Priority Area Review:
Animal Health & Welfare

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EXECUTIVE SUMMARY

In 2012, the Beef Cattle Research Council (BCRC) committed to completing an evaluation of the value of research funded in each priority area: Animal Health & Welfare, Beef Quality, Feed Efficiency, Forage and Grassland productivity, and Food Safety. The goal of these priority area reviews was to provide a cost:benefit analysis of research to identify research areas within each priority that were potentially under- or over-funded. This is intended to inform the next round of priority setting sessions by providing more in-depth background for the participants.

OVERARCHING OBJECTIVE for ANIMAL HEALTH & WELFARE:

Reduce costs and losses incurred as a result of major production limiting diseases and animal health issues that affect primary production sectors through the development of effective and economical management practices, diagnostic, and treatment tools. To develop a scientific base for best management practices and assist in effectively communicating current industry practices to consumers.

Animal health and welfare are large topics with many **research areas** contributing to the overarching goal of providing producers with the best set of tools available to address the situation they are in.

Disease and lack of market access are two of the most significant deterrents to an economically successful beef industry. New, foreign, or emerging diseases result in economic crises for industry if not detected early through surveillance and mitigated promptly through biosecurity.

Disease surveillance networks can provide timely, organized and scientific answers to questions regarding animal health, welfare, biosecurity, animal nutrition, and other production practices. The value of surveillance programs is in the information that reduces the economic burden of disease on industry. Surveillance requires accurate diagnostic tests. Improved tests are needed for a number of diseases. The Canadian Animal Health Surveillance System (CAHSS) is an initiative of the National Farmed Animal Health and Welfare Council (NFAHWC). CanSurvBSE, the Bovine Serological Survey and the Western Cow/calf Surveillance are all involved in this project.

Surveillance work can be very expensive and involves long term programming. An appropriate role for BCRC is to support project work that establishes user friendly methodologies and demonstrates value for long term development and investment. A key role for the Western cow/calf network is around (1) production limiting diseases and (2) vector borne diseases (i.e. insects, ticks). Further work is needed to prioritize which production limiting diseases surveillance should focus on. Industry has a role in encouraging participation by veterinarians and producers in the Western cow/calf surveillance network.

Prevention of disease includes an understanding of immunology, vaccination, nutrition, mineral supplementation, and water quality. Base research in the area of immunology is ongoing and supports vaccine development.

Whether it is vaccines, antibiotics, antimicrobials or parasite control it must be recognized that Canada is a small market for multinational drug companies and as an exporting nation we need to have animal health products that are internationally accepted and do not create non-tariff trade barriers. This means Canada is not necessarily the right location to be developing these products. It is no surprise that vaccine development requires large investments and has historically been left to the drug companies. However, there is a role for BCRC to test efficacy of vaccines, parasite control, antibiotics, etc. in Canadian conditions to ensure they work as well ere as where they were developed and communicate results to producers.

Nutrient deficiencies increase susceptibility to most infectious diseases, including bacterial, viral and parasitic diseases. Mineral programs can make a significant difference in productivity (e.g. the increase in weaning percentage can pay for the mineral). Local and regional nutrition research addresses climatic differences, breeds and available feedstuffs. There has been significant work done in Canada, but research needs to be ongoing to (1) increase our understanding of digestion of alternative feedstuffs; (2) identify the symptoms and cost of nutrition deficiencies; and (3) study the macro and micro nutrient issues in various regions across the country.

Nutritional diseases associated with **high concentrate feeding** include acidosis, liver abscesses and laminitis. Research is needed to define the prevalence of acidosis in Canadian feedlots and to further define how ruminal pH influences animal welfare, such as whether acidosis and/or sub-clinical acidosis are painful for cattle. Also needed is continued research to: (1) identify optimal feedlot transition strategies; (2) identify differences in feeding behaviour, ruminal physiology, metabolism and genetics that lead to individual variations in susceptibility to acidosis; (3) in extremely painful cases/situations there must be focus on decreasing incidence; and (4) determine which diets produce the best weight gain and carcass with the least digestive upset. Economic analysis to compare the cost of reduced final weight to the cost of nutritional diseases associated with high concentrate feeding (i.e. drug treatment costs and carcass value losses) is also needed.

Endemic **production limiting diseases** inflict an on-going economic burden on the industry. Despite numerous advances in bovine infectious disease research, **bovine respiratory disease** (BRD) remains highly prevalent in Canadian feedlots and contributes to decreased cattle performance. Several areas can be improved to better control BRD. To advance BRD prevention, development of alternatives to on-arrival mass medication with antimicrobials (e.g., probiotics, gNO, etc.) and development of efficacious vaccines against *M. bovis* (and *P. multocida*) are needed. The cost-effectiveness of preconditioning (in various forms) and cattle acclimation procedures (such as low-stress cattle handling or cattle training) should also be investigated. To enhance BRD treatment response and decrease the impact of BRD, the benefit of health monitoring systems (location tracking devices, IRT cameras installed at a watering system, rumen temperature boluses, etc.) should be evaluated and these systems should be promoted if found cost-effective. Methods to augment chute-side accuracy of the BRD diagnosis (thoracic ultrasonography and lung auscultation) should also be further evaluated. Finally, antimicrobial sensitivity testing of bacteria currently involved in BRD cases occurring in Canadian feedlots is needed to optimize treatment regimes and ensure sustainable use of antibiotics.

