FEEDYARD BIOCONTAINMENT, BIOSECURITY, AND SECURITY RISKS AND PRACTICES OF CENTRAL PLAINS FEEDYARDS

by

ARIC BRANDT

B.S., University of Nebraska, 2001
D.V.M., Kansas State University, 2005

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Clinical Sciences
College of Veterinary Medicine

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2007

Approved by:

Major Professor
Michael Sanderson

Abstract

Biosecurity, biocontainment and security practices are important in production animal agriculture. Procuring cattle from multiple sources and commingling them into a single confinement operation increases risk of disease introduction. The large concentration of animals makes a feedyard a more likely target of a domestic or international terror group. Controlling or eradicating an intentionally introduced pathogen or toxin would be costly. The aim of these surveys was to gather information from experts about perceived risks and mitigation strategies and to assess current practices of biosecurity, biocontainment and security in Central Plains feedyards. Consulting veterinarians and feedyard managers shared similar views on the likelihood of disease caused by terrorism, natural introduction or accidental introduction, and on the importance of on-site security. They disagreed on the importance of preventative products, disease transmission control, and environmental control. Generally speaking, feedyard managers believed environmental control to be more important than consulting veterinarians. In reference to a survey of current practices, some feedyards use equipment for both manure and feed handling. Many feedyards are not cleaning and disinfecting oral treatment equipment, treatment facilities, or unloading facilities on a regular basis which may increases their risk for indirect disease transmission of endemic agents such as *Salmonella* or BVDV. Most feedyards in this survey import some cattle directly from an auction market, do not require clean boots or foot covering to be worn by visitors, and do not require trailers to be cleaned. Smaller feedyards were more likely to require trailers to be cleaned before loading incoming cattle. Less than half of the feedyards reported having a fence that will stop humans or kept protein supplements or micro-nutrients secured from access. Some feedyards enforced a visitor log or employed a night watchman. Most feedyards learned about a future employee by calling references listed in resume, but some performed a criminal background check. A cost-benefit analysis should be done on all management practices to determine economic benefits. More research is needed to better understand which practices are most beneficial.

Table of Contents

List of Tables

Acknowledgements

I want to thank my Lord and Savior Jesus Christ for this opportunity to study and gain a degree in addition to my dream of becoming a veterinarian.

My wife Toni deserves the credit for this work just as much as I do. She told me I could do it when I my confidence waned. Toni was a source of encouragement to me and was willing to join me in the sacrifices necessary to accomplish the goal. She was also praying for me diligently throughout and now I can see how God has answered her prayers.

I am thankful for the blessing of wisdom and knowledge through my committee, but especially by working with Mike Sanderson. Mike gave me an opportunity to learn how to research while sharpening my clinical skills as a veterinarian. I am thankful that Mike was patient with me as I struggled through balancing my clinical appointment with the deadlines of the research. I realize most graduate students may not have the opportunity to be advised by someone who provides as much direction, focus, and time that Mike provided during the last two years.

Dan Thomson provided me with this opportunity to gain veterinary knowledge and experience while attaining a degree. I am grateful for his foresight in hiring me and giving me an opportunity I did not know I had. Thanks for giving me advice and guidance on how to conduct myself in the feedyard.

Brad DeGroot was fundamental in developing the database needed to record the survey data. I am thankful for Brad's hard work and input throughout the development of the survey tool.

Larry Hollis was fundamental in crafting thesis and helping me think about how to capitalize on every opportunity to educate managers and veterinarians. Thank you for serving on my committee.

My office mates Eric Moore and Dennis Hermesch taught me how to develop my skills as a veterinarian and were great friends as we learned how to research and write together. I will take many fond memories with me of the times we shared together.

My research assistant, Clay Adair, was a very faithful worker and helped me contact veterinarians and managers, making it possible for me to really enjoy traveling and visiting with the managers and veterinarians.

I am thankful for Brian Lubbers, Shelie Laflin, Meredyth Jones, Matt Miesner, Sylvain Nichols, Kara Schulz, and Sharon Tucker because they gave me the time necessary to complete my research and the freedom to focus my efforts when necessary. It was a blessing to learn how to practice and teach from them as I worked alongside them in the clinics. I am grateful for our section leader, Dave Anderson, who was always supportive of my work.

I am grateful to everyone in the department of clinical sciences, the veterinary teaching hospital, and the college of veterinarian who helped me take steps to complete this project. Thanks to Joe Nisil in ITC and Somil Chandwani who were fundamental in the planning and development of the survey software.

I am also grateful for countless other friends and family members that encouraged me along the way. I have much to be thankful for.

Aric Brandt

Dedication

This work is dedicated to my Lord and Savior Jesus Christ. He has gifted me with this degree and people who were fundamental in performing the research, writing this thesis, and encouraging me along the way. It is only by His grace and provision that I was able to have the opportunity to work on this project and receive this education.

CHAPTER 1 - Review of Relevant Literature

Overview of beef industry

The beef industry is a prominent sector in United States agriculture. Cash receipts from cattle and calves in 2006 was estimated at over 50.5 billion dollars.[1] Total beef production in 2006 averaged over 505 million pounds each week.[2] The cattle feeding portion of the industry was developed as an alternative revenue generator for farmers with cash crops.[3] While farmer-feeders began feeding cattle to market harvested grain and continue to do so today, cattle feeding has become an independent industry sector apart from farming. Feedyards have grown in size and procure most or all feed instead of raising it themselves. Feedyards with a one-time capacity in excess of 1,000 head marketed 22.4 million fed cattle in 2006 and had almost 12 million cattle on feed in the January 1, 2007 US inventory.[4] Current commercial cattle feeders manage cattle all year round compared to the seasonal beef production that characterized the pioneers in the industry. In 2006 farmer-feeders (less than 1,000 head) marketed 3.6 million cattle in 86,000 feedyards across the United States, while 126 feedyards with more than 32,000 head marketed over 11 million cattle.[4]

As the industry began to grow from farmer-feeder to commercial beef production, the larger feedyards began to concentrate west of the Mississippi river where most the cow-calf population was historically located and which also is in close proximity to an ample supply of feed commodities.[5] Meat packers and auction markets followed the industry to the developing beef belt that was forming from the Texas panhandle north into the panhandle of Oklahoma, western Kansas, eastern Colorado and Nebraska. This geographical area is where the majority of US cattle are fed today.

Risks faced by the feedyard industry

Biosecurity is defined as management strategies for prevention of disease entry and are different for each animal production system.[6] These strategies should be identified and implemented on the basis of a risk assessment of which diseases are most threatening and would create the biggest impact in the feedyard from a herd health or an economic standpoint.[6] Understanding the disease agents and their routes of transmission is important in identifying mitigation strategies. Biocontainment, that is strategies to control transmission of disease within an operation, should be emphasized with diseases that are endemic within a population of animals. Biocontainment strategies within the feedyard are important because biosecurity efforts to prevent introduction of endemic diseases may be impractical in the high turnover environment of a modern feedyard and the current marketing channels in the U.S.

There are many attributes unique to feedyards that make prevention of disease introduction challenging. Feedyards typically feed cattle for a period of 90 to 150 days and the population turns over on average 2.5 times each year. While the broiler and swine industries may have higher importation rates than feedyards, because of management requirements, the animals are not exposed to a constant influx of incoming animals as occurs in the feedyard. Swine and poultry barns are designed to place a group of animals of similar age and size. When the animals are harvested, the entire barn is emptied and thorough cleaning and disinfection of the facility is performed (all-in-all-out). New animals are never introduced to animals in a more advanced stage of production. This helps break the cycle of disease and helps prevent disease transmission between animal groups. Feedyards do not practice all-in-all-out management methods. Standard US feedyard facility design typically includes outdoor pens with dirt pen floors. Incoming cattle have the potential to introduce new diseases to animals in the resident herd and to be exposed to diseases already present within the feedyard population. In contrast to the swine and poultry industries where total confinement is utilized, the cycle of disease cannot be interrupted as easily.

Feedyard design not only presents challenges with biocontainment of disease, but it also becomes a security challenge. The extensive perimeter of a typical feedyard provides numerous opportunities for unauthorized entry to the feedyard by individuals or groups with malicious intent. While total confinement operations can be secured by locked doors, the outdoor environment of the typical feedyard is secured by using a perimeter fence and locked entrance gates to deter entry. Intentional introduction by a terrorist group may be unlikely, but it is a concern because of the high concentration of animals, the relative ease of entry, and the potential for a large impact depending on the infectious agent or toxin used. If the goal of the terror group was to deflate the economy of the beef industry and the US in general, millions of cattle could be infected by selected agents with a relatively small amount of knowledge, resources or time.[7]

Feedyards are particularly vulnerable to disease introduction because of the large number of cattle procured annually from multiple sources[8] including the reliance upon auction markets to provide a year around supply of cattle and meet the demands of optimum throughput for profitable feeding. Transport and commingling associated with auction markets may increase stress due to commingling and exposure to pathogenic agents in cattle. Some disease agents like *Salmonella* spp.[9] may be shed more in times of stress. Knowles et al.[10] described live auction markets as "a process which extends transport times and multiplies the number of occasion that animals are loaded, unloaded, driven, introduced to unfamiliar environments and mixed with unfamiliar animals." It would be ideal to purchase cattle in a way that might decrease the stress associated with commingling. Some have suggested that video auctions should be used to decrease stress induced by commingling, relocation, and transport. Video auction markets allow cattle to be marketed directly from the farm, eliminating the commingling with cattle from other sources, and eliminating transport from the farm to the auction market location.[10] In addition to potential health advantages, prices paid by buyers are higher at video auctions than traditional auction markets in the United States.[11,12]

Transportation may be more than a source of stress to cattle, but also an environment that permits direct and indirect disease transmission. Barham et al.[9] showed that approximately 7% of trailers utilized for hauling feeder cattle were positive for *E. coli* O157:H7 and 74.5% were positive for *Salmonella*. They suggested that trailers may be a critical control point for reducing exposure of animals to these agents. Parker et al.[13] found FMDV in samples of feces taken from the floor of isolation boxes containing steers up to 10 days after parenteral inoculation. Prior research has shown that while fecal shedding of virus may be low, virus is shed in higher concentrations from the nose and mouth.[14] The virus concentration in the fecal samples was likely attributed to the total environmental load with higher concentrations of virus likely coming from saliva and nasal discharge. Therefore, cleaning and disinfection is warranted to prevent spread of disease agent from one load to the next, but may not be economically feasible for the trucking company because of the additional expense of time and labor. If FMDV is introduced to the United States, it will likely be useful in limiting transmission after transport restrictions are lifted.

Dee et al.[15] supported the theory that trailers are a source of infection in a study of experimental transmission of porcine reproductive and respiratory syndrome virus (PRRSV) to pigs by contact with an infected trailer model. Limitations of the study included using a scaled model of a trailer with only one sentinel pig per treatment and artificial inoculation of the model trailers. A high concentration of PRRSV was used to contaminate the trailer, and the inside of the trailer was washed with a power washer. Sentinel pigs were placed in the trailer and left for 2 hours resulting in infection of 2 of 4 pigs. The high level of contamination in the trailer may not be representative of typical field contamination, however in field conditions many animals are transported and exposed for longer periods of time. While this study was not designed to answer questions about the transmission of bovine pathogens, it suggests trailers can serve as fomites in disease transmission.

In a separate study, Dee et al.[16] found that drying the trailers after cleaning and disinfection further reduced the infectivity of PRRSV from infected trailers compared to cleaning and disinfection alone. While this study cannot be directly extrapolated to other pathogens in swine or in cattle, it may be an indication of the value of appropriate cleaning and disinfection methods in the beef industry. More research is needed in this area to determine the efficacy and economic value of cleaning and disinfection of trailers in the reduction or elimination of bovine viral and bacterial pathogens.

Before cattle are considered for purchase, feedyard managers may want to weigh cattle rearing procedures performed prior to auction as another method to decrease prevalence of some diseases. Bach et al.[17] showed that a long transport to the feedyard in the absence of preconditioning increased fecal shedding of *E. coli* O157:H7 and *E. coli* in feeder calves on arrival at the feedyard. While findings were suggestive that short transport and preconditioning may decrease shedding, the authors recognized the need for future research to determine the possible and likely sources of *E. coli* O157:H7 infection for feedyard cattle to further characterize effective intervention strategies. While *E. coli* O157 is not a pathogen of cattle these results suggest that management practices may impact shedding and environmental contamination from other pathogens as well.

Barham et al.[9] showed that *Salmonella* spp. prevalence increased from 6% to 87% in hides and from 18% to 43% in feces when comparing prevalences at the feedyard and the slaughter facility, respectively. Transport time in this study was 30-40 minutes. This suggests the stress of transport may increase shedding for some agents even following a short duration of transport.

Biosecurity and biocontainment strategies are aimed at preventing disease agent introduction from a herd and controlling the agents already present within a herd.[18] Disease is dependent on the number and virulence of agents an animal is exposed to as well as the immune status of the animal.[19] Immunity is influenced by many factors including stress, vaccines, and previous disease exposure. The strategies included in a biosecurity plan focus on reducing the number of pathogens introduced to the facility from outside sources, including cattle, and in elevating the immunity of cattle within the feedyard when possible. When biosecurity fails, it is important to have measures in place to prevent transmission of the agents introduced to the feedyard.[20] Outlining biocontainment procedures is most important in preventing the transmission of endemic disease pathogens already present within the operation.

All animal production systems face disease biosecurity and biocontainment challenges, but some of these practices are unique to the feedyard industry and need to be identified and addressed to decrease risks of disease introduction to cattle.

Current Practices in the Feedyard industry

Currently very little data is available on biocontainment, biosecurity and security procedures in US feedyards. The USDA NAHMS Feedlot 99 survey[21] asked several questions about non-employee restrictions, wildlife control, water trough maintenance, and feedstuff storage. In reference to security, it was reported that 18% of feedyards restricted movement of people on the feedyard. Larger feedyards (25.6%) were more likely to restrict movement of people than smaller feedyards (15.5%). Controlling unauthorized visitors from access to the feedyard may help to prevent both unintentional and intentional types of disease introduction. Determining the purpose of the visit, previous animal contact, and the destination within the feedyard may help deter feed contamination or contagious disease introduction. Feedyard management may want to escort visitors to prevent access to restricted areas and to deter accidental or malicious disease introduction. Consideration should be given to the cleanliness of the visitor's footwear because of the potential for introduction of pathogens in feces carried on contaminated footwear. Visitors should not be allowed to have direct contact with feedstuffs or cattle.

