). As infection with BVDV is immunosuppressive, secondary bacterial infections may necessitate the use of antibiotics. As concerns continue to increase regarding the generation of antibiotic resistance in pathogenic bacteria, action to prevent the initiating viral infection that leads to use of antibiotics in cattle appears prudent.

Challenges to effectively controlling BVDV in the USA

Little research is available to understand industry level barriers to BVDV best practices in the USA. Many educational efforts assume that understanding the disease risks associated with BVDV infection is sufficient to lead to action; however, unanticipated barriers may prevent action. Often the most common barrier to disease control is monetary, and some countries that enact effective BVDV control programs circumvent this issue with government-funded control programs. Facilitating and supporting efforts to develop clear and stable market-based incentives might encourage positive behaviors such as testing and removal of PI animals and quarantine of new herd additions.

One critical industry-level barrier to controlling BVDV is segmentation of the beef industry. For instance, a cow–calf operation may consider that their production inputs to support the sale of a weaned calf involve approximately 9 months of gestation and 6 months of extra-uterine calf growth. If this is the mindset, then to test a newborn calf for persistent infection with BVDV is to test a production unit after 60% of the production inputs have been committed. If a producer were to maintain ownership until humane euthanasia and slaughter, then testing at birth for persistent infection with BVDV would seem to be a more intuitive investment in the long term health of the developing calf crop.

Based on research demonstrating a host range for BVDV that includes some wildlife species and domestic ruminants other than cattle (Van Campen *et al.*, 2001; Walz *et al.*, 2010; Bachofen *et al.*, 2014), concern is expressed regarding the ability to control BVDV in geographic areas where significant contact occurs with other host species. While there is much that remains to be understood regarding the practical challenges presented by wildlife and domestic species other than cattle, countries other than the USA have made notable progress in controlling and even eradicating BVDV with regulatory measures focused almost exclusively on cattle (Walz *et al.*, 2010).

A critical aspect of infrastructure in the methodology of controlling BVDV is the systematic and methodical implementation of permanent individual animal identification in cattle beginning at a very early age. Currently, the USA does not require permanent individual animal identification of beef cattle younger than 18 months of age unless those cattle are involved in interstate transport. This current regulation limits the traceback of PI cattle and hampers methods to enact a widespread systematic control program for BVDV.

Opportunities to advance efforts to control BVDV in the USA

Critical aspects of advancing efforts to control BVDV in the USA include (a) facilitation of a collective decision-making process on how best to mitigate industry losses associated with BVDV infections, (b) producer support of a systematic, well-coordinated BVDV control program, and (c) continuing advances in methodologies for diagnosis of PI animals. If programs to control BVDV are to advance in the USA, multiple organizations of producers must work collaboratively to embrace the collective value of a systematic disease control program. These organizations would need to promote the collective benefits of a systematic program while seeking to minimize costs to each individual producer. This collective decision-making, minimization of costs to individual producers, and effective communication of benefits may solidify producer support of a systematic, well-coordinated BVDV control program.

An effective BVDV control program could be catalyzed by validation of a safe and sensitive diagnostic methodology to detect a PI fetus after 5 months of gestation (Lanyon and Reichel, 2014). While currently available diagnostic tests are sufficient to support BVDV eradication via systematic, well-coordinated programs, the validation of a diagnostic procedure to safely and sensitively detect the gestation of a PI fetus after 5 months of gestation would be a valuable research breakthrough. This desired testing modality would allow diagnosis of PI calves while the dam continues to provide biocontainment of the infected fetus. While the concentration of serum antibodies that neutralize BVDV may be used to differentiate cows gestating PI fetuses from other cows, this methodology appears to lack the needed diagnostic sensitivity (Brownlie *et al.*, 1998). Prior reports have described blind or ultrasound-guided collection of fetal fluids to be used for detection of virus or viral RNA in fetal fluids (Callan *et al.*, 2002; Lindberg *et al.*, 2002). One blind method for fetal fluid collection involved sedation and local anesthesia during the last month of gestation and was not reported to be associated with fetal loss (Lindberg *et al.*, 2002). One ultrasound-guided method for fetal fluid collection during the sixth to eighth month of gestation involved local anesthesia and was reported to be associated with abortion or premature delivery of calves in 8.3% (14/169) of animals (Callan *et al.*, 2002). Development of a safe and sensitive method to detect gestation of a PI fetus could speed the progress of control programs in achieving the goal of BVDV control and eventual eradication.

Conclusion

For the current structure of the segmented USA beef cattle industry, the path forward to develop a systematic, well-coordinated program for control of BVDV involves facilitation of a collective decision-making process regarding how best to mitigate industry losses associated with BVDV infections; development and maintenance of producer support; and continued advancement in methodologies to easily and consistently detect PI animals, even gestating fetuses. As individuals within the industry embrace the collective benefit of control and eventual eradication of BVDV, compulsion to pragmatically implement an effective control program may mitigate the impact of this problematic pathogen. While effective methods to eradicate BVDV are available, the motivation to mitigate collective losses must exceed the challenges to implementation of BVDV control programs within an intricate, segmented beef cattle industry for true progress to become a reality.

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