The apparently low prevalence of **bovine viral diarrhea virus** (BVDv) infected beef herds based on PI animal detection is likely to be an underestimate of true herd prevalence. In Canada the prevalence of PI calves in feedlots populations has not been well established. More precise and current surveillance information would help the industry evaluate the appropriate level of emphasis to place on BVDv research. While there are estimated economic impacts of BVDv in North America, economic analysis focusing on the Canadian beef cattle herd is limited. Economic analysis on the impact of BVDv in Canadian beef and cattle operations would help to evaluate the feasibility of BVDv control programs in Canada. There is a lack of scientific literature examining the effects of BVDv vaccination on subsequent health parameters of feedlot cattle. Assessment on health impact of different BVDv subtypes and detection of new subtypes will have important implication on BVDv control and vaccine development. Evaluation of current vaccines against BVDv at feedlot and cow-calf levels as well as the development of innovative vaccines is also important. Two BCRC projects completed in 2007 and 2011 shed light to DNA-based vaccines against BVDv. The results show that a DNA vaccine for BVD could be administered to newborn calves via electroporation and provide excellent protection.

Gastro-intestinal nematode (GIN) infections (roundworms) have a negative impact on production. The effectiveness of the macrocyclic lactones has resulted in a lack of investment in cattle **GIN parasite** research for almost three decades. Consequently, there are a now large number of both basic and applied research priorities. The most urgent of these include: (1) Obtaining regional information on GIN parasite infection intensities, parasite species distributions, production impacts and on the prevalence of anthelmintic resistant parasites in Canadian beef cattle; (2) Developing more accurate, accessible and affordable diagnostic tools to measure parasite infection intensities, production impacts and to detect anthelmintic resistance; (3) Elucidating the epidemiology of the major cattle parasite species in Canada and using this information to inform evidence---based control practices; and (4) Investigating producer perceptions and developing policies to maximize the adoption of new technologies and sustainable parasite control programs such as targeted selective treatments. Longer term research is also needed to stay ahead in this area.

One of the most important production factors influencing the economics of the beef cow calf farm is the calf crop percentage. This is impacted by **reproductive failure** and survival to weaning. Many factors can lead to reproductive failure, including poor cow nutrition, mineral imbalance, bull infertility, and other diseases. The 2012 National Beef Research Strategy calls for reduced incidence of reproductive failure through improved nutritional management, diagnostic tests, vaccination and biosecurity by 2016. Research on reproductive efficiency frequently has overlaps with research on diseases (e.g. BVD, IBR). Basic and applied reproductive research may not always be disease prevention related, but may include more basic reproductive research into hormones, how reproductive cycles can be manipulated and looking at evaluation of reproductive success (e.g. bull evaluations, body condition score). Cow-calf herd size is increasing and management strategies are evolving to adapt. Research is needed to provide evidence-based advice on the best practices to balance economic outcomes, animal health and welfare. **Neonatal diseases** that continue to challenge producers include pneumonia and enteritis (calf scours). There are outstanding needs for vaccine research and evaluation for important neonatal diseases in beef herds. Better information on current antimicrobial use and resistance in cow-calf herds is urgently required to address growing international concerns.

Animal welfare is closely linked with animal health. Overall, understanding how multiple stressors affect the animal and determine the least stress alternatives for recommended practices. A number of standard animal husbandry procedures that are performed cause pain, even though many procedures such as dehorning, may provide net welfare benefits through reduced animal injury or carcass bruising. In general, there needs to more focus on animal health and welfare of subclinical disease and clinical disease.

Pain mitigation in beef cattle is becoming increasingly important. However, there are a number of information gaps that need to be addressed including: (1) practical methods of administering anesthetic on extensive beef operations and reducing window of time required between administration and procedure; (2) effective chronic or longer-term pain mitigation that is safe for food animals; (3) optimum drug dosages for use of topical and local anesthetics for specific procedures; (4) effect of social behaviour of herdmates on pain and recovery. Significant communication is needed to increase awareness of the Beef Code of practice requirements and pain mitigation methods current available of both producers and veterinarians. But further research is needed to determine if the current requirements are sufficient (i.e. are the current methods we have for pain control sufficient).

The Beef Cattle Code of Practice identified the following research needs for **lameness**: (1) Risk factors, prevalence, characteristics, and management of lameness in Canadian feedlots; (2) Cause of toe tip necrosis; and (3) Frequency of pen cleaning required to prevent foot rot as well as economic analysis of the benefits of pen cleaning.

Weaning is a natural part of the life cycle of a beef animal however it is also one of the most challenging periods of an animal's life. A greater understanding is needed on the effect of weaning strategy on calf health, particularly as it relates to respiratory health and reducing incidence of BRD.

While the industry has benchmarked **transportation** outcomes research is still needed on the impact of cumulative transport hauls, space allowance, transport duration and unloading delays, bedding, pre-transport handling, high-risk animals and trailer design.