One way to secure feedstuffs is to store them in a sealed container. In the Feedlot 99 survey[21] feedyards reported using sealed containers (silos, tanks, bins, drums) to store protein supplements (86.3% of feedyards), fat supplements (36.0% of feedyards), feed additives (64.7%of feedyards), and energy concentrate (65.1% of feedyards). Remaining feedyards stored these feedstuffs in piles, bunks, and pits that are easily accessible once entry was gained inside the perimeter fence. Locking the supplements within containers or behind a fence may deter malicious intentional feed contamination. Discussion on this subject is continued later.

Diseases shed in feces, urine, or saliva can be transmitted by contamination of the drinking water source and subsequent ingestion by another animal. In regards to biocontainment, over 95% of feedyards reported routinely cleaning water troughs.[21] Average days between cleanings for all feedlots ranged from 13 to 16 depending on the season of year. Larger feedyards (>8,000 head) cleaned water troughs more often than smaller feedyards (1,000-7,999 head).[21] Smith et al.[22] found that draining, physically scrubbing and refilling did not change *E. coli* O157 levels in the water. Draining, scrubbing and 15 minutes of chemical disinfection decreased coliform levels but they returned to pre-clean levels within 24 hours, suggesting the cattle were re-contaminating the water. In order for this practice to decrease the risk of enteric disease transmission it may need to be performed every day or involve some continuous method of water treatment. Daily disinfection of water troughs is not considered to be practical in a commercial feedyard.

Biosecurity

Biosecurity was defined earlier as management strategies for *prevention* of disease entry which are different for each animal production system.[6] Feedyards accept various degrees of risk depending on the different sources of cattle imported, but observing cattle at arrival will help determine their arrival state of health and may reduce the risk of importing disease into the feedyard. Griffin[23] suggested a health certificate should be required on all purchased cattle. Sanderson et al.[24] recommend receiving animals in the daylight for better assessment of health at the time of unloading.

Traditional biosecurity involves controlling introduction of disease by quarantine and testing of imports prior to introduction to the resident herd. During a quarantine period, animals should be monitored for signs of illness, tested and vaccinated to match the immune status of the herd. If animals cannot be kept on another site, they should be kept on the edge of the premises away from contact with other cattle. They should not share bunk space, water source or a fenceline.[25] Pens should be sloped so runoff does not enter other pens occupied with resident herd cattle. Most feedyards keep cattle in the receiving facility until they are processed and within three days they are introduced to the rest of the cattle and placed in their home pen. The idea of quarantine may not be well accepted because facility design will not support separation of cattle for a long period of time when the optimal goal is to keep every pen full.[25]

A quarantine period also allows time for testing cattle for potential high risk diseases.[25] Testing cattle on arrival at the feedyard is impractical for most diseases with the possible exception of bovine viral diarrhea virus (BVDV). This disease will be discussed in further detail later. However, feedyards will likely continue to import cattle that have been commingled with other cattle at the auction market without testing or a period of isolation.

.

Biocontainment

Cleaning and Disinfection

As Elbakidze[26] states, prevention or biosecurity is most desirable, but not always attainable, so detection and control or biocontainment in the face of an outbreak are also important. Instructing visitors about the risks and asking them to comply with practices aimed at reducing exposure is central to these biosecurity strategies. Non-feedyard personnel should enter only after compliance with policies limiting exposure to potential fomites. Clean coveralls, clean boots or foot covering should be used if visitors have soiled clothing or boots. Visitor vehicles should be kept off the facility or entry should be permitted only after thorough cleaning and disinfection. Dead animals should be picked up on the periphery of the facility to keep the rendering truck from introducing disease.

Stevenson et al.[27] suggested that the facilities where processing or treatment occurs may be a source of disease dissemination if they are not cleaned and disinfected after each use. They also suggested that transmission will be more likely when animals are allowed direct contact with infected animals, such as within the same pen or by fence line contact between adjacent pens. This may also be an issue for contact between the hospital pen cattle and healthy cattle. Regular cleaning and disinfection is a cornerstone to decreasing risk of disease transmission.[28] Gross contamination must be removed and washed away for disinfectants to work properly. Both viral agents such as foot-and-mouth disease (FMDV) and bacterial agents such at *Mycobacterium bovis* and *Salmonella* can survive outside the host, especially in areas of high traffic such as the processing barn.

According to Buhman et al.,[29] sanitation should encompass every vehicle on the feedyard. The equipment used for handling feedstuffs should not be used for anything else whenever possible. Only the loader and feed trucks should be permitted in the pit silo and feed trucks should maintain a distance of at least 100 feet from the working face of the feedstuff. Vehicles and loaders used for dead stock should be cleaned and disinfected before leaving the animal disposal area to prevent pathogen dissemination to other parts of the facility. This area should be located on the periphery of the feedyard where animals can be easily accessible to the rendering company without driving across the normal feedyard traffic pattern.

Diseases endemic to the feedyard such as Salmonellosis can be shed in saliva and become a risk for indirect disease transmission. Oral treatment equipment should be cleaned and disinfected after each animal to prevent transmission of pathogens shed in saliva.[30] Store the equipment in clean, dry areas, avoiding permanent storage in disinfectant baths. Disinfectant baths have been blamed for disease transmission after the baths were inactivated by organic debris. Minimize the usage of oral treatment equipment whenever possible to reduce risk of indirect transmission.[29]

Segregation

Buhman et al.[29] noted the importance of minimizing the commingling of cattle, especially after arrival at the feedyard. The authors recommended returning cattle as soon as possible to the home pen after treatment to minimize transfer of infectious agents between pens through direct nose-to-nose contact.

Security

Security begins with identifying the factors posing the biggest threat in terms of both likelihood and impact. Threats to the feedyard may include everything from theft of feed, supplies or cattle by disgruntled neighbors, employees or activist groups intending to make a statement of their ideology. Potential threats should be evaluated in reference to the likelihood of occurrence. Animal agriculture has been consistently antagonized by groups like the Earth Liberation Front (ELF), Animal Liberation Front (ALF) and People for the Ethical Treatment of Animals (PETA). Domestic terrorists like PETA have publicly stated they would welcome FMDV into the United States primarily because they believe it would be good to relieve production animals from their captivity and suffering.[31] It is uncertain how many resources should be devoted to prevention of domestic terrorism in feedyards. However, it is clear domestic terrorist groups have demonstrated they will resort to extreme measures in an attempt to publicize their views and influence public policy. In 2003, members of ELF were blamed for burning a 206 unit apartment complex in San Diego, CA when a banner was left that read, "if you build it we will burn it". The damage was estimated at $50 million dollars.[32]

In contrast, international terrorists may use a bioterrorism agent for the potential trade restriction and negative consequences on the US economy.[33,34] Al Qaeda documents found during execution of the war in Afghanistan indicate anthrax has been considered as an agent of bioterrorism.[35,36] Although motives of terror groups may stem from religious, political, or ecological beliefs, the methods of preventing an intentionally introduced disease or toxin remain similar and challenging. Understanding the real risks faced by feedyards is difficult because there is no data available on the risk of a terrorist disease introduction.

Historically toxins have been used to intentionally contaminate feed ingredients fed to animals. While it may not be considered bioterrorism, cattle have been casualties of several malevolent events. In March of 1970, members of the Ku Klux Klan were blamed for poisoning cattle via the water source with cyanide. The thirty cattle that died from cyanide poisoning were owned by a group of Black Muslims in Alabama.[37] This example suggests it may be important for access to wells and storage tanks to remain locked so they cannot be contaminated and result in widespread dissemination of a toxin or disease agent.

Neher[38] recounts a December 1996 incident where chlordane, a pesticide, was used to intentionally adulterate liquid fat at a feedstuff manufacturer that supplied feed to more than 4,000 farmers in Wisconsin, Minnesota, Michigan, and Illinois. Milk from dairies receiving contaminated feed had already been processed into other products such as cheese, butter, and ice cream at the time of the investigation. Samples taken from the farms and animals at slaughter were either negative or well below the concentration considered unsafe for human consumption. The resulting recall of 4,000 tons of feed and 500,000 pounds of fat however cost nearly $4 million dollars. In the spring of 1997, a customer of the same feed manufacturer received a threat regarding contamination at the plant. Learning from the first incident, the plant had instituted additional quality assurance measures to test for contaminants before distributing the products. A fungicide called folpet was identified as the chemical used to contaminate materials. The contaminated materials were destroyed and no manufactured products were contaminated as a result. This event indicates that on-site security at the manufacturer and quality assurance testing are necessary and valuable to prevent costly recalls. Feedyards may consider evaluating the quality assurance methods used by their feedstuff suppliers including requiring high risk feed suppliers to have a hazard analysis critical control point (HACCP) plan to prevent feed contamination.

In 1981, 135 Wisconsin beef cattle were intoxicated by organophosphate insecticide after someone poured a bag of insecticide into a silo, contaminating the silage within.[38] While no one was prosecuted, only 4 animals survived the incident. The event was suspected to have been the result of a grudge toward the farmer. On-site security on the feedyard that limits outside access to feedstuffs may prevent incidents like this one. Feedyards cannot control access to feedstuffs prior to delivery, but once a commodity is delivered to the facility it should be protected from contamination.

More recently in April 2003, a Nebraska cattleman lost 250 head of cattle do to organophosphate poisoning.[39] This incident was thought to be intentional, but there were no conclusive findings in the investigation. Again there was reason to believe the incident may have been the result of a grudge against the feedyard owner. Losses were estimated at $120,000. The person responsible for feeding the cattle denied the possibility of accidental feed contamination because there were no organophosphates stored on the facility.[40] Evidence that all cattle were fed at the same time, but only pens fed from the first load of feed were contaminated suggesting the toxin may have been present in the truck. Feeding equipment should also be secured to prevent opportunity for feed contamination in this way.

Intentional disease introduction is a crime feedyards should address. Security of feedstuffs and quality control are important before feedstuffs enter the facility, but are not the sole responsibility of the feedyard. HACCP programs implemented by feed suppliers are necessary for control of risk for feed at this stage. However, after arrival at the facility, security measures such as locking feedstuffs in storage containers, bins, or behind fences may deter contamination. Feed trucks, feed mills, and micro-ingredient handling equipment should be secured as well. As mentioned earlier, feedyards are storing some feed ingredients in sealed containers, but more security is needed to prevent access to those containers.[21]

Swine model

Other animal production systems may provide information regarding effective biosecurity, biocontainment and security practices although not all practices from other systems are appropriate for feedyards because of differences in management systems, facility designs, disease agents, and species of animals. Moore[41] made the following recommendations regarding swine biosecurity and management of disease.

Loading should be done on the edge of the facility.

The facility for loading pigs should be cleaned and disinfected after each use.

Dead animals should be placed outside the farm perimeter.

Vehicles owned by rendering companies should be kept at least 1 mile away from the facility. Dead stock should be taken to the pick up site using farm equipment.

The facilities should be located on a dead end road as far as possible from major highways.

Only one entrance should be used to the facility and the office should be in close proximity to the perimeter of the operation and the gate to monitor vehicles and incoming people.

Visitors should be kept to a minimum and only allowed if they have not been around other pigs for 36 hours.

They should sign in a log book with their name and the number of hours since and the location where they were last in contact with other pigs.[41]

Another valuable resource to help understand effective practices utilized in the swine industry is Part One of the NAHMS 2001 swine survey[42] which shows 65.5% of swine farms restricted entrance into the facility to employees only. Of those facilities that permitted visitors, 52.1% required clean boots and coveralls, 23.6% required 24 hours of downtime from other swine contact prior to entry and 9.3% required showers.

Entry of outside trucks or trailers was allowed by 56.8% of swine operations in the survey, however of those that allowed entry of outside trailers, 65.4% required the interior of the trailers to be cleaned and 47% required the interior of the trailer to be disinfected.

Some of the practices used in the swine industry are recommended in the feedyard industry as well. Facility design should allow for cattle to be unloaded and loaded near the edge of the facility so if cattle are diseased they can be isolated from the resident herd. It may be beneficial to clean and disinfect trailers at the source before loading incoming cattle since some research has suggested PRRSV of swine can be transmitted while animals are in a contaminated trailer.[16] Cleaning and disinfecting transportation vehicles may be effective at reducing transmission diseases such as PRRSV and suggests these practices may be of benefit to limit exposure of cattle to pathogens on trailers as well.[15] Some studies have shown these procedures may be beneficial at limiting transmission of FMDV as well.[13]

Another common principle is the placement of dead stock outside the perimeter of the feedyard which provides access for the rendering company so the truck does not have to enter the facility and introduce pathogen-laden drainage from diseased animals from another facility. Except for delivery of feedstuffs, it would be beneficial for feedyards to be located out of the public eye to minimize visibility to a potential terrorist looking for a target. Visibility may also be increased by advertising in trade publications as well as the internet. It is may also be wise to reduce the number of visitors and to keep a record those who do visit as a deterrent and to decrease the risk of introducing disease unintentionally. The visitor log would be beneficial in an outbreak where traceability would be desirable. Limiting access to the feedyard to personnel directly involved with the operation (i.e. transportation of cattle and commodities, service providers, cattle buyers) would certainly require fewer resources to be devoted to visitor security, but it is uncertain if risk of disease introduction would be significantly different. More work is needed to determine the real risks guest visitors pose. Access to the facility could be better controlled in a feedyard if they have only one entrance that may be monitored by office staff during regular business hours.

Introduction of certain foreign animal diseases like FMD may require more stringent cleaning and disinfection protocols for individuals traveling between feedyards. Amass et al. [43] found that strict personal hygiene and changing of coveralls may be an appropriate replacement of lengthy periods of animal avoidance for one strain of FMDV. In a swine study of PRRSV Otake et al.[44] found that contaminated hands, boots and coveralls may harbor PRRSV and infect other pigs upon exposure. Sanitation procedures commonly used in the swine industry were effective in preventing transmission of PRRSV by fomites and the hands of personnel. Similar procedures may be useful in preventing transmission in the feedyard, but much more work is needed to evaluate if these practices are applicable to endemic bovine diseases of concern.

Poultry Model

Another model to use for comparison of good management practices for biosecurity and biocontainment is the NAHMS Layers 1999 survey.[45] This survey shows 68.1% of operations did not allow non-business visitors to enter the chicken houses, 11.7% did with sign in and 20.2% did without sign in. Sixty-two percent of operations that allowed non-business visitors (such as friends, family members, tourists) did not allow access if they drove onto another poultry farm earlier that day. Poultry farms restricted access to their operations by using gated entrances (16.5%), a perimeter fence (26.7%), and signage (72.9%) in addition to having animals housed within an enclosed building.