There is not a lot of research being done related to **heat and cold stress** and beef cattle welfare in Canada in a practical context. Many feedlot operators and management companies conduct their own applied research related to temperature, stress, pen size and groupings. Current research may largely be performed by veterinarians and results may be retained in-house. There is also a need to investigate the effect of climate change and frequency of extreme weather on animal welfare.

Greater understanding is needed on the more nuanced effects of **Growth Enhancing Technologies** (GET) on beef cattle welfare. As GETs are increasingly used as non-tariff trade barriers understanding the impact on animal welfare and human health is necessary to continue using these products. Products whose impacts have been questioned have been eliminated from the marketplace. Industry must have a solid understanding of the impacts in order to decide what prudent and responsible use looks like. The challenge is studies need to be very large numbers as prevalence appears to be very small and impacted by multiple stressors and some products are no longer being accepted by packers.

Research priorities around antimicrobial use (AMU), antimicrobial resistance (AMR) and alternatives will be addressed by a BCRC workshop scheduled in December 2015.

INTRODUCTION

In 2012, the Beef Cattle Research Council (BCRC) committed to completing an evaluation of the value of research funded in each priority area: Animal Health & Welfare, Beef Quality, Feed Efficiency, Forage and Grassland productivity, and Food Safety. The goal of these priority area reviews was to provide a cost:benefit analysis of research to identify research areas within each priority that were potentially under- or over-funded. This is intended to inform the next round of priority setting sessions by providing more in-depth background for the participants.

Why invest in animal health and welfare research?

The beef industry is primarily about the beef animal. Its health and welfare is of primary importance to the producer. Disease outbreaks can have a major impact on profitability of individual operations (from death loss, treatment costs and productivity losses), but also on the industry as a whole if market access is closed. Nutrition not only provides optimal animal performance but supports the immune system to have healthy animals that do not get as sick as often. But animals do get sick and when they do having diagnostic tools and treatments available that are effective are critical to avoiding prolonged stress to the animal.

OVERARCHING OBJECTIVE:
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There is rising interest by the public and consumers on production practices. The Beef Code of Practice was developed through a multi-stakeholder process initiative overseen by the National Farm Animal Care Council (NFACC), it provides recommendations and requirements for animal care. Animal welfare organizations, such as farm and food care organizations and humane societies have an interest in the research that feeds into that process.

Report Structure

Evaluating research benefits to producers is often challenging due to unreliable or insufficient data. In this case, there is a lack of incidence, prevalence and production impact data to complete an economic analysis. Hence, the Economic Evaluation summarized estimates from the literature and where possible extrapolates from U.S. studies.

Animal health and welfare are large topics with many **research areas** contributing to the goal of providing producers with the best set of tools available to address the situation they are in. These include:

1. Disease surveillance (e.g. diagnostics, zoonotics, biosecurity),
2. Prevention of disease (e.g. immunology, vaccination, nutrition, mineral supplementation, water quality),
3. Production limiting diseases (e.g. BRD, BVD, parasites, reproductive efficiency) and
4. Animal welfare (e.g. stressful and painful practices).

A number of researchers have provided summaries of the topics. These summaries outline areas of research within each topic, existing Canadian and international research, and provide some recommended priorities and technology transfer opportunities for industry.

ECONOMIC EVALUATION

Investments in prevention, control of disease, parasites and injuries pay off by improving productivity and reducing economic losses associated with animal morbidity and mortality. Producers must evaluate the costs and benefits of prevention and control options. In some cases the cost-effectiveness is easy to measure. If a $50 treatment allows the survival of a calf valued at $1200 the benefit is obvious. However, other services particularly around disease prevention, risk management or long-term investment into herd productivity can be more difficult to quantify.

Evaluating research benefits to producers is often challenging due to unreliable or insufficient data. This is the case in measuring the benefits from animal health and welfare as data on the **incidence** (the proportion of new cases that occur in a population over a defined time period), **prevalence** (the proportion of the population that is impacted) and **production impacts** (which can vary with the severity of a disease) is rarely available.

The lack of data in Canada on prevalence, incidence and production impacts of individual diseases highlights the importance of disease surveillance, particularly for production limiting diseases that are not covered by current networks. Where data is available it is summarized below, but many estimates include dairy cattle or are based on the U.S. industry ($/head) and applied to the Canadian inventory.

Many costs can be measured at the farm level, including production loss (e.g. reduced feed intake or feed efficiency, more days on feed), treatment costs (e.g. product, labour), disposal and the opportunity cost from lost revenue if disease ends in death. However there are costs that cannot be captured at the farm level including increased food costs from inefficiencies and potential spread of disease to other populations. Analysis is frequently limited to on farm costs and benefits.

There is a cost both to producers but also to the industry from trade limitations caused by disease status. There are also implications to consumer demand as perceptions are formed around production practices (e.g. antimicrobial use and painful procedures).

Prevention of Disease

The cost of a zoonotic or highly contagious disease (e.g. Foot and Mouth Disease) from shutting down trade to control measures such as liquidation of the herd is large. Several researchers estimated direct economic costs of Canada's May 2003 Bovine Spongiform Encephalophathy (BSE) case. Carlberg and Brewin (2005) reported that the industry is estimated to have incurred over **$5.5 billion (approximately $11 million per day)** in direct financial losses as a result of closures of international borders for live cattle exports. Le Roy.et.al (2006) reported that the $5.5 billion loss is overstated and that **$4.9 billion** was the loss due to reduced exports, imports and extra processing costs and redistribution costs due to BSE. However, none of these studies account for indirect costs through the **multiplier effect** in the Canadian economy, making these estimates conservative. Steve Key reported in November 2014 that 'the full costs of BSE might never be known. But to date, BSE has cost the Canadian industry **C$5 billion to $7 billion** and the U.S. industry more than **US$16 billion**. Costs remain, because neither country has regained full access for cattle and beef to every market it had in early 2003'.[1]

Base research in understanding both the animal and the environment they live in is required to understand animal health and the factors impacting it. Animals that are stressed experience weakened

[1] http://www.canadiancattlemen.ca/2014/11/14/working-for-the-beef-industry/

immune systems and ultimately become sick. The prevention of disease is the best defense against the cost of treatment.

The multiplying impact of **cow nutrition** ripples through the production system impacting everything from reproductive efficiency, calf immunity and weaning weights. The ability to measure these costs and benefits are limited with research just now making connections between cow herd management and performance throughout the production chain.

Cost of morbidity

The highest risk time for respiratory disease is the 45 days after weaning[2]. The multiple stressors on the animal at this time can deplete the immune system and overwhelm the animal resulting in disease. Transferring the problem from one sector to another (e.g. from feedlots to cow-calf) is not a solution; incidence of disease must be reduced in order for any solution to be successful. Preconditioning has been shown to be successful in reducing the incidence of both morbidity and mortality. But there is a cost for cow-calf producers to adopt this practice which requires a premium in the market for these animals. A lack of premiums in the Canadian market has discouraged preconditioning. A clear definition of preconditioning can assist the market in clearly communicating to both cow-calf producers what is needed and provide feedlots the confidence in what they are purchasing to pay to the premium. Even with a clear definition, validation through a veterinary certificate may be needed by feedlots to instill confidence in the market.

Most “chronic” or “convalescent” pens in feedyards confine predominantly lame cattle, presenting a glaring problem for the industry. Livestock operations throughout western Canada vary in their attention to the detail of formal “welfare evaluation” of chronically affected cattle. Almost nothing appears in the literature on the diagnosis, management and animal welfare of beef cattle lameness; most publications specifically address dairy cattle. There is a need for a good definition of when an animal should be culled due to lameness.

Economic Cost	International	Canada
BRD	>$500 million per year in North America	
BVD	$20 million for every million calves for low-virulent strains $57 million for every million calves for high-virulent strains AUD$57.9 million annually (Lanyon et al., 2014) NZD$3,000-$9,000 per 100 cows in infected herds	$78-220 million (Clarke, 2014)
GIN parasites	$2 billion in the U.S. $7 billion in Brazil (Stromberg and Gasbarre 2006)	$71.6-247 million *19% increase in 2014 feedlot breakevens
Reproductive Failure	$441-502 million (1999) includes US dairy cattle *~$12-15/head	$74.9 million $20/head or 3% increase in cow-calf breakevens in 2015

Production limiting diseases (PLD) like parasites increase stress and reduce animal welfare and performance, but do not result in mortality. While incrementally these may seem small the cost can be significant. Research suggests that the economic benefit of anthelmintic use for GIN parasite control to

[2] Has anyone quantified the relative importance of various weaning stressors (e.g. weaning itself, vs. marketing, vs. transport, vs. commingling vs. diet changes) and the degree to which spreading them out would reduce the need for metaphylaxis at the feedlot (encouraging satellite vs. auction vs. direct sales). Maybe breaking them up will reduce the incidence of BRD. There is some research comparing home weaned calves versus calves sent to the feedlot right off the cow. Home weaned calves get sick less, but there is still a lot of disease just after weaning. All of these factors have not been picked apart yet though.

the cattle industry of North America is >2.5 times that of growth promoters (Lawrence 2006). The cost of losing effective GIN parasite control from the entire production chain would negatively impact breakeven prices by 19%. This implies a cost of $71.6-247 million per year to the Canadian industry. GIN parasite control is something that all sectors benefit from. Right now GIN parasite control is losing efficacy and potentially is the largest opportunity cost to industry. The implications of being able to effectively control GIN parasites to improve productivity (i.e. average daily gains) could offset losses occurring elsewhere in the supply chain. This requires a better understanding of GIN levels in the Canadian cattle herd and the prevalence of resistance. As well as understanding alternative management options for parasite control to ensure that new treatments remain effective.

While the **cost of stress** is not explicitly estimated, it should be noted that stress, like parasites, has an impact on performance that is cumulative over time. In addition, negative social perception about animal care gets wrapped up in demand. Controlling pain in food animals is necessary because it is the right thing to do. Economic costs and benefits are a secondary consideration.