Signage, fences and gates are a visual reminder to personnel and visitors that the animals are valuable for deterring unauthorized access. Some poultry farms are utilizing on-site security measures to limit access to the chicken barns. It is conceivable that these measures may be useful in restricting access within feedyards. Feedyards can further maximize security by locking gates when the facility is left unattended.

Dairy Model

The USDA NAHMS 2002 dairy survey[46] indicated that 75.5% of dairies required no testing of purchased cattle. Only 20.5% of dairy operations quarantined cattle on arrival at the dairy. Only 5.1% of dairy farms had written specific biosecurity and biocontainment strategies. Almost all dairy producers (97.9%) reported they would contact their local veterinarian if they suspected a foreign animal disease on their operation. No visitors were allowed on 13.5% of diaries. Disposable boots were available for visitors in 16.3% of dairy operations. Some (38.6%) dairies included in the survey had guidelines that set conditions for visitor access to cattle.[47] Outside vehicles had restricted access to the cattle in 44.2% of dairies. Of dairies with more than 30 dairy cows, only 42.1% trained personnel in biosecurity and biocontainment practices. Equipment was used for both feed and manure handling in 58.8% of dairies. Only 5.7% of dairies cleaned and disinfected equipment after hauling manure when the same equipment was also used for feedstuffs.

This model may have even less in common with the feedyard industry aside from a commonality of species as compared to the above mentioned models. Population turnover is much slower in dairies than the meat production systems. Some testing on arrival is done in the dairy system. Villarroel et al.[20] recommends dairy cattle be tested for diseases such as BVDV and Johne's disease prior to introduction.

Testing cattle in the feedyard is impractical with most diseases with the possible exception of BVDV. Persistently infected cattle can be identified using an ear notch sample and results can be known within 12 hours of submitting the sample, depending on the laboratory doing the testing. The effects of persistently infected (PI) BVD calves on pen morbidity are a controversial topic of discussion. O'Connor et al.[48] found that PI cattle were not associated with increased disease prevalence among commingled groups while Loneragan et al.[49] found there to be increased incidence of respiratory disease in cattle that had contact with PI individuals. Feedyards will of necessity continue to import cattle that have been commingled with other cattle at the auction market without testing or a period of isolation.

Quarantine and isolation is another principle of traditional biosecurity programs. While only one-fifth of dairies quarantine, recommendations are to keep new cattle separate from the resident herd for 30 days before introduction.[25] During this period, animals should be monitored for signs of illness, tested and if necessary vaccinated to match the immune status of the herd. If animals cannot be kept on another site, they should be kept on the edge of the premises away from contact with other cattle. The resident herd should not share bunk space, water sources, fence lines, and should not be exposed to drainage from the quarantine pen.[25]

Most feedyards keep cattle in the receiving area until they are processed (vaccinated, dewormed, identified, and possibly implanted, castrated and/or dehorned . Within three days of arrival they are introduced to the rest of the cattle and placed in their home pen. The idea of quarantine may not be well accepted because facility design will not support separation of cattle for a long period of time when the optimal goal is to keep every pen full.

Results from the USDA NAHMS 2002 dairy survey show dairies that allowed visitors sometimes required disposable boots to be worn. Biosecurity practices regarding clean boots and outer clothing have been previously recommended for dairies.[25] This practice is particularly important if fecal contamination of clothing or shoes occurs. Feedyards should also instruct personnel and visitors to avoid walking across feed bunks or in feed storage areas because of the risk of fecal-oral transmission of diseases like Salmonellosis. Restricting visitors and vehicles from accessing cattle is a good biosecurity practice. If vehicles are allowed on the dairy, Wells et al.[25] suggests they should be cleaned and disinfected before entry to decrease the risk of indirect transmission by a contaminated vehicle. Similarly, signage at the feedyard will give feedyard personnel an opportunity to enforce cleaning and disinfection procedures and reduce the likelihood of indirect disease transmission. Prevention of unauthorized access in this way may decrease risk of accidental disease introduction.

Cleaning and disinfection must be central to activities in any facility that uses equipment for both feed handling and for hauling manure. Only a small number of dairies disinfected equipment used for both manure and feed handling, contrary to recommendations by experts to keep equipment used for hauling manure away from feedstuffs.[25] Feedyards may be using equipment for both tasks because smaller operations cannot justify purchasing equipment to be dedicated to a single task.

Less than half of the dairies trained personnel in biosecurity and biocontainment practices. Villarroel et al.[20] suggested guidelines in dairies should be structured in a way similar to a HACCP system where a risk assessment is conducted to identify areas were disease transmission could be controlled. These guidelines apply directly to the feedyard industry as well and should be practiced by the feedyard management and veterinarian to better control disease risk. Prevention strategies are written for each control point and a method of monitoring is used to evaluate the effectiveness of each strategy. Not all measures will be practical or economically feasible depending on the operation. Evaluation of the cost-benefit ratio for biosecurity and biocontainment practices is important. However, some practices may directly benefit an operation's production efficiency and reduce clinical disease providing the foundation for a more profitable operation.[6] Plans will also be different dependent on the pathogen considered and the desired relative risk reduction. The next step is writing a procedural outline for personnel to follow when an actionable animal disease is suspected.

More research is needed to understand the value of these practices in feedyards. Dairies typically have a much lower turnover in personnel than feedyards, but some of the principles mentioned above will be useful in both operations. Poultry and swine production practices may be useful in some cases. It is important to note the differences between agents and industries that make a large impact on which biosecurity and biocontainment strategies should be adopted by feedyards. Research is needed to further characterize the value of these strategies.

Foreign Animal Disease

Foot and Mouth Disease

Of all the bovine diseases, FMD is one of the most contagious bovine viruses and would cause the most disruption of the US economy if introduced. In one survey veterinarians considered this disease to be the most likely agent to be introduced by a terrorist.[7] Feedyard biosecurity and security practices should be written so that if FMDV enters the US, mitigation strategies can be implemented to prevent introduction of disease into individual production units.

Foot-and-mouth disease is best known for the vesicular lesions found in the mouth that result in inappetance and excessive salivation. Lesions are also located at the coronary band resulting in lameness, and on the teats. Although the disease is rarely fatal in adults, morbidity is nearly 100%.

There are seven serotypes of FMDV with over 60 subtypes. There is no cross-protection between serotypes. This lack of cross protection is a challenge when designing a vaccine.[50] Bates et al.[51] suggested vaccinating might be more economical than slaughter if it was possible to differentiate between vaccinated and naturally-infected animals assuming that a vaccine stockpile was available for use and contained the serotype of the strain involved in the outbreak. Vaccine production, storage, and efficacy should be evaluated before considering vaccination as a method of FMDV eradication.

The rate of disease spread will be an important factor in determining the cost of an outbreak.[26] The rate of FMDV spread depends upon the spatial distribution of animals, the species of animals present and the size of the operations themselves.[52] Contact rates between ranches and farms should be analyzed to better understand the rate of spread. Immediate action should be taken to decrease the rate of commingling in the case of disease introduction. Preventing animal contact with animals in other herds is an important method used to decrease the number of animals infected, culled, and the duration of the outbreak.[52]

Keeling et al.[52] found that control strategies need to occur at the very onset of the outbreak to be effective by using Monte Carlo simulation. Taking immediate action would be a challenge, dependent upon early detection and effective response. Doing so would reduce the number of cases, the number of animals that need to be depopulated, and the duration of the outbreak.

Detection requires identification to locate animals with a history of contact with infected animals. Disney et al.[53] suggested that improved animal identification may reduce foreign animal disease (FAD) consequences and justify implementation of the system improvements needed in cattle operations. Additional benefits included increased consumer confidence in the cattle industry and associated premiums to producers for herd disease certification.[53]

Cost of FMDV introduction

Many economists have attempted to estimate costs associated with an FMDV outbreak. Since the last outbreak in the US occurred in 1929, it is difficult to assess how the economy would react. One of the immediate impacts of an FMDV introduction to the US would be the immediate loss of export markets. The December 2003 case of bovine spongiform encephalopathy (BSE) dropped export quantities 82% below the $3.95 billion value for 2003. The estimated losses associated with BSE in 2004 from exportation of beef and offal ranged from $3.2 to $4.7 billion.[54]

On a national level, lost jobs, complying with described regulations and responding to the outbreaks would be costly.[26] The economic destruction of an introduction of FMDV would include cost of preventative measures to decrease spread coupled with the loss of consumers and a surplus of beef.[26] International exports would be limited and the U.S. would lose the 50-60% premium paid for beef resulting from the U.S.'s FMDV free, vaccination free countries.[55] Cupp et al.[56] estimated direct and indirect costs associated with the accidental introduction of FMDV into the United Kingdom in 2001 cost approximately 11 billion US dollars. Knowles et al.[31] estimated losses from an introduction of FMDV in the United States to be $14 billion while Paarlberg et al.[57] estimated the costs to be as high as $60 billion. One disease model used to evaluate the impact of FMDV introduction in southwest Kansas showed that the more animal identification and records were available during an outbreak, the lower the costs associated with FMDV.[58]

While there are other foreign animal disease risks, FMDV is included in the Class A listing by the Office International des Epizooties (OIE) because of high morbidity and ease of dissemination.[56] The U.S. has not experienced an outbreak since 1929, but with the globalization of society, it seems it is only a matter of time before the US faces an outbreak. Feedyard personnel should be trained to recognize and respond to a FMDV outbreak.

First Responders

Foreign animal disease agents will likely be first discovered by livestock managers, although it may be difficult for them to identify the disease without training.[59] Once they recognize an unusual syndrome they will need to contact their local veterinarian who will contact the Animal Plant Health Inspection Service (APHIS) Veterinary Service (VS) for confirmation and sample collection. Collection of diagnostic samples will be done by a foreign animal disease diagnostician (FADD). The samples will be sent to a National Veterinary Services Laboratory in either Ames, IA or Plum Island, NY for diagnosis of disease and identification of the infectious agent.

The producer, federally accredited veterinarian, state animal health agency, and APHIS must work together for early detection, control and eradication. If an exotic disease outbreak occurs, USDA Veterinary Services has an Eastern and Western Regional Emergency Animal Disease Eradication Organization (READEO). These organizations help coordinate efforts among all parties involved in the eradication efforts. They are trained in confirming the presence of disease, animal appraisal, humane euthanasia and disposal, and ensure proper cleaning and disinfection of premises where infected animals were kept. If an exotic disease is suspected to be introduced as an act of terror, the Federal Bureau of Investigation (FBI) becomes the lead agency.

Endemic Disease

Some diseases are endemic to the feedyard population. Research has been done to better understand the sources of diseases like Salmonellosis and BVD. Biosecurity and biocontainment practices may help decrease morbidity associated with these diseases. Managers may be more willing to adopt procedures to prevent diseases they know currently reside in their feedyards.

Bovine Viral Diarrhea Virus

Bovine viral diarrhea virus (BVDV) is introduced to feedyards primarily by the introduction of persistently infected (PI) animals. It is estimated that the prevalence of PIs in the US beef herd ranges from 0.13-2.0%.[60] Feedyard cattle have multiple opportunities to be exposed to PIs during transport, commingling during marketing and at the feedyard itself. Cattle can transmit the virus by direct nose-to-nose contact or through indirect contact with fomites such as processing facilities and oral treatment equipment. Within the feedyard, exposure to BVDV PI animals can cause immune-suppression leading to respiratory disease in animals with a naïve immunity for BVDV. Strategies to prevent morbidity associated with BVDV include testing and removal of positive animals prior to introduction to the feedyard. The economic value of this strategy is controversial.[48,49]

Salmonellosis

Salmonella is an organism that is endemic in feedyards. The NAHMS 1999 Feedyard survey reported a prevalence of 6.3% by fecal culture in feedyard cattle.[61] Surveys report an infection rate of 13-15% in beef cattle in New Zealand.[62] Salmonellosis is usually transmitted by ingestion of feedstuffs or water contaminated by fecal waste from an infected animal. The ability for enteric agents like *Salmonella* to survive in the environment makes transmission more difficult to control. Animals with diarrhea can shed up to 10^8 *Salmonella* per gram of feces.[63] Plym-Forshell et al.[64] showed *Salmonella dublin* survived in dried manure on the wall of an old barn for over 5 years on both concrete and rubber surfaces. The same research team isolated *Salmonella typhimurium* from a slurry pit that had been empty for 4 years.[64] Because of the survival of *Salmonella* in feces it is also important for feedyard personnel to avoid walking in the bunk with manure contaminated boots. Personnel should clean manure from the tires of equipment and vehicles before driving through feed storage areas. Equipment used to handle carcasses or manure should not be used to handle feedstuffs.[65] Proper cleaning and disinfection is important to minimize disease transmission by equipment in the feedyard.

Salmonella are also shed by cattle in salivary and nasal secretions, making proper cleaning and disinfection of oral treatment equipment important in preventing disease transmission. Removal of the organic material is necessary before the disinfectant maximum efficacy can be achieved.[28]

It has been estimated that *Salmonella* bacteria contaminate 40-50% of protein supplements used in the dairy industry.[63] It is also present in some forages, but proper ensiling will create an environment unfavorable for growth.[65] Estimates for feedstuffs used in the feedyard may be similar to those from the dairy industry. Fedorka-Cray et al.[66] found *Salmonella* spp. as a contaminant in 22.5% of pig feed trucks and 23.5% of pig feed. Feed trucks should be sanitized with hot water and disinfectants between loads to minimize the risk of transmission.[66]

Education

Veterinarians can play a crucial role in biosecurity and biological risk assessment. Wenzel and Nusbaum[67] describe the importance of the veterinarian as a skilled, knowledgeable leader when an outbreak of disease requires a quick response. Veterinarians as defined by the Homeland Security Presidential Directive 8 are first responders responsible for protecting and preserving life, property, public health, and providing clinical care.[68] Their role in providing leadership in the application of an eradication program will be important during an emergency outbreak of disease. The therapy delivered during an emergency could be very critical to the longevity and duration of the disease. Veterinarians can gain information about disaster management to supplement their current knowledge of foreign animal diseases from the American Veterinary Medical Association[69] and from the Animal Plant and Health Inspection Service.[70] Unfortunately, a shortage of veterinarians has been predicted among the agencies that oversee public health and the care of food animals.[71]

Contribution of this Research

There is little research data available in the area of feedyard biosecurity, biocontainment, and security. Objective data on real versus perceived risk is difficult to obtain for intentional disease introduction risks. Data about endemic agents in feedyards are more readily available but still limited. Some data is available on current practices in other animal production systems. Unique characteristics of the design of feedyards and the management of the cattle make adoption of some practices difficult or impractical. More research is needed to understand which practices will be economically rewarding.