The Western Cow-Calf Survey (WCCCS) reported the average open rate was 7% in cows and 10% in heifers. The conception rate for all females was 92.8%, compared to 95.6% in AB in 1998. Work is underway within the industry to gain a better understanding of the reasons behind the current lower conception rates. The lower reproductive efficiency is estimated to increase cow-calf breakevens by 3% or around $20 per head for an opportunity cost to industry of **$74.9 million** in 2015.

Research suggests that over 8% of the calf crop is lost after the cow becomes pregnant through abortions, stillbirths and neonatal diseases. This implies a cost equal or greater than that of reduced reproductive efficiency.

Cost of mortality

Most calf losses occur in the first seven days of life. The move to calving on pasture has reduced the risk of contamination and subsequent pathogen exposure to neonatal diseases. This means infectious neonatal disease in western Canada is not the high risk disease it was 25 years ago. Neonatal diseases that continue to challenge producers include pneumonia and enteritis (calf scours).

The most expensive mortality for feedlots is bloat late in the feeding period. Anecdotal reports suggest very little of the mortality diagnosed as “bloat” is definitive. Less than 5% of “bloat” mortalities have froth present, suggesting the bloated cadaver may be the predominant sign of an underlying cause of death or post mortem change. Clarifying the actual cause of “free gas bloat” is needed.[3]

Conclusion

The value of animal health and welfare is large. Continual investment is needed to support accurate diagnostics for surveillance of new and emerging diseases, enhancing base knowledge of nutrition, stress responses and environmental impacts, and addressing loss of efficacy of products over time.

[3] This would require a case definition with post-mortem signs.

ANIMAL HEALTH

DISEASE SURVEILLANCE & BIOSECURITY- *Rob McNabb*

Globalization of trade combined with emerging and endemic production limiting diseases, as well as zoonotic diseases are placing greater demands on animal health information and data dissemination. There is also increasing interest by the public health sector in farmed animals with zoonotic diseases such as pandemic influenza (H_1N_1). The FAO estimates that 70% of new infectious human diseases detected in recent decades are of animal origin. Animal health remains one of the weakest links in terms of how the world deals with disease risks according to the FAO Chief Veterinary Officer (August 2014)[4]. Many diseases are carried by migratory birds and other wildlife, making the spread of new and existing diseases a matter of time determined by the effectiveness of biosecurity measures in place. Existing domestic reportable disease programs are being challenged by the growing demands of endemic/zoonotic diseases and trade.

Disease and lack of market access are two of the most significant deterrents to an economically successful beef industry. Endemic production limiting diseases inflict an on-going economic burden on the industry. New, foreign, or emerging diseases result in economic crises for industry if not detected early and mitigated promptly. All of these circumstances require timely information to avoid economic losses.

Surveillance is the systematic ongoing collection, collation, and analysis of information related to animal health and the timely dissemination of information so that action can be taken by appropriate parties. Disease surveillance provides and interprets data to facilitate risk analysis and decision making to serve national, provincial, and regional needs of the livestock sector. This broader epidemiology looks at the incidence and prevalence of disease in large populations and with detection of the source and cause of epidemics of infectious disease informs the effectiveness of biosecurity measures.

Surveillance **networks** can provide timely, organized and scientific answers to questions regarding animal health, welfare, biosecurity, animal nutrition, and other production practices. The value of surveillance programs is in the information that reduces the economic burden of disease on industry.

The National Farmed Animal Health and Welfare Council has set out a number of principles for surveillance that highlight the value to industry. Disease and vector surveillance:[5] (1) informs government and industry decision making (including research priorities); (2) provides baseline information, defining normal and abnormal incidence of disease and changes from that status quo that allow for the early detection of disease and the identification of emerging endemic diseases; (3) Is the only mechanism for establishing disease status and freedom from disease, which is essential for permitting and facilitating international trade and market access; (4) Supports and verifies the effectiveness of biosecurity, by evaluating the level of diseases in a population the effectiveness of practices that prevent disease outbreaks are measured; and (5) Is critical in the effective management of important zoonotic diseases that have implications on public health.

Characteristics of an animal health surveillance system include rapid detection and reporting of disease. This requires veterinary diagnostics for the various diseases of interest in surveillance programs. Information is typically collected on five categories of diseases including: foreign and reportable, production limiting, trade limiting, new and emerging, significant zoonotic. Rapid detection requires an

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[4] http://www.thebeefsite.com/news/46381/fao-urges-continued-support-for-animal-disease-monitoring

[5] National Farmed Animal Health and Welfare Strategy. May 2009. http://www.ahwcouncil.ca/pdfs/background-materials/NFAHWSFinalMay2009ENG.pdf

understanding of the disease itself at various stages including investigation of how pathogens are transmitted, infectivity, clinical effects, and new pathogens (microbial, viruses and parasites).

Diagnostic testing: Developing and evaluating diagnostic methods for a variety of diseases or conditions. Is a diagnostic test accurate? Can a new test accurately determine who is infected for disease control purposes? Diagnostic testing also branches into non-infectious diseases such as toxicological testing[6] and testing for genetic diseases. In addition to diagnostics, maintaining a current understanding of the "state of" various organisms of interest to the public health sector is useful. For example, tick vectors in western Canada would address concerns about the potential threat of "Lyme Disease".