Gathering data through surveys is an effective way to determine what the current biosecurity practices are in feedyards. Surveys also help identify perceptions held by industry representatives about biological threats, routes of introduction, and the importance of mitigation strategies aimed at prevention or control. The results of this work will provide benchmarks for feedyard managers in the areas of biocontainment, biosecurity and security. Consulting veterinarians can use this information for comparison when making recommendations in these areas.

References

1. Web site. U.S. Cash Receipts from Farming available at https://www.beef.org/uDocs/uscashrecieptsfromfarming.pdf Accessed on June 5, 2007.

2. Website. Monthly Federally Inspected Weekly Average Beef Production. Available at http://www.cattle-fax.com/data/. Accessed on May 11, 2007.

3. Ball CE, Cornett S. Cattle feeding in the United States: the first 300 years In: Albin RC,Thompson GB, eds. *Cattle feeding: a guide to management*. Amarillo, TX: Trafton Printing, Inc., 1990;3-15.

4. USDA: Agriculture Statistics Board: National Agricultural Statistics Service: Cattle on feed, February 23, 2007. Available at http://www.nass.usda.gov/Publications/Todays_Reports/reports/cofd0207.pdf. Accessed on May 10, 2007.

5. Ensminger ME, Perry RC. *Beef Cattle Science*. 7th ed: Interstate Publishers, Inc., 1997.

6. Wells SJ. Biosecurity on Dairy Operations: Hazards and Risks. *J Dairy Sci* 2000;83:2380-2386.

7. Brandt AW, Sanderson MW, DeGroot BD, et al. Feedyard manager and veterinarian responses to a feedyard biosecurity survey. *Bov Pract (IN PRESS)* 2007.

8. Breeze R. Agroterrorism: betting far more than the farm. *Biosecurity and bioterrorism: biodefense strategy, practice, and science* 2004;2:1-14.

9. Barham AR, Barham BL, Johnson AK, et al. Effects of the transportation of beef cattle from the feedyard to the packing plant on prevalence levels of *Escherichia coli* O157 and *Salmonella* spp. *J Food Prot* 2002;65:280-283.

10. Knowles TG. A review of the road transport of cattle. *Vet Rec* 1999;144:197-201.

11. Bailey D, Peterson MC, Brorsen BW. A Comparison of Video Cattle Auction and Regional Market Prices. *American Journal of Agricultural Economics* 1991;73:465-475.

12. Kettle R, Bailey D, Torell R, et al. Marketing Cattle in 2000 and Beyond: Technology's Role in Livestock Marketing In: Service E, ed: University of Nevada, Reno, 2000.

13. Parker JJ. Presence and inactivation of foot-and-mouth disease virus in animal faeces. *The Veterinary Record* 1971;88:659-662.

14. Sellers RF, Burrows R, Garland AJ, et al. Exposure of vaccinated bulls and steers to airborne infection with foot-and-mouth disease. *Vet Rec* 1969;85:198-199.

15. Dee S, Deen J, Burns D, et al. An assessment of sanitation protocols for commercial transport vehicles contaminated with porcine reproductive and respiratory syndrome virus. *Can J Vet Res* 2004;68:208-214.

16. Dee SA, Deen J, Otake S, et al. An experimental model to evaluate the role of transport vehicles as a source of transmission of porcine reproductive and respiratory syndrome virus to susceptible pigs. *Can J Vet Res* 2004;68:128-133.

17. Bach SJ, McAllister TA, Mears GJ, et al. Long-haul transport and lack of preconditioning increases fecal shedding of *Escherichia coli* and *Escherichia coli* O157:H7 by calves. *J Food Prot* 2004;67:672-678.

18. Dargatz DA, Garry FB, Traub-Dargatz JL. An introduction to biosecurity of cattle operations. *Vet Clin North Am Food Anim Pract* 2002;18:1-5.

19. Anderson JF. Biosecurity-a new term for an old concept-how to apply it. *Bov Pract* May 1998: 32.2: 61-70.

20. Villarroel A, Dargatz DA, Lane VM, et al. Suggested outline of potential critical control points for biosecurity and biocontainment on large dairy farms. *Journal of the American Veterinary Medical Association* 2007;230:808-819.

21. USDA. Part III: health management and biosecurity in U.S. feedlots, 1999. Ft Collins, Colorado.: USDA:APHIS:VS:CEAH, 2000 #N336.1200.

22. Smith DR, Klopfenstein T, Moxley R, et al. An evaluation of three methods to clean feedlot water tanks. *Bov Pract* 2002;36:1-4.

23. Griffin DD. Feedlot Biosecurity-Security in the Real World, 2005. Available at http://gpvec.unl.edu/files/feedlot/internettempfiles/. Accessed on May 1, 2007.

24. Sanderson M, Sargeant J, Spire M. Biosecurity health protection and sanitation strategies for cattle: College of Veterinary Medicine, Kansas State University, 2001. Available at http://www.oznet.ksu.edu/fmd/biosecurity.htm. Accessed on April 10, 2007.

25. Wells SJ, Dee S, Godden S. Biosecurity for gastrointestinal diseases of adult dairy cattle. *Veterinary Clinics of North America: Food Animal Practice* 2002;18:35-55.

26. Elbakidze L. The Economics of Agricultural Bio-security: An Interpretive Literature Review. *Department of Agricultural Economics, Texas A&M University*. College Station, Texas. Accessed on April 15, 2007. Available at http://txspace.tamu.edu/handle/1969.1/3076., 2003.

27. Stevenson SML, McAllister TA, Selinger LB, et al. Transfer of a rifampicin-resistant *Escherichia coli* strain among feedlot cattle. *Journal of Applied Microbiology* 2003;95:398-410.

28. Kahrs RF. General disinfection guidelines. *Rev Sci Tech* 1995;14:105-163.

29. Buhman M, Dewell G, Griffin D. Biosecurity basics for cattle operations and good management practices (GMP) for controlling infectious diseases: University of Nebraska-Lincoln Extension, Institute of Agriculture and Natural Resources, 2005. Available at http://www.vetlife.com/support/techtalks/web/index.html?page=source%2Fhtml%2Fbiosecurity.htm. Accessed on January 10, 2007.

30. Cobbold RN, Rice DH, Davis MA, et al. Long-term persistence of multidrug-resistant *Salmonella enterica* serovar Newport in two dairy herds. *Journal of the American Veterinary Medical Association* 2006;228:585-591.

31. Knowles T, Lane J, Bayens G, et al. Defining law enforcement’s role in protecting American agriculture from agroterrorism. Accessed on October 15, 2007.

Available at http://www.ncjrs.gov/pdffiles1/nij/grants/212280.pdf.: U.S. Department of Justice, 2005.

32. Ackerman GA. Beyond Arson? A Threat Assessment of the Earth Liberation Front. *Terrorism and Political Violence* 2003;15:143-170.

33. Cameron G, Pate J. Covert biological weapons attacks against agricultural targets: assessing the impact against US agriculture. *Terrorism and Political Violence* 2001;13:61-82.

34. Wheelis M, Rocco Casagrande, and Laurence v. Madden. Biological Attach on Agriculture: Low-tech, high-impact bioterrorism. *Bioscience* 2002;52:569-576.

35. Leitenberg M. Biological weapons and "bioterrorism" in the first years of the 21st century. Conference on the Possible Use of Biological Weapons by Terrorists Groups: Scientific, Legal, and International Implications: Rome, Italy. 2002. Available at http://www.armscontrolcenter.org/cbw/papers/journals/apr_2003_bioterrorism_21st_century.pdf. Accessed on October 15, 2006.

36. Abt CC. Current and improved biodefense cost-benefit assessment In: Richardson HW, Gordon P,II JEM, eds. *The Economic Impacts of Terrorist Attacks*: Edward Elgar Publishing, 2005;119-132.

37. Poison is suspected In death of 30 cows on a Muslim farm. *New York Times, p 30*, 1970.

38. Neher NJ. The need for a coordinated response to food terrorism: the Wisconsin experience. *Ann NY Acad Sci* 1999;894:181-183.

39. Shaw T. Poison intentional, cattle owner says. Omaha World-Herald. April 28, 2003. Available online at http://savrx.pcpcorp.net/cows/. Accessed on June 5, 2007.

40. Hovey A. Somebody killed cattle, owner says. *Lincoln Journal Star*, April 30, 2003. Available online at http://savrx.pcpcorp.net/cows/.

41. Moore C. Biosecurity and minimal disease herds. *Vet Clin North Am Food Anim Pract* 1992;8:461-474.

42. USDA. Part I: reference of swine health and management in the United States, 2000. Fort Collins, CO: USDA:APHIS:VS:CEAH, 2001 #N338.0801.

43. Amass SF, Mason PW, Pacheco JM, et al. Procedures for preventing transmission of foot-and-mouth disease virus (O/TAW/97) by people. *Vet Microbiol* 2004;103:143-149.

44. Otake S, Dee SA, Rossow KD, et al. Transmission of porcine reproductive and respiratory syndrome virus by fomites (boots and coveralls). *J Swine Health Prod* 2002;10:59-63.

45. USDA. Part II: reference of 1999 table egg layer management in the U.S. Fort Collins, CO: USDA:APHIS:VS:CEAH, 2000 #N323.0100.

46. USDA. Part I: reference of dairy health and management in the United States, 2002. Fort Collins, Colorado: APHIS:VS:CEAH, 2002 #N377.1202.

47. USDA. Dairy 2002. Descriptive report part III: Reference of dairy cattle health and health management practices in the United States, 2002.: USDA:AHPIS:VS, CEAH, National Animal Health Monitoring System, 2002.

48. O'Connor AM, Sorden SD, Apley MD. Association between the existence of calves persistently infected with bovine viral diarrhea virus and commingling on pen

morbidity in feedlot cattle. *American Journal of Veterinary Research* 2005;66:2130-2134.

49. Loneragan GH, Thomson DU, Montgomery DL, et al. Prevalence, outcome, and health consequences associated with persistent infection with bovine viral diarrhea virus in feedlot cattle. *Journal of the American Veterinary Medical Association* 2005;226:595-601.

50. Ekboir JM. Potential impact of foot-and-mouth disease in California: the role and contribution of animal health surveillance and monitoring services: Agricultural Issues Center: Division of Agriculture and Natural Resources: University of California. Available at http://aic.ucdavis.edu/pub/fmd.html. Accessed on November 1, 2006., 1999.

51. Bates TW, Carpenter TE, Thurmond MC. Benefit-cost analysis of vaccination and preemptive slaughter as a means of eradicating foot-and-mouth disease. *American Journal of Veterinary Research* 2003;64:805-812.

52. Keeling MJ, Woolhouse MEJ, Shaw DJ, et al. Dynamics of the 2001 UK Foot and Mouth Epidemic: Stochastic Dispersal in a Heterogeneous Landscape. *Science* 2001;294:813-817.

53. Disney WT, Green JW, Forsythe KW, et al. Benefit-cost analysis of animal identification for disease prevention and control. *Rev Sci Tech Off int Epiz* 2001;20:385-405.

54. Coffey B, Mintert J, Fox S, et al. *The economic impact of BSE on the US beef industry: product value losses, regulatory costs and consumer reactions*: United States Department of Agriculture Economic Research Service, 2005.

55. Javier Ekboir LSJDASJEBWRS. Changes in foot and mouth disease status and evolving world beef markets. *Agribusiness* 2002;18:213-229.

56. Cupp OS, II DEW, Hillison J. Agroterrorism in the U.S.: key security challenge for the 21st century. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 2004;2:97-105.

57. Paarlberg PL, Lee JG, Seitzinger AH. Potential revenue impact of an outbreak of foot-and-mouth disease in the United States. *Journal of the American Veterinary Medical Association* 2002;220:988-992.

58. Pendell DL. Value of animal traceability systems in managing a foot-and-mouth disease outbreak in southwest Kansas. *Department of Agricultural Economics*. Manhattan, KS: Kansas State University, 2006. Available at http://krex.ksu.edu/dspace/handle/2097/199. Accessed on May 15, 2007.

59. Williams JL, Sheesley DAN. Response to Bio-terrorism Directed against Animals. *Annals of the New York Academy of Sciences* 2000;916:117-120.

60. Larson RL. Why control BVD: Economic and production costs, tools to accomplish. Available at http://www.ars.usda.gov/SP2UserFiles/Place/36253000/BVD2005/Produce1_Larson_Hout.pdf. Accessed on May 1, 2007.

61. USDA:APHIS:VS. *Salmonella* in United States Feedlots. *Info Sheet* Fort Collins, CO, 2001 #N346.1001.

62. Ekperigin HE, Nagaraja KV. Microbial food borne pathogens. *Salmonella*. *Vet Clin North Am Food Anim Pract* 1998;14:17-29.

63. House JK, Smith BP. Profitable strategies to control salmonellosis in dairy cattle. 23rd World Buiatrics Congress July 11-16, 2004 Accessed on April 15, 2007 Available at http://wwwivisorg/proceedings/wbc/wbc2004/WBC2004-House-simplepdf.

64. Plym-Forshell L, Ekesbo I. Survival of *salmonellas* in urine and dry faeces from cattle--an experimental study. *Acta Vet Scand* 1996;37:127-131.

65. House JK, Smith BP. Profitable strategies to control salmonellosis in dairy cattle. World Buiatrics Congress 2004.

66. Fedorka-Cray PJ, Hogg A, Gray JT, et al. Feed and feed trucks as sources of *Salmonella* contamination in swine. *Swine Health and Production* 1997;5:189-193.

67. Wenzel JGW, Nusbaum KE. Veterinary expertise in biosecurity and biological risk assessment. *Journal of the American Veterinary Medical Association* 2007;230:1476-1480.

68. Bush GW. Homeland Security Presidential Directive/HSPD-8. Washington, DC: The White House, Office of the Press Secretary, 2003. Accessed June 2, 2007.

69. Disaster preparedness. AVMA Website. Available at www.avma.org/producs/disaster/responseguide/responseguide_toc.asp. Accessed June 2, 2007.

70. Animal and Plant Health Inspection Service. National Veterinary Accreditation Program. Available at : www.aphis.usda.gov/animal_health/vet_accreditation/. Accessed June 2, 2007.

71. Prince JB, Andrus DM, Gwinner KP. Future demand, probable shortages, and strategies for creating a better future in food supply veterinary medicine. *Journal of the American Veterinary Medical Association* 2006;229:57-69.

CHAPTER 2 - Feedyard Manager and Veterinarian Responses to a Feedyard Biosecurity Survey

Abstract

A Delphi-like survey series was used to gain knowledge about feedyard biosecurity and security from feedyard managers and feedyard veterinarians. A panel of managers and a panel of veterinarians were selected after being recommended as experts in the industry. Three rounds of the same survey were used to gather consensus opinion from each expert panel about perceived disease risks and mitigation strategies. The two groups were given the same survey with two additional questions about domestic and international terrorists asked of veterinarians. Results showed veterinarians and managers have very similar views on the likelihood of disease caused by terrorism, natural introduction, or accidental introduction and on the importance of on-site security. Both groups agreed that foot-and-mouth disease virus (FMDV) or toxins would be the most likely agents to be introduced by a terrorist. Respondent groups disagreed on the importance of preventative products, disease transmission control, and environmental control. Most of the differences can be attributed to the veterinarians placing less importance on the aforementioned categories when considering likely routes of introduction for diseases considered in the survey. Difference in awareness of these issues is significant because veterinarians are pivotal in educating the feedyard staff about the prevention of disease entry and transmission.

Introduction

Biosecurity and security are important aspects of disease prevention in any agricultural production system. Feedyards are particularly vulnerable to disease introduction because of the large number of cattle procured annually from multiple sources, as well as the large concentration of animals in one place.[1] Further, feedyards are mostly outdoor facilities with the exceptions of a few total confinement facilities. Unlike the indoor, total confinement operations in the swine industry, with this natural environment comes a large perimeter that is much harder to control. The high cattle turnover rate in the feedyard allow new cattle arrivals to introduce pathogens and be exposed to pathogens already at the yard, making it difficult or impractical to control disease introduction to the feedyard in some instances. The high concentration of animals in a feedyard is a potentially attractive target for bioterrorism by domestic or international terror groups. The extensive perimeter of a typical feedyard provides numerous opportunities for unauthorized entry to the feedyard by individuals or groups with malicious intent. If the goal of the terror group was to damage the economy of the beef industry and the United States in general, large numbers of cattle could be infected by selected agents with a relatively small amount of resources or time. The economic losses that accompany the treatment or elimination of a toxic (i.e. organophosphate) or infectious (i.e. foot-and-mouth disease virus (FMDV)) agent in a feedyard would be substantial. These issues highlight the need for appropriate security and biosecurity practices in feedyards.

This paper discusses the findings from a survey of two expert groups associated with the feedyard industry: feedyard veterinarians and feedyard managers. The information from these experts is a valuable resource for determining the current understanding of real and perceived threats to feedyard security as well as strategies to minimize routes of disease introduction. The purpose of this survey was to utilize the knowledge of feedyard veterinarians and feedyard managers to determine the importance of different aspects of biosecurity/security in feedyards using a Delphi-like survey.

Materials and Methods

Survey development

A Delphi-like survey series was submitted to feedyard veterinarians and managers of Central Plains feedyards to assess expert knowledge and opinion regarding security and biosecurity risks and practices. The survey followed the iterative nature of a Delphi survey, but without the exploration phase employed in a traditional Delphi survey. Experts responded directly to pre-established questions regarding disease introduction and mitigation strategies. Questions were asked about the probability of accidental, natural, and terrorist introduction of specific disease agents or toxins. Natural introduction was defined as one in which human activity is not directly involved such as an introduction of disease agents by wildlife or introduction of toxins by mechanical failure. Accidental introduction was defined as involving direct but unintentional human activity such as an introduction of a disease agent by unclean boots or introduction of toxins by feed mixing errors. Terrorist introduction was defined as involving intentional human activity to introduce a disease agent or toxin. Six choices were provided for respondents to rank the probability of each agent’s introduction by accidental, natural and terrorist means. Respondent choices were: very high probability, high probability, moderate probability, low probability, no probability and I don't know, represented by the numbers 1-6 respectively.

Questions were also asked about the importance of preventative products (available vaccines, dewormers, antibiotics and veterinary health care), environmental control (wildlife control, bird control, insect control, cleaning procedures and decontamination procedures), disease transmission control (isolation of incoming animals and isolation of sick animals), and on-site security (guards, fences, movement of vehicles on the property, traffic control, employee screening and employee education) in minimizing the probability of introduction of disease into a feedyard. Again, six choices were provided for respondents to rank the importance of preventative products, environmental control, disease transmission control, and on-site security for each agent. Respondent choices were: very high importance, high importance, moderate importance, low importance, not important and I don't know, represented by the numbers 1-6 respectively.

Fourteen disease agents and toxins were considered for each question (Tables 1-2). Feedyard managers and veterinarians were given the same survey (total of 98 possible responses) with the addition of two questions in the veterinary survey (total of 107 possible responses). The additional questions asked veterinarians about security measures and risks associated with domestic and international terrorist groups. Veterinarians were provided one free form response question for other comments.

Initially, six feedyard managers were chosen to pre-test the design of the survey and the clarity of the questions. Four managers reviewed and commented on the survey structure and clarity. Revisions were made and the survey was prepared for data collection. The survey was approved by the Kansas State University Institutional Review Board committee for Research Involving Human Subjects prior to submission to the participants. A copy of the survey is available from the corresponding author.

Cooperator recruitment

Nineteen Central Plains feedyard managers were recommended for inclusion by academic and consulting feedyard veterinarians. Based on recommendations by academic veterinarians associated with the beef industry, 15 veterinarians in consulting practice, academia, and industry were recommended for the survey. Both groups were contacted by phone, given an explanation of why they were selected as well as a description of the survey series and asked to participate.

Survey conduct

In order to maximize response the survey was offered to managers and veterinarians as either an electronic survey utilizing the Kansas State University on-line survey system or as a hard copy sent by mail. Participants were allowed to respond by whichever means they preferred. Reminders were emailed every five days for three weeks or until the participants completed the survey. If necessary, participants were also contacted by phone to encourage completion of the survey. Three rounds of the same survey were given to each feedyard manager and veterinarian. Following each round, median responses were calculated for each question and each group separately (feedyard managers and veterinarians). Therefore, the second round had the same question set including the median response to each question from the first round. This process was repeated again providing the median scores from the second round of the survey to cooperators and eliciting their answers for the third round.

Analysis

The third round median responses were calculated and summarized for each question and each group for comparison utilizing a commercially available spreadsheet program (Excel 2003, Microsoft Corp, Redmond, WA). For questions where the median score of veterinarians and managers differed by more than 2, a Wilcoxon rank-sum test was used to determine if significant differences were present between the responses of the two groups.

Results

Of the 19 managers recommended for the survey, 18 managers contacted by phone agreed to participate in the survey. A current phone number was not found for one manager. One manager that agreed to cooperate was inadvertently dropped from the survey list. The 17 managers surveyed represented KS (12), NE (2), and TX (3). Of the 15 veterinarians contacted 13 agreed to participate in the survey. One veterinarian did not respond to messages and was not contacted and another did not consent. The 13 veterinarians surveyed represented KS (5), TX (2), NE (1), MO (1), OK (1), ID (1), CO (1), and IA (1). Fourteen managers (82%) responded to the first round of surveys, 10/17 (59%) responded to the second round, and 12/17 (71%) responded to the third round of surveys. The reported manager response rate in the second round was lower than the actual response rate because some managers responded both electronically and by mail. The duplicate surveys could not be identified because of the anonymous nature of both methods, so only the electronic surveys were used. All cooperating veterinarians responded to the first round of surveys, 11/13 (85%) responded to the second round, and 9/13 (69%) veterinarians responded to the third round of surveys.

A summary of the median responses from the third round of surveys are shown in Tables 1 and 2. Between the first and third rounds of the survey 29% of question specific median responses changed in the manager survey and 33% changed in the veterinarian survey. Ranges narrowed in 71% (70/98) of the manager's responses, and in 68% (73/107) of the veterinarian's question specific responses from the first to the third round of the survey. Veterinarians and feedyard managers had similar views on the likelihood of disease introduction from terrorism, natural introduction, or accidental introduction, and on the importance of on-site security. Veterinarian responses indicated preventative products, disease transmission control and environmental control to be less important in regards to minimizing the probability of disease introduction when compared to feedyard managers. This difference between respondent groups was most consistent in the area of environmental control across all diseases included in the survey except salmonellosis and toxicosis (Table 2).

Manager and veterinarian responses were significantly different when asked about the importance of environmental control in minimizing the probability of introduction of Bovine Spongiform Encephalopathy (BSE) ($p<.05$). Veterinarians thought environmental control was not important, while managers thought environmental control was of high importance in minimizing the probability of introduction of BSE.

Manager and veterinarian responses were also significantly different when asked about the importance of disease transmission control in minimizing the probability of introduction of *Cysticercus bovis* ($p<.05$). Veterinarians thought disease transmission control was not important (range 4-5), while managers thought it was of high importance (range 1-2) in minimizing the probability of introduction of *Cysticercus bovis.*

Veterinarians indicated they believed properly maintained perimeter fences and locked perimeter gates were very highly important, while they considered decreased feedyard visibility and decreased media exposure to be moderately important in preventing the probability of domestic or international terrorism (Table 3). Veterinarians also believed feedyards had a very high probability of being attacked by a domestic terrorist group, and a high probability of being attacked by an international terrorist group. Veterinarian free form responses indicated a recognition of the importance of feed source and feed storage security, of evaluating the economic feasibility of control measures and of raising the general level of awareness of these issues in feedyards.

Discussion

This Delphi-like survey method is useful for eliciting expert opinion in areas where relevant data from the scientific literature is scarce.[2] Utilizing pre-existing questions effectively reduced the time commitment required by respondents to provide valid responses while maximizing response rate. Within each peer group, question specific median responses from the previous round were provided to respondents for consideration during the last two rounds of the survey. Participants answered the same survey multiple times which allowed them to reconsider their responses in light of their peer's response to the same questions from the previous round. Unlike a face-to-face round table discussion, individual responses are equally represented without the potential social pressure to agree with an out-spoken peer.

Feedyard veterinarians noted the need for increased education and awareness of security and biosecurity issues. The difference in responses between veterinarians and managers indicates an opportunity for consulting veterinarians to provide education to feedyard managers and staff on the relative importance of disease introduction risks and routes of transmission (Table 2). This survey series identified environmental control of disease, disease transmission control, and preventative products as particular areas where perception of risk and effectiveness of mitigation strategies differs between feedyard managers and feedyard veterinarians. For example, the difference between feedyard managers and veterinarians in the importance of preventive products and environmental control for BSE risk in the feedyard indicates an area of needed education. There are no available preventive products for bovine spongiform encephalopathy (BSE) and while the agent may survive in the environment it seems more likely that BSE would be introduced through contaminated feedstuffs which would not be prevented through environmental control.

The difference between the two groups when asked about *Cysticercus bovis* showed a similar difference of knowledge regarding the importance of disease transmission control. Feedyard managers believed disease transmission control was of high importance for control of *Cysticercus bovis* risk in the feedyard while veterinarians believed disease transmission control was not important (range 4-5) in controlling *Cysticercus bovis* risk in the feedyard. Humans are the host needed to complete the life cycle of this disease, so the route of transmission for *Cysticercus bovis* may fall more into the area of feedyard staff education and awareness. The disease can be prevented if infected humans are not allowed to defecate in and contaminate animal feed. By definition in this survey, disease transmission control included isolation of incoming animals and isolation of sick animals. Feedyard managers are either unaware of the transmission of *Cysticercus bovis* or did not apply this description in categorizing the importance of disease transmission control for *Cysticercus bovis*.

Differences in awareness of these issues are significant because veterinarians are pivotal in educating the feedyard staff about the prevention of disease entry and spread. If managers are not cognizant of the relative importance of interventions for biosecurity and security, they will benefit from additional expertise from consulting veterinarians in these areas. Veterinarians should be experts on disease risks and routes of transmission in the feedyard.

Veterinarians can provide training to managers and feedyard employees on security and biosecurity practices and the development of effective and economic plans. Although the managerial duties differ between feedyards, the managers share the role as a decision maker in all feedyards. Decisions made by an informed manager will contribute to the health of the cattle and the success of the feedyard. This survey provided information on the views of each group which are useful in developing effective security and biosecurity programs. Development of a security program starts with a good understanding of the disease threats and routes of introduction. The survey identified diseases that are perceived to be most threatening. It has also identified some differences in knowledge between veterinarians and managers regarding disease transmission and provides guidance to veterinarians on what areas managers need additional training.

Understanding the disease increases the effective application of practical and effective prevention protocols.

Because of the high turnover of cattle in feedyard systems, some traditional biosecurity methods of preventing endemic disease introduction are not applicable. There are however security and biosecurity measures that may be warranted to prevent intentional introduction of disease agents and toxins. Veterinarians recognized the need for increased awareness and security. They considered some practices to be valuable deterrent measures, particularly perimeter fences and locked gates. Veterinarians should communicate the perceived importance of these deterrents, however perimeter fences capable of stopping human access may be quite expensive and the cost benefit should be examined. Further research is needed to quantify the value of specific deterrent practices in decreasing the likelihood of a terrorist introduction. Relevant literature is lacking on the most important risks and the effectiveness of security and biosecurity risk mitigation strategies.[3] Discussions and examination of general law enforcement and corporate data on the effectiveness of deterrent practices may be useful.