INTERNATIONAL & CANADIAN SURVEILLANCE NETWORKS

The Global CZ project is a joint effort including the Department of Defense, CFIA and others that scans news reports of disease and connects it with actual data. This provides an early warning system for emerging diseases.

In the USA, the National Animal Health Monitoring Service (NAHMS) has a long term surveillance network that supports a variety of animal industries and is a critical resource for specific research initiatives.

The CanSurvBSE provides ongoing monitoring for BSE across Canada. The Bovine Serological Survey focuses on foreign animal diseases. Researchers are currently working to establish a western Canadian cow-calf surveillance network, with funding through the Beef Science Cluster.

The challenge with any surveillance program is low participation. Paying for information is unsustainable in the long run, but provides short term participation levels. Creating value through information provided back to participants (both veterinarians and producers) is potentially a way that would support long term participation and reduce the cost of surveillance. The Western Cow/calf Surveillance project is designed to provide proof of this concept. If successful, developing a program with a suite of production limiting diseases and vectors being monitored would be the next step.

The Canadian Animal Health Surveillance System (CAHSS) is an initiative of the National Farmed Animal Health and Welfare Council (NFAHWC). The intent is to bring together stakeholders in animal and public health to address gaps. This would consolidate information from the various networks into intelligence that can set priorities. **Diseases of interest include reportable, notifiable, zoonotic, emerging and production limiting disease**. CanSurvBSE, the Bovine Serological Survey and the Western Cow/calf Surveillance are all involved in this project.

RESEARCH PRIORITIES & CAPACITY

Surveillance work can be very expensive and involves long term programming. An appropriate role for BCRC is to support project work that establishes user friendly methodology and demonstrates value for long term development and investment. A key role for the Western cow/calf network is around (1) production limiting diseases and (2) vector borne diseases (i.e. insects, parasites, ticks). Further work is needed to prioritize which production limiting diseases surveillance should focus on. Industry has a role in encouraging participation by veterinarians and producers in the Western cow/calf surveillance network.

Improved diagnostic tests are needed for a number of diseases including Johnes and mycoplasma.

[6] **Toxicological research** examines non-infectious diseases caused by exposure to toxins. How do various toxins manifest disease? What are mitigation and testing strategies?

There is a new tick specialist in Lethbridge. But there is enough work to support more than one epidemiologist as long as they were covering a suite of vectors.

PREVENTION OF DISEASE

IMMUNOLOGY AND VACCINATIONS

Disease prevention is an important component of any beef herd's management. A producer has three management options to address the effects of diseases: (1) prevent the access of the disease to the herd; (2) increase the resistance to the disease within the herd; and (3) treat infected animals. Biosecurity is the main method used to prevent diseases from entering the herd. The only direct means a producer has to increase resistance to an infectious disease is through vaccination. Successful vaccination results from the stimulation of the acquired immune response. Indirect means of supporting the immune system include balanced nutrition that meet the individual animal type, age, and stage of growth; supported by appropriate mineral supplementation and water quality. Treatment of susceptible animals can be done on arrival with antimicrobials and antibiotics. But better disease definitions and diagnostics for on arrival treatment would enable targeted treatment of individual sick animals rather than whole herd treatment. Optimizing the immune response and minimizing stress and nutritional deficiencies has a direct and positive impact on the production and profitability of a beef operation.

RESEARCH AREAS

Immunology - The immune system is responsible for recognizing, resisting, and eliminating health challenges, including pathogens, injuries, parasites, and stress. The immune system should react and respond quickly when necessary so the productive functions of the animal are not impaired. The immune system has two lines of defense.

First, the natural or innate immune system is made up of the physical and physiological barriers or functions of the body and is critical for the survival of all species. Natural barriers include things such as intact skin, mucous membranes, intestinal motility, gastric juices, salvia, and sweat. If the innate immune system does not eliminate the health challenge the adaptive system takes over. The adaptive or acquired immune system can take up to several days following an infection before a precise response is created. The adaptive system is characterized by the production of antibodies that are specific for each foreign pathogen and also by its "memory" feature. If the animal is infected the second time, the adaptive system remembers the first infection and elicits a faster and stronger response to eliminate the pathogen. The components of the adaptive immune system include: lymphoid organs, B cells, and T cells. Both antibody and cell immunity are often needed for complete protection from an infectious disease (Woodward 1997[7]).

Passive and Active Immunity - Passive immunity occurs when the animal receives antibodies from an external source, such as another animal. The classical example of passive immunity is the transfer of antibodies from the cow to the calf via colostrum. This transfer is extremely important to newborn calves because their immune system is not mature enough to develop its own antibodies. The calf should be immune to most of the pathogens present in the environment because the dam has already been exposed to them and developed protective antibodies (Cooke 2010[8]). Active immunity is acquired

[7] Woodward, Lynn F. December 1997. Basic Immunology. Proceedings , The Range Beef Cow Symposium XV. Rapid City, South Dakota.