Veterinarians and feedyard managers had similar views on the likelihood of disease introduction from terrorism, natural introduction, or accidental introduction, and on the importance of on-site security. Both groups believed that FMDV was a high probability threat within the category of terrorist introduction. Managers also thought anthrax was a high probability threat. Al Qaeda documents found during execution of the war in Afghanistan indicate recognition of anthrax as an agent of bioterrorism.[4-6] Despite the evidence of Al Qaeda intent to use anthrax, veterinarians thought anthrax to be a low probability event. Clearly introduction of FMDV to the United States could have massive economic consequences. The accidental introduction of FMDV into the United Kingdom in 2001 cost approximately 11 billion US dollars in direct and indirect costs.[7] Losses from an introduction of FMDV in the United States have been estimated from $14 billion to $60 billion.[8,9] Prevention of its introduction into the country is largely a function of the United States Department of Agriculture (USDA). Once introduced the USDA would implement its plan for response to a highly contagious disease including zones of eradication.[10] Both veterinarians and managers agreed on-site security may be a valuable tool in deterring terrorists from introducing FMDV to a particular feedyard. However, if a neighboring feedyard is infected the "secure" feedyard may still be in the resulting quarantine and "stamping out" area. According to the National Animal Health Monitoring System Feedlot 99 survey, only 18% of feedyards restrict movement of people on the facility for biosecurity/security purposes.[11] If FMD is introduced to the US a ready plan to increase on-site security at the feedlot would be beneficial.

Both groups believed toxins were a moderate to high probability threat from terrorist introduction. Historical precedents exist for both intentional and accidental introduction of toxins into livestock feed.[12] Contamination could occur at the feed manufacturing facility, subsequently exposing numerous livestock facilities. This highlights the need for feedyards to preferentially deal with feed manufacturers that maintain security systems analogous to the Hazard Analysis Critical Control Points (HACCP) model. Alternatively, toxins could be introduced directly to a particular feedyard by a terrorist group or by disgruntled neighbors, competitors or employees. Numerous domestic terrorist groups do exist and have made attacks on animal agriculture which suggests the importance of deterrent security measures.[13] On-site security practices may make this more difficult to achieve and deter all but the most determined attempts or send the terrorist off to an "easier" facility.

The information gathered in this survey is not sufficient to identify all the data necessary to make economic decisions regarding security and prevention of disease introduction. It does provide an understanding of the perception of potential threats to the feedyard industry. Groups like the Earth Liberation Front, Animal Liberation Front and People for the Ethical Treatment of Animals are active antagonists of animal agriculture of all species. They have publicly stated they would welcome FMDV into the United States primarily because they believe it would be good to relieve production animals from their captivity and suffering.[9] In contrast, international terrorists may use a bioterrorism agent for the potential detrimental effects on the economy of the United States.[13,14]

Assessing the economic value of biosecurity and security plans is challenging because good estimates of the probability of a terrorist event are lacking. While we have some historical precedent of feed poisoning, the probability that a domestic or international terrorist group would employ these techniques is unknown. Clearly domestic terrorist groups have shown themselves willing to resort to extreme measures in an attempt to publicize their views and influence public policy.[15]

Conclusion

Objective data on real versus perceived risk is difficult to obtain for terrorist disease introduction risks. However, bioterrorism agents such as anthrax have been considered by Al Qaeda, suggesting that protective measures may be needed.[4-6]

Objective data on natural or accidental disease introduction risk and impact is more available but still incomplete.[16-18] Further data from experimental studies and disease modeling would be helpful to further characterize these risks and impacts. Additional knowledge of the probability and magnitude of risks and the effectiveness of mitigation strategies is needed for risk assessment and the development of economic and effective biosecurity plans for feedyards. The results reported here are helpful in further understanding risk perception in the feedyard from those who likely know it best. Recognition of educational and training needs will help veterinarians to direct implementation of rational biosecurity and security plans on feedyards.

References

1. Breeze R. Agroterrorism: betting far more than the farm. *Biosecurity and bioterrorism: biodefense strategy, practice, and science* 2004;2:1-14.

2. Jones J, Hunter D. Qualitative Research: Consensus methods for medical and health services research. *BMJ* 1995;311:376-380.

3. Moon HW, Kirk-Baer C, Ascher M, et al. US Agriculture is Vulnerable to Bioterrorism. *JVME* 2003;30:96-104.

4. Abt CC. Current and improved biodefense cost-benefit assessment In: Richardson HW, Gordon P,II JEM, eds. *The Economic Impacts of Terrorist Attacks*: Edward Elgar Publishing, 2005;119-132.

5. Anthrax vaccine immunization program. Several potential adversaries have worked to develop an offensive biological warfare capability using anthrax. Available at www.anthrax.osd.mil/threat/potential.asp. Accessed October 16, 2006.

6. Leitenberg M. Biological weapons and "bioterrorism" in the first years of the 21st century. Conference on the Possible Use of Biological Weapons by Terrorists Groups: Scientific, Legal, and International Implications 2002.

7. Cupp OS, II DEW, Hillison J. Agroterrorism in the U.S.: key security challenge for the 21st century. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 2004;2:97-105.

8. Paarlberg PL, Lee JG, Seitzinger AH. Potential revenue impact of an outbreak of foot-and-mouth disease in the United States. *Journal of the American Veterinary Medical Association* 2002;220:988-992.

9. Knowles T, Lane J, Bayens G, et al. Defining law enforcement's role in protecting American agriculture from agroterrorism. Accessed on October 15, 2007. Available at http://www.ncjrs.gov/pdffiles1/nij/grants/212280.pdf.: U.S. Department of Justice, 2005.

10. Ekboir JM. Potential impact of foot-and-mouth disease in California: the role and contribution of animal health surveillance and monitoring services: Agricultural Issues Center: Division of Agriculture and Natural Resources: University of California. Available at http://aic.ucdavis.edu/pub/fmd.html. Accessed on November 1, 2006., 1999.

11. USDA. Part III: health management and biosecurity in U.S. feedlots, 1999. Ft Collins, Colorado.: USDA:APHIS:VS:CEAH, 2000 #N336.1200.

12. Kosal ME, Anderson DE. An unaddressed issue of agricultural terrorism: A case study on feed security. *Journal of Animal Science* 2003;82:3394-3400.

13. Cameron G, Pate J. Covert biological weapons attacks against agricultural targets: assessing the impact against US agriculture. *Terrorism and Political Violence* 2001;13:61-82.

14. Wheelis M, Rocco Casagrande, and Laurence v. Madden. Biological Attach on Agriculture: Low-tech, high-impact bioterrorism. *Bioscience* 2002;52:569-576.

15. Ackerman GA. Beyond Arson? A Threat Assessment of the Earth Liberation Front. *Terrorism and Political Violence* 2003;15:143-170.

16. Millan J, Aduriz G, Moreno B, et al. Salmonella isolates from wild birds and mammals in the Basque Country (Spain). *Rev sci tech Off int Epiz* 2004;24:905-911.

17. Sutmoller P. The Fencing Issue Relative to the Control of Foot-and-Mouth Disease. *Ann NY Acad Sci* 2002;969:191-200.

18. Woodroffe R, Donnelly CA, Jenkins HE, et al. Culling and cattle controls influence tuberculosis risk for badgers. *PNAS (Proceedings from the National Academy of Sciences)* 2006;103:14713-14717.

Table 1 - Comparison of Managers and Veterinarian Responses* to Probability of Disease Introduction by Terrorist, Natural, or Accidental Introduction.

	Terrorist Introduction		Natural Introduction		Accidental Introduction	
Diseases	Managers	Veterinarians	Managers	Veterinarians	Managers	Veterinarians
Anthrax	2	4	4	4	4	4
Beef Measles [a]	4	5	4	3	4	3
TB [b]	4	4	4	3	4	4
BVD	4	4	2	1	3	2
BSE	5	5	4	5	4	5
CBP [c]	4	4	2	4	3	4
FMD	2	2	4	4	4	3
Lice	5	5	2	1	3	4
MCF [d]	4	5	4	4	4	4
Mange [e]	4.5	5	3	2	4	3
Salmonellosis	4	4	2.5	2	3	3
Screwworm [f]	4.5	5	4	4	4	5
Toxins [g]	2.5	3	4	4	4	3
VS [h]	3	4	4	3	4	4

SCALE:

1-very high probability.

2-high probability.

3-moderate probability.

4- low probability.

5- no probability.

*Median responses from round 3.

[a] *Cysticercus bovis.*

[b] *Mycobacterium bovis.*

[c] Contagious Bovine Pleuropneumonia-*Mycoplasma mycoides mycoides.*

[d] Malignant Catarrhal Fever.

[e] Sarcoptic or Psoroptic.

[f] Old or New World.

[g] Heavy metals or pesticides.

[h] Vesicular Stomatitis.

Table 2 - Comparison of Managers and Veterinarian Responses* to the Importance of Preventative Products, Environmental Control, Disease Transmission Control and On-Site Security in Preventing Disease Introduction.

	Preventative Products		Environmental Control		Disease Transmission Control		On-Site Security	
Diseases	Managers	Veterinarians	Managers	Veterinarians	Managers	Veterinarians	Managers	Veterinarians
Anthrax	4	4	2	4	2	4	3	3
Beef Measles [a]	4	4	2	3	2	5	3	3
TB [b]	3	4	2	4	2	3	4	4
BVD	1	2	2	4	2	2	3	4
BSE	3	5	2	5	4	5	4	4
CBP [c]	2	4	2	4	2	2	3	4
FMD	2	4	1	3	1	2	1	2
Lice	2	1	2	4	2	3	4	4
MCF [d]	3	4	3	4	2	4	4	4
Mange [e]	2	1	2	4	2	2	4	4
Salmonellosis	3	3	2	2	2	2	3	3
Screwworm [f]	3	4	3	4	3	4	4	4
Toxins [g]	4	4	2	2	4	5	2	3
VS [h]	3	4	2	4	2	3	3	3

SCALE:

1-very high importance.

2-high importance.

3-moderate importance.

4- low importance.

5- not important.

*Median responses from round 3.

[a] *Cysticercus bovis.*

[b] *Mycobacterium bovis.*

[c] Contagious Bovine Pleuropneumonia-*Mycoplasma mycoides mycoides.*

[d] Malignant Catarrhal Fever.

[e] Sarcoptic or Psoroptic.

[f] Old or New World.

[g] Heavy metals or pesticides.

[h] Vesicular Stomatitis.

Table 3 - Veterinarian Responses* to the Importance of Deterrent Measures in Decreasing the Probability of Domestic or International Terrorism in a Feedyard.

Deterrent Measures	Veterinarians
On-Site Security Guard(s)	2
Maintaining a Perimeter Fence	1
Locking Perimeter Gates	1
Video Surveillance	2
Employee Background Screening	2
Decreasing Feedyard Visibility [a]	3
Decreasing Feedyard Media Exposure [b]	3

SCALE:

1-very high importance.

2-high importance.

3-moderate importance.

4- low importance.

5- not important.

*Median responses from round 3.

[a] Visibility from highway or road.

[b] Internet presence, name recognition associated with marketing.

CHAPTER 3 - Biosecurity Practices of Beef Feedyards

Introduction

Biosecurity is an important aspect of disease prevention in any agricultural production system. Traditional biosecurity at the herd level has played a role in animal husbandry since the late nineteenth century eradication of contagious bovine pleuropneumonia from the United States.[1] Diseases such as bovine spongiform encephalopathy and the 2001 outbreak of foot-and-mouth disease (FMD) in the United Kingdom have made biosecurity more important now than ever before. The global marketplace in agricultural trade coupled with increasing international travel has created a demand to consider interventions to prevent unintentional foreign animal disease introduction. Furthermore the rise of international terrorist groups with intent to harm the US coupled with domestic terrorist groups intent on harming US agriculture have increased the potential for an intentional disease introduction to US agriculture.[2,3] The beef feedyard is particularly vulnerable to disease introduction because of the large numbers of cattle arriving from multiple sources making practical biosecurity challenging. For the purposes of this paper, the term biosecurity refers to reducing risk associated with the entry of pathologic agents to a particular feedyard by the implementation of mitigation strategies.

Biocontainment is related to biosecurity. Biocontainment is achieved by implementing strategies to reduce risk associated with the transmission of pathologic agents between animals already within a feedyard. The large number of animals and the relatively high population density in a modern feedyard make biocontainment an important issue. Disease within the feedyard is inevitable, but can be managed with strategies such as segregation of sick animals from the healthy animals or cleaning and disinfection of equipment and facilities to decrease exposure of naïve cattle. These principles apply to many diseases endemic to the United States feedyard industry.

The large concentration of animals makes a feedyard an inviting bioterrorism target for domestic or international terror groups, highlighting the need for good feedyard security. Security practices in the feedyard are aimed at controlling access to the facility in an effort to protect everything within it from theft, damage, or contamination. Although there have been no reports of intentional disease introductions reported in the US, toxins have been intentionally introduced to feedstuffs fed to food animals in the United States. These intentional introductions have resulted in cattle deaths as well as losses from extended withdrawal times.[4] Contamination of animal feed with chemical or biologic agents is a current threat of extremist groups and activists.[5,6] While objective data describing real versus perceived risk of intentional disease introduction is difficult to obtain, data describing biocontainment, biosecurity and security in feedyards is feasible to obtain. Economic losses resulting from introduction of a contagious foreign animal disease to a feedyard would be substantial, but biosecurity and security plans for each individual feedyard must be economically justifiable.[7] Feedyards in the high plains were surveyed regarding biocontainment, biosecurity and security to characterize current standard practices and assess their impact on the potential biological and economic risks faced by the feedyard industry.

Materials and Methods

Survey data were collected from feedyard managers during a personal interview. Managers were asked to respond to questions and answers were collected into an electronic database. Approval was obtained by the Kansas State University Institutional Review Board Committee for Research Involving Human Subjects. The database and questions were tested using the draft version of the program by visiting with six Kansas feedyard managers. Following revision, the survey was administered in person to feedyard management personnel from feedyards in several central plains states.

Feedyards were sampled from a list of active, confined animal feeding operation (CAFO) permits obtained from Kansas, Nebraska, Colorado, Texas and Oklahoma. Only feedyards with the capacity to feed more than 1,000 head of cattle and that finished cattle for slaughter were included in the study. Feedyard sampling was stratified by one-time capacity categories as defined by the National Agricultural Statistics Service (NASS). The strata were 1,000-4,000 head, 4,000-16,000 head, 16,000-32,000 head, and >32,000 head. Sample size was calculated to allow estimation of the prevalence of management practices within feedlot one-time capacity categories with a 90% confidence interval (+/- 15%) for practices with a prevalence of approximately 25%. In Kansas, contact was attempted with all feedyards holding a CAFO permit for more than 1,000 head. Non-Kansas feedyards were selected for contact based on geographical location in the panhandles of Oklahoma and Texas, northeastern Colorado, and throughout Nebraska in geographic locales to facilitate travel and collection of data. Up to four phone calls were attempted per feedyard in an effort to contact management personnel about participating in the survey.