[8] Cooke, Reinaldo F. June 2010. Overview of the Cattle Immune System. BEEF043. Orgeon State University: Beeeff Cattle Sciences. Fact Sheet.

when the animal is infected by a specific pathogen, creates a "memory" against it, and successfully eliminates the disease and pathogen. The next time the animal is infected the adaptive immune response will be faster and stronger, quickly eliminating the pathogen and preventing the disease. Vaccination is an example of active immunity. Some management considerations to improve the immune system of cattle are: nutrition, reducing stress, and vaccination.

Vaccination - Preventing disease in beef cattle has many benefits, including health benefits for the animals themselves and economic benefits for the cattle producer. In today's beef cattle production, cattle are often vaccinated to prevent a number of diseases. Vaccination stimulates the animal's immune system with an infectious agent, or components of an infectious agent, that has been modified to prevent the vaccine itself from causing the disease. The agent that stimulates the immune response is called an antigen. This disease-prevention approach has been used in humans and livestock for over 100 years.[9]

Factors which can affect the immune response are the nature, quantity and route of administration of an antigen. Having a good understanding of immunology is needed in vaccine development.

There are two main types of vaccines, killed and modified live. Vaccine selection should be based on the type of disease agent involved. For those that replicate in body fluids and outside of the body's cells, killed or inactivated vaccines are generally adequate to stimulate protective antibody. For agents that replicate inside body cells, different processing of the antigens is needed to stimulate the cell-mediated arm of the immune system. Modified live vaccines are generally more effective in stimulating cell-mediated immunity.

Effectiveness - Taylor *et al.* (1995) and Tripp *et al.* (2013) provide reviews on the efficacy of utilizing viral vaccines upon arrival in a feedyard. In 1997, Perino and Hunsaker reviewed multiple publications on the efficacy of respiratory tract immunogens (combinations of viral and bacterial antigens) in the field. The conclusions in all these publications reveal that it is very difficult to show that they are effective in preventing undifferentiated respiratory disease in feedlot calves. The main reason for this is that it is so difficult to diagnostically differentiate the etiology of BRD and that most of the time there is an array of pathogens that either initiate or complicate the pathogenesis. The net result is that veterinarians and their clients resort to the use of multi-valent immunogens, hoping that an immune response to an array will fend off the multi-factorial pathogen insult.

CANADIAN RESEARCH PRIORITIES:

Base research in the area of immunology is ongoing and supports vaccine development.

Whether it is vaccines, antibiotics, antimicrobials or parasite control it must be recognized that Canada is a small market for multinational drug companies and as an exporting nation we need to have animal health products that are internationally accepted and do not create non-tariff trade barriers. This means Canada is not necessarily the right location to be developing these products. It is no surprise that vaccine development requires large investments and has historically been left to the drug companies. However, there is a role for BCRC to test efficacy of vaccines and communicate results to producers.

The 2012 National Beef Research Strategy calls for:

[9] http://www.beefresearch.ca/fact-sheets/seeking-better-vaccines-for-livestock.pdf

- Strategies to optimize or improve the effectiveness of existing vaccination programs identified and developed by 2016.
- Improved immune system function, vaccine efficacy and animal health management to reduce the need for Health Canada Category I and II antimicrobial drugs by 50% by 2018.

COW NUTRITION, WATER QUALITY AND MINERAL SUPPLEMENTATION

A special thanks to Dr. John McKinnon who was interviewed, any errors or omissions is on the part of CRS

Factors relating to cow nutrition accounted for 25% of deaths in a 2001 study (Waldner et al. 2009[10]) emphasizing the importance of feeding management as a determinant of cow health in western Canada. The immune system, as well as other body functions, requires nutrients to work properly. When the animal is infected by a pathogen, energy and protein that were supposed to support productive functions, such as growth, reproduction, lactation, are diverted to support the immune response. These nutrients are required for production of white blood cells, support the inflammation process, multiplication of T and B cells, antibody synthesis, and many other immune processes. Therefore, maintaining cattle in good health will improve nutrient utilization and productivity. Similarly, cattle should always be maintained in adequate nutritional status so their immune system can work properly when needed.

Nutrient deficiencies increase susceptibility to most infectious diseases, including bacterial, viral and parasitic diseases. Once disease has developed, nutritional deficiencies increase the severity of the disease and the probability of secondary infections. Deficiencies of vitamins or trace minerals significantly depress immune function and resistance to stress even when animals are otherwise well fed with sufficient energy and protein. Stress increases requirements of many nutrients essential for immune function and leads to multiple short term deficiencies in shipping-stressed cattle.

Deficiencies in trace minerals can result in reduced feed intake and feed efficiency; reducing growth in calves, reproductive disorders (delayed or depressed estrus) and infertility issues, as well as skin abnormalities, rough hair coat, hoof and leg problems (lameness), and cardiac failure. Mineral programs can make a significant difference in productivity (e.g. the increase in weaning percentage can pay for the mineral). There has been significant work done in Canada.

The National Research Council (NRC) publishes nutrient requirements for beef cattle (1996[11], 2015). These requirements vary with the biological stage of the animal (e.g. pregnancy stage, lactation, breeding, or growing). Feed makes up 50-70% of the cost of production. High feed costs encourage producers to explore alternatives; in addition regional differences in feed availability require continual research on animal performance from different feedstuffs. For example, the introduction of dried distiller grains (DDGs) in regions where ethanol boomed required research into maximum inclusion levels in rations for various animal types.