For feedyards that agreed to participate, visits were scheduled by a second phone call and a meeting time was arranged with a member of feedyard management. The consulting veterinarian for the feedyard was notified of the survey in advance. Feedyards were called and visits were scheduled for each size category until the required number of feedyards for that category was filled. Questions regarding the facility design, security, employees, disease preparedness, feedstuffs, hospital/treatment systems, sanitation, cattle source, handling of sick cattle, and disposal of carcasses were included in the survey.

All data were summarized to provide the frequencies of responses to individual questions. Fisher's exact test was used to assess relationships between cross-classified question responses. P-values < 0.05 were regarded as significant. Odds ratios with 95% confidence intervals were calculated where applicable.

Results

Feedyards

Table 4 illustrates the results of efforts to contact feedyard management for completion of the survey. The survey was performed in 106 feedyards. Of feedyards that were contacted and met the inclusion criteria 72% (159/221) agreed to participate and

67% (106/159) of these were surveyed. The frequency distribution of feedyards surveyed in each of the four NASS categories were: 1,000-4,000 head (29), 4,000-16,000 head (32), 16,000-32,000 head (25), and >32,000 head (20). One-time capacity in feedyards in this survey ranged from 1300 to 125,000 head. Surveys were answered by owners (19), managers (85), and assistant managers (2).

Descriptive responses to areas of biocontainment, biosecurity and security are reported in tables 5, 6 and 7 respectively. In this survey, 44.3% of feedyards cleaned oral treatment equipment weekly or less often, 69.3% cleaned the unloading facility monthly or less often, and 24.5% cleaned the treatment facility monthly or less often. Feedyards that unloaded cattle into a multi-purpose facility used for both treatment and unloading did not clean the facility more often than those that used a separate unloading facility (P=.35).

The majority of feedyards import cattle directly from the auction market. Feedyard size had no association with the likelihood of importing more than 51% auction market cattle (P=0.90). Thirty-four percent of feedyards reported importing >25% backgrounded cattle directly into the feedyard. The dead stock were located outside of the normal feedyard traffic pattern in 71.7% of feedyards.

Forty-seven percent of the feedyards in the survey did not lock cattle behind gates or employ a night watchman. Only 26.4% of feedyards performed both a criminal background check and checked on resume references given by new employees.

Discussion

The purpose of this survey was to assess the current practices of feedyards in biocontainment, biosecurity and security. The states included in the survey represent 5 of the top 7 beef producing states in the nation. These states feed 77% (9,230,000 head) of the total cattle fed in US feedyards with a one-time capacity of 1,000 head or more as of January 1, 2007.[8]

Biocontainment

The feedyard is a population dense environment with numerous opportunities for disease transmission. Biocontainment practices should be implemented to reduce disease transmission. Segregation of diseased cattle to avoid direct exposure of healthy cattle is the basis of transmission control for endemic agents.[9,10] Despite this a substantial number of feedyards surveyed (36.8%) allowed fence-line contact between sick cattle in the hospital system and healthy cattle.

One quarter of feedyards use the same equipment to handle both manure and dead stock and feedstuffs (Table 5). This practice is most common among the smallest feedyards. Among those yards that handle manure, dead stock and feed with the same equipment, only 15% clean and disinfect that equipment prior to handling feed. Dead animals can continue to threaten healthy cattle if equipment is used for handling carcasses and subsequent feed handling. This risk is highest if feedyards do not thoroughly clean and disinfect the equipment before using it for feedstuffs. Transmission and persistence of agents such as *Salmonella, E. coli* O157 and bovine viral diarrhea virus (BVDV) may be facilitated by this practice. *Esherichia coli* O157 can survive for days in manure depending on the storage temperature.[11] *Salmonella dublin* has been found in dried manure after 5 years and in an empty slurry pit after 4 years.[12] Ideally feed equipment should be only used for handling feed. Proper cleaning and disinfection or the use of changeable loader buckets is the best protocol for feedyards where the feed equipment must be used for handling carcasses or manure.

Most feedyards in this survey piled the dead stock outside of the normal feedyard traffic pattern. They may have perceived the carcasses were a potential source for pathogen transmission to other healthy animals. Dead stock should be placed outside the normal feedyard traffic pattern to reduce potential transmission within the feedyard and keep the rendering truck and impending pathogens outside the facility.

Another potential vehicle of transmission is oral treatment equipment. Small feedyards were less likely to clean oral treatment equipment than were larger yards. Enteric agents such as *Salmonella* or BVDV are shed in saliva and may be transmitted iatrogenically between calves when proper sanitation is not practiced. Less than half of the feedyards in this survey cleaned oral treatment equipment after each animal and roughly one quarter disinfected such equipment between animals. Feedyards that clean and disinfect the oral equipment daily or less often are unlikely to reduce the risk of disease transmission.

Effective cleaning and disinfection strategies can decrease risk of indirect transmission within the treatment facilities as well, especially if the facilities are also being used to unload healthy incoming cattle. Feedyards were not more likely to clean and disinfect their facilities if they were used for both treatment and unloading compared to feedyards that used separate facilities for each. Studies have suggested that transport increases the fecal shedding of agents such as *E. coli* O157 and *Salmonella* therefore an accumulation of agents can occur in the unloading facility if it is not cleaned regularly.[11,13] The majority of feedyards are cleaning the unloading facility monthly or less often, while fewer than one-fourth reported cleaning the treatment facility at the same frequency. Cleaning facilities infrequently may not decrease the risk of transmission when compared to the feedyards that do nothing. Data regarding the risk of disease transmission in the unloading facility and the effectiveness of cleaning and disinfecting strategies are not available. However, it seems likely dirty facilities would increase the risk for incoming cattle and cattle that are being treated in the in the same multi-purpose facility.

Small feedyards were less likely that large feedyards to employ biocontainment practices in this survey. Smaller feedyards may be more likely to use a multi-purpose facility for both treatment and unloading newly-received cattle compared to larger feedyards because they have fewer cattle to treat. The lower number treated may result in a perception of lower pathogen exposure of new arriving cattle as compared to larger feedyards. Alternately they may not be able to justify the capital investment necessary to build separate facilities for unloading and treatment. While fewer cattle are treated in smaller feedyards, the pathogens shed by morbid animals will not differ greatly between feedyards.   Risk of feed contamination from carcasses or manure is related more to the amount of gross contamination of the feed which is likely increased by using the same equipment for handling manure and dead stock and feed. Small feedyards were more likely to use feed loaders to handle dead stock or manure than were larger yards. Smaller feedyards may face financial constraints that prevent complete dedication of equipment solely for feedstuffs. In order to decrease risk of transmission, the smaller feedyards should clean and disinfect the equipment after it has been used to haul potential contaminants but these data suggest they generally do not.

Biosecurity

Traditional biosecurity in the sense of preventing introduction of disease onto a feedyard is difficult at best and in many cases impractical. By the nature of the industry, feedyards accept risks by purchasing a large number of cattle from multiple sources. In many cases these cattle may have been purchased at an auction market where they have been commingled with other cattle prior to transport to the feedyard. In addition, feedyards may import from multiple different auction markets on a continuous basis. Many of the diseases of importance to the feedyard industry are also relatively ubiquitous within the cattle population and shedding may increase during transport for agents like *E. coli* 0157:H7[13] and *Salmonella*.[12] The agents associated with Bovine Respiratory Disease Complex for example are present in all cattle populations and efforts to exclude them are fruitless. This large and continuous influx of cattle and the endemic nature of many diseases of importance to feedyards makes it challenging and often impractical to control disease introduction. However, the feedyards importing cattle directly from a backgrounder facility may face fewer disease outbreaks and will require fewer resources to be devoted to treatment. One study showed preconditioning cattle and minimizing transport to the feedyard decreases fecal shedding of *E. coli* 0157:H7 and *Salmonella*.[13]

The feedyard cannot control exposure to pathogens at the auction market but may be able to control transportation practices. While a relatively uncommon practice, requiring trailers to be cleaned and when possible disinfected before incoming cattle are loaded for shipment to the feedyard may help control exposure to pathogens such as *E. coli* 0157:H7, *Salmonella* or BVDV.[14] Other food animal industries have already accepted standards of cleanliness for prevention of disease introduction into a facility. Research has shown that cleaning and disinfecting livestock trailers can prevent indirect infection for porcine reproductive and respiratory syndrome in swine.[15] Feedyard managers may consider requiring trucking companies to comply with these requirements to decrease the risk of transmission from previously shipped loads.

Rational biosecurity on a feedyard may include practices to prevent feed contamination with agents of enteric disease such as *Salmonella* or *Eimeria* from off-site sources. Keeping employees and visitors from stepping in the bunks, or walking or driving through feed storage areas may decrease risk. Visiting vehicles should not be allowed to contact feed storage areas such as silage pits or commodity storage areas.

Fomites such as shoes and clothing worn by humans may serve to transmit foot-and-mouth disease virus (FMDV) and other diseases and thus pose a threat to feedyard cattle. Feedyard personnel should screen visitors for previous animal contact, especially if visiting or returning from a foreign country where FMDV is present, or if FMDV is introduced into this country. A recent survey of feedyard managers and consulting veterinarians indicates they believe FMDV to be the most likely pathogenic agent to be introduced by bioterrorism.[16]

Wearing clean boots or shoes around the feedstuffs is important to decrease the risk of fecal-oral contamination, yet feedyards in this survey rarely required visitors to wear clean boots or shoes. Wearing clothing and shoes that have not been contaminated by exposure to other animals or animal waste is a standard of practice in swine confinement systems. Some studies have shown that wearing clean outerwear may even prevent transmission of FMDV in swine.[17] The authors are unaware of investigations of footwear transmission of disease in the feedyard industry, but one study in the swine industry suggests that plastic booties over the top of personal footwear may decrease transmission of some viral agents.[18]

Feedyard size did not affect the likelihood of utilizing any of the biosecurity practices mentioned above except requiring cleaning of trailers prior to loading incoming cattle. Smaller feedyards may have more control over this activity because they work more directly with the trucking companies. Biosecurity mitigation strategies could be improved in most of the feedyards included in this survey. Veterinarians will be needed to address biosecurity standards and to explain the importance of proactive biosecurity plans. Should FMDV enter the US, individual feedyard risk will be higher and justify more careful implementation of biosecurity measures. It would be preferable if those measures were ready for implementation should a FMDV outbreak occur.

Security

Security plays an important role in feedyards particularly because in most operations the cattle and some feedstuffs are kept outdoors. Several incidents involving cattle in the U.S. and other countries have been characterized by feed contamination and intoxication.[5,19,20] History suggests cattle producers should consider the risk of feed contamination and methods of risk reduction. A perimeter fence with restricted access entrance gates allows the feedyard management to limit access to only authorized personnel. This will limit access to the mill where micronutrients and protein supplements could be contaminated and then fed unknowingly to the cattle as well as the feed bunks should a perpetrator desire to contaminate feed already fed to the cattle. Less than half of the feedyards reported having a fence that will stop humans. Deterrence of unauthorized entry may reduce the risk of intentional disease or toxicant introduction by increasing the difficulty of gaining access to critical areas. Although a determined terrorist may still gain access through a well built fence, the terrorist may be inclined to target a facility with less security measures and easier access. Objective data on real versus perceived risk is difficult to obtain for intentional disease introduction risks. Domestic terrorist groups have targeted animal-related facilities but the authors are unaware of a known attack on a feedyard. People for the Ethical Treatment of Animals (PETA) have made statements indicating they would welcome the introduction of FMDV to the United States.[6]

In the USDA Feedlot 99 survey[21] 86.3% of feedyards reported storing protein supplements and 37.3% reported storing mineral supplements in sealed containers (silos, tanks, bins, drums) and the remainder of feedyards in the survey that utilized protein and mineral supplements stored them in covered piles, bunks, pits, or sheds. Piles, bunks, and pits are easily accessible in most feedyards. Locking the sources of the supplements within a container or behind a fence may deter malicious intentional feed contamination.

Security is especially important at night, yet over half of feedyards are not keeping cattle locked up and two thirds are not utilizing a night watchman. In some cases, managers or other employees live on or near the facility which may serve to deter unauthorized entry. A personal encounter with feedyard personnel may be even more effective than the best of locks. Signage directing traffic and visitors to the office communicates the importance of biosecurity and security to visitors and gives feedyard staff an opportunity to discuss the purpose of the visit. In addition to asking visitors to sign their name, visitors should be questioned about previous animal exposure which may increase the risk of accidental disease introduction through contaminated clothes or boots. Asking visitors to sign out as they leave also conveys the perception of surveillance by feedyard employees to visitors within the facility. Controlling both direct and indirect animal contact with visitors will be much more important if a contagious disease like FMDV is introduced to the country. Additionally, identifying visitors that have checked in through the office and training feedyard personnel to challenge all visitors not so identified may be useful in deterring malicious acts. Terrorist organizations, both domestic and international, commonly probe defenses of prospective targets to identify security weaknesses. Disgruntled employees or neighbors may also be aware of weaknesses. A well implemented security policy, while not invulnerable, may make the feedyard a less inviting target.

Most feedyards are active in learning about an employee's history prior to hiring. Checking references and visiting with a previous employer may provide information regarding experience and beliefs about production agriculture. A criminal background check may reveal illegal actions taken against other animal facilities in the past. Feedyards in this survey may not have pursued knowledge about potential future employees by both methods because in some cases the new employees are well-known long-time members of the local agricultural community. In instances where the applicant is not known by the feedyard personnel a more thorough check of references and background may be prudent to assess whether potential employees can be trusted to work in vulnerable areas of the feedyard.

The NAHMS Feedlot 99[21] study showed that 25.6% of feedyards >8,000 head restricted people (for example, deny access or require clean clothing) compared to 15.5%

of feedyards 1,000-7,999 head. A similar trend occurs among the security questions of our survey that shows larger feedyards were more likely to have implemented strategies to reduce unauthorized visitors from accessing cattle and feed. The larger feedyards have more money invested in the livestock operation and they may feel security measures are justified to decrease the risk to their assets. Larger feedyards also have more staff to support the monitoring of feedyard traffic both during the day and at night. By monitoring the activity of visitors, the feedyard staff can limit exposure to the cattle and feedstuffs which may prevent unintentional, or deter intentional disease introduction or feedstuff contamination. It also portrays to personnel on the facility the importance of security measures and the value of the commodities and cattle within.

This survey has revealed benchmark practices for biocontainment, biosecurity and security in central plains state feedyards. Benchmarks are commonly used in the feedyard industry for comparison of a feedyard to the larger population of feedyards in the industry.[22] Information gained from the survey results can be used by consulting veterinarians and feedyard managers for discussion and to target training efforts. While the feedyards included here are not a random sample of all yards in the states represented they do capture a large portion of the central plains states where the majority of the cattle in the US are fed as well as a wide range of feedyard sizes. Of feedyards that we were able to contact and that met the inclusion criteria we had a high acceptance rate and subsequently were able to survey most of those. While this may have left opportunity for some bias in the estimates of practices, we believe that the data provide valuable insight into the practices of feedyards in the central plains and surrounding areas.

Production animal agriculture has advanced in the development of practices that decrease the risks of biosecurity and biocontainment. The swine and poultry[23] industries have tailored production systems around these practices. Biosecurity and biocontainment in the feedyard industry however is more challenging in many ways. While the swine and poultry industries are able to operate in an indoor controlled environment and practice all-in, all-out management, the feedyard industry operates in an open environment with continual flow of cattle. Careful assessment and implementation of key principles may however be effective in controlling risk from disease or toxin introduction by either accidental or intentional means.

Feedyards included in this survey may not implement more of these biocontainment, biosecurity, and security practices for several reasons. They may be unaware of the risks or the appropriate mitigation strategies to decrease risk. Veterinarians should help managers to better understand the routes of transmission for the diseases that are most threatening to their operation and develop optimal plans aimed at preventing disease transmission. In contrast, managers may understand the risks but perceive the mitigation strategies to be ineffective or uneconomical. Information about disease risks and mitigation strategies should be used with cost-benefit analyses by veterinarians and managers to establish best management practices for each feedyard. Action plans for disease outbreaks developed with veterinary consultation would be valuable to managers to educate feedyard employees and plan for an effective response. Additional research will be helpful to better understand the real risks and to determine which mitigation strategies provide the most economic benefits. Veterinarians are pivotal in educating the feedyard staff about the dynamic risk of disease introduction into and transmission within the feedyard which characterizes the industry.

References

1. Martin S, Meek A, Willeberg P. *Veterinary epidemiology*. Ames, IA: Iowa State University Press, 1987.

2. Abt CC. Current and improved biodefense cost-benefit assessment In: Richardson HW, Gordon P,II JEM, eds. *The Economic Impacts of Terrorist Attacks*: Edward Elgar Publishing, 2005;119-132.

3. Leitenberg M. Biological weapons and "bioterrorism" in the first years of the 21st century. Conference on the Possible Use of Biological Weapons by Terrorists Groups: Scientific, Legal, and International Implications: Rome, Italy. 2002. Available at http://www.armscontrolcenter.org/cbw/papers/journals/apr_2003_bioterrorism_21st_century.pdf. Accessed on October 15, 2006.

4. Kosal ME, Anderson DE. An unaddressed issue of agricultural terrorism: A case study on feed security. *Journal of Animal Science* 2003;82:3394-3400.

5. Neher NJ. The need for a coordinated response to food terrorism: the Wisconsin experience. *Ann NY Acad Sci* 1999;894:181-183.

6. Knowles T, Lane J, Bayens G, et al. Defining law enforcement's role in protecting American agriculture from agroterrorism. Accessed on October 15, 2007. Available at http://www.ncjrs.gov/pdffiles1/nij/grants/212280.pdf.: U.S. Department of Justice, 2005.

7. Elbakidze L. The Economics of Agricultural Bio-security: An Interpretive Literature Review, 2003. *Department of Agricultural Economics, Texas A&M University*. College Station, Texas. Accessed on April 15, 2007. Available at http://txspace.tamu.edu/handle/1969.1/3076.

8. USDA: Agriculture Statistics Board: National Agricultural Statistics Service: Cattle on feed, February 23, 2007. Available at http://www.nass.usda.gov/Publications/Todays_Reports/reports/cofd0207.pdf. Accessed on May 10, 2007.

9. Smith RA, Stokka GL, Radostits OM, et al. Health and Production Management in Beef Feedlots In: Radostits OM, ed. *Herd health: food animal production medicine*. 3rd ed. Philadelphia, Pennsylvania: W. B. Saunders Company, 2001;581-633.

10. Marshall B, Petrowski D, Levy SB. Inter- and Intraspecies Spread of *Escherichia coli* in a Farm Environment in the Absence of Antibiotic Usage. *PNAS* 1990;87:6609-6613.

11. Himathongkham S, Bahari S, Riemann H, et al. Survival of *Escherichia coli* O157:H7 and *Salmonella typhimurium* in cow manure and cow manure slurry. *FEMS Microbiol Lett* 1999;178:251-257.

12. Plym-Forshell L, Ekesbo I. Survival of *salmonellas* in urine and dry faeces from cattle--an experimental study. *Acta Vet Scand* 1996;37:127-131.

13. Bach SJ, McAllister TA, Mears GJ, et al. Long-haul transport and lack of preconditioning increases fecal shedding of *Escherichia coli* and *Escherichia coli* O157:H7 by calves. *J Food Prot* 2004;67:672-678.

14. Barham AR, Barham BL, Johnson AK, et al. Effects of the transportation of beef cattle from the feedyard to the packing plant on prevalence levels of *Escherichia coli* O157 and *Salmonella* spp. *J Food Prot* 2002;65:280-283.

15. Dee S, Deen J, Burns D, et al. An assessment of sanitation protocols for commercial transport vehicles contaminated with porcine reproductive and respiratory syndrome virus. *Can J Vet Res* 2004;68:208-214.

16. Brandt AW, Sanderson MW, DeGroot BD, et al. Feedyard manager and veterinarian responses to a feedyard biosecurity survey. *Bov Pract (IN PRESS)* 2007.

17. Amass SF, Mason PW, Pacheco JM, et al. Procedures for preventing transmission of foot-and-mouth disease virus (O/TAW/97) by people. *Vet Microbiol* 2004;103:143-149.

18. Dee S, Deen J, Pijoan C. Evaluation of 4 intervention strategies to prevent the mechanical transmission of porcine reproductive and respiratory syndrome virus. *The Canadian Journal of Veterinary Research* 2004;68:19-26.

19. Carus WS. Bioterrorism and biocrimes: the illicit use of biological agents since 1900. Washington D.C.: National Defense University Center for Counterproliferation Research, 2001.

20. Cameron G, Pate J. Covert biological weapons attacks against agricultural targets: assessing the impact against US agriculture. *Terrorism and Political Violence* 2001;13:61-82.

21. USDA. Part III: health management and biosecurity in U.S. feedlots, 1999. Ft Collins, Colorado.: USDA:APHIS:VS:CEAH, 2000 #N336.1200.

22. Loneragan GH, Dargatz DA, Morley PS, et al. Trends in mortality ratios among cattle in US feedlots. *J Am Vet Med Assoc* 2001;219:1122-1127.

23. Shane SM, Halvorson D, Hill D, et al. Biosecurity in the poultry industry. *American Association of Avian Pathologists*. Kennett Square, PA: University of Pennsylvania, 1995;26-28.

Table 4 - Efforts to contact feedyard management about participation in the survey

State	Attempted Contact	Unable to Contact	Consented	Refused	Did not meet inclusion criteria	Visited
Kansas	308	124	110	33	41	72
Nebraska	46	8	17	19	2	12
Colorado	39	15	17	5	2	12
Texas	40	28	10	2	0	7
Oklahoma	14	6	5	3	0	3

Table 5 - Responses to questions related to Biocontainment within the feedyard

	Number of affirmative responses				
		One-time capacity (head)			
Question (number of responses)	All	1,000-4000	4,000-16,000	16,000-32,000	>32,000
Is the oral treatment equipment cleaned ever?* (106)	98 (92.5%)	23 (79.3%)	31 (96.9%)	25 (100.0%)	19 (95.0%)
Is the oral treatment equipment cleaned after each animal? (106)	48 (45.3%)	10 (34.5%)	15 (46.9%)	13 (52.0%)	10 (50.0%)
Is the oral treatment equipment disinfected ever?* (106)	68 (64.2%)	13 (44.8%)	18 (56.3%)	22 (88.0%)	15 (75.0%)
Is the oral treatment equipment cleaned and disinfected after each animal? (106)	28 (26.4%)	2 (6.9%)	7 (21.9%)	11 (44.0%)	8 (40.0%)
Is the processing facility cleaned daily?* (106)	51 (48.1%)	3 (10.3%)	12 (37.5%)	18 (72.0%)	18 (90.0%)
Is the processing facility cleaned and disinfected daily? (106)	11 (10.4%)	0	3 (9.4%)	5 (20.0%)	3 (15.0%)
Is the treatment facility cleaned daily?* (106)	43 (40.6%)	2 (6.9%)	10 (31.3%)	16 (64.0%)	15 (75.0%)
Is the treatment facility cleaned and disinfected daily? (106)	12 (11.3%)	0	3 (9.4%)	6 (24.0%)	3 (15.0%)
Are cattle treated and separated in hospital pens? (106)	95 (89.6%)	24 (82.8%)	28 (87.5%)	25 (100.0%)	18 (90.0%)
Do sick cattle in hospital pens have fence-line contact with healthy cattle? (95)	35 (36.8%)	7 (29.2%)	11 (39.3%)	9 (36.0%)	8 (44.4%)
Is the loading/unloading facility cleaned weekly or more often?(106)	31 (29.2%)	7 (24.1%)	11 (10.4%)	5 (20.0%)	8 (40.0%)
Is the loading/unloading facility cleaned and disinfected weekly or more often? (106)	2 (1.9%)	1 (3.4%)	1 (3.4%)	0	1 (3.4%)
Are cattle unloaded in the same facility used to treat sick cattle?* (106)	38 (35.9%)	22 (75.9%)	13 (40.6%)	1 (4.0%)	2 (10.0%)
Is the facility used for both treatment and unloading disinfected weekly or more often? (38)	1 (2.6%)	1 (4.5%)	0	0	0
Are feedyard loaders and trucks used to handle dead stock and manure ever used for feed handling?* (106)	27 (25.5%)	13 (44.8%)	9 (28.1%)	3 (12.0%)	2 (10.0%)
Is equipment always thoroughly cleaned and disinfected after handling dead stock or manure before handling feed? (27)	4 (14.8%)	2 (15.4%)	1 (11.1%)	0	1 (50.0%)

*Significant (P<.05) differences between feedyard size

All 106 feedyards responded to the survey. Questions with less than 106 responses are due to dependence on the response to a previous question in the survey tool.

Table 6 - Responses to questions related to Biosecurity in the feedyard

	Number of affirmative responses				
		One-time capacity (head)			
Question (number of responses)	All	1,000-4000	4,000-16,000	16,000-32,000	>32,000
Is history of animal contact collected from visitors/vendors? (106)	3 (2.8%)	0	1 (3.1%)	0	2 (10.0%)
Is history of international travel collected from visitors/vendors?* (106)	5 (4.7%)	0	1 (3.1%)	0	4 (20.0%)
Are visitors required to use feedyard vehicles when on the facility? (106)	42 (39.6%)	13 (44.8%)	12 (37.5%)	10 (40.0%)	7 (35.0%)
Are clean boots or foot coverings required for visitors? (106)	2 (1.9%)	0	1 (3.1%)	0	1 (5.0%)
Are all cattle with unknown BVDV status ear notched and tested so persistently infected (PI) animals can be removed from the feedyard. (106)	3 (2.8%)	0	1 (3.1%)	1 (4.0%)	1 (5.0%)
Are new arrivals separated from other cattle until BVDV PI status is known? (3)	2 (66.7%)	-	0	1 (100.0%)	1 (100.0%)
Are trailers required to be cleaned before loading incoming cattle?* (106)	15 (14.2%)	8 (27.6%)	5 (15.6%)	0	2 (10.0%)
Are more than 51% of cattle arriving from the auction market? (106)	61 (57.6%)	18 (62.1%)	18 (56.3%)	13 (52.0%)	12 (60.0%)
Are carcasses disposed of by a rendering service? (106)	92 (86.8%)	23 (79.3%)	27 (84.4%)	23 (92.0%)	19 (95.0%)
Does the rendering truck drive across the normal feedyard traffic pattern to access the dead pile? (92)	75 (81.5%)	17 (73.9%)	24 (88.9%)	19 (82.6%)	15 (78.9%)

*Significant ($P<.05$) differences between feedyard size

All 106 feedyards responded to the survey. Questions with less than 106 responses are due to dependence on the response to a previous question in the survey tool.

Table 7 - Responses to questions related to Security in the feedyard

	Number of affirmative responses				
		One-time capacity (head)			
Question (number of responses)	All	1,000-4000	4,000-16,000	16,000-32,000	>32,000
Does the feedyard have a perimeter fence?* (106)	67 (63.2%)	8 (27.6%)	20 (62.5%)	20 (80.0%)	19 (95.0%)
Will the perimeter fence stop vehicles?* (67)	45 (67.2%)	2 (25.0%)	14 (70.0%)	14 (70.0%)	15 (78.9%)
Will the perimeter fence stop humans?* (67)	10 (14.9%)	0	2 (10.0%)	3 (15.0%)	5 (26.3%)
Are all cattle behind locked gates?* (106)	43 (40.6%)	5 (17.2%)	9 (28.1%)	13 (52.0%)	16 (80.0%)
Is there signage directing visitors to check in at the office?* (106)	44 (41.5%)	0	9 (28.1%)	17 (68.0%)	18 (90.0%)
Is a visitor log maintained and enforced?* (106)	25 (23.6%)	0	3 (9.4%)	7 (28.0%)	15 (75.0%)
Is a night watchman employed?* (106)	35 (33.0%)	0	7 (21.9%)	12 (48.0%)	16 (80.0%)
Are employee resume references checked at hiring?* (106)	80 (75.5%)	18 (44.8%)	28 (87.5%)	24 (96.0%)	15 (75.0%)
Is a criminal background check performed at hiring?* (106)	28 (26.4%)	3 (10.3%)	8 (25.0%)	12 (48.0%)	5 (25.0%)
Are all micro-nutrients secured from unauthorized access?* (106)	47 (44.3%)	7 (24.1%)	10 (31.3%)	18 (72.0%)	12 (60.0%)
Are all protein supplements secured from unauthorized access? (106)	44 (41.5%)	10 (34.5%)	10 (31.3%)	15 (60.0%)	9 (45.0%)

*Significant (P<.05) differences between feedyard size

All 106 feedyards responded to the survey. Questions with less than 106 responses are due to dependence on the response to a previous question in the survey tool.