Local and regional nutrition research addresses the climatic differences, breeds and available feedstuffs. For example, in the northern portion of the Prairie Provinces molybdenum in the soil and sulfates in the water contribute to copper deficiency. Local expertise assists in growing and developing the beef industry.

[10] Waldner, Cheryl, Richard Kennedy, Leigh Rosengren, Edward Clark. 2009. A Field Study of culling and mortality in beef cows from western Canada. Can Vet J 50:491-499.
[11] http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-1921/E-974web.pdf

RESEARCH AREAS

In order to develop a balanced ration, the animal's nutrient requirements must be taken into account as well as the feed sources that are available.

Soil types vary in mineral contents, with some being deficient (e.g. molybdenum) while others are not. If deficient, trace mineral availability in the forage grown can be negatively impacted and must be supplemented.

Forages vary in structure and nutrient value. Feed testing is important to understand the quality and nutrient value. For example, in western Canada many types of forage are low in Calcium and Phosphorus, but high in Potassium. Requiring supplementing of Ca and P, but not necessarily to the level provided in some commercial mineral packages.

Water quality: sulfates in water will tie up copper. Heavy rains, runoff, flooding and drought can impact water quality from year to year.

Mineral absorption: Chelated minerals are trace minerals that have been attached to an organic compound such as an amino acid. They can be beneficial if the producer has a specific problem - breeding, scours, foot rot, grass tetany, weaning, calving, or uses other practices like AI or embryo transfer.

It should be noted that copper requirements are not static, as they will vary with the amount of antagonists (molybdenum, sulfur, iron and zinc) in the feed and water that will it tie up. Hence the local situation and environment is important to take into consideration.

TECH TRANSFER OPPORTUNITIES:

There are several key technology transfer opportunities around nutrition, mineral supplementation and water quality from existing research that would support recommended practices and adoption.

- Value of testing feed and water regularly.
- Impact of soil type, water quality and forage test results on mineral programs
- Production impacts from trace mineral deficiencies, what to look for and how to identify if your farm is at risk.
- Managing and evaluating a mineral program – monitor intake, how to deal with mineral intake challenges (e.g. too much or too little, seasonal variation), location and management of mineral feeder. Delivery of mineral (total mixed ration or free choice).
- A lot of work has been done in western Canada on water quality looking at dugout versus trough water, mineral properties and their impact on palatability and metabolism.
- Clarifying in what situations chelated minerals make a difference

RESEARCH PRIORITIES:

Research around nutrition is never finished. Base research needs to be ongoing to ensure there is capacity when it is needed including:

- increasing our understanding of digestion of alternative feedstuffs;
- identifying the symptoms and cost of nutrition deficiencies;

- studying the macro and micro nutrient issues in various regions across the country.

Increased use of “extensive grazing” for wintering the cow herd means the delivery of water and micronutrients to the cow herd should be explored. There is a definite scarcity of reports in the peer-reviewed literature on the methods and evaluations of wintering cows in this fashion.

NUTRITIONAL DISEASES ASSOCIATED WITH HIGH CONCENTRATE RATIONS - *STACEY DOMOLEWSKI*

Nutritional diseases associated with high concentrate feeding include acidosis, liver abscesses and laminitis. In most cases acidosis is the predisposing factor with liver abscesses and laminitis occurring secondary to acidosis. Nutritional diseases can have a range of negative effects on normal behaviour and welfare. As they progress, they can lead to chronic debilitating conditions or death. The control and treatment of nutritional diseases is necessary to ensure beef cattle welfare. The particle length of forages in the diet can impact the risk of sub-acute and acute ruminal acidosis. Feedlot bloat can occur with over processed feed. Acidosis in the feedlot is most likely to occur during transition from a forage-based diet to a grain-based (high concentrate) diet. Gradual shifts from high forage to high concentrate diets allow for healthy populations of ruminal microbes to develop and for the ruminal epithelium to adapt; generally it takes 3 to 4 weeks to adapt to high concentrate diets. Feeding ionophores, such as monensin, minimizes sub-acute acidosis. Antibiotics in the feed decrease the incidence of liver abscesses.

ACIDOSIS

Ruminal acidosis is a digestive disorder that is characterized by low rumen pH (usually defined when rumen pH is below 5.5). Cattle consuming feed that is high in fermentable carbohydrates are at risk. This includes feedlot cattle and cattle grazing high quality pasture. Cattle that go off feed are also at risk when they start to return to normal intake. Acidosis is generally divided into subacute and acute forms based on how low pH goes and whether clinical signs (low and variable feed intake, stiffness, diarrhea, and sometimes death) are observed. It should be noted that temporary reductions in rumen pH are normal and in some cases can be associated with improved performance. That said, there is no doubt that when pH is too low or is low for too long, negative effects occur. Such effects include a reduction in rumen contractions, decreased fibre digestion, decreased nutrient absorption, and damage to the rumen epithelium. When damage to the rumen wall is severe, bacteria may cross the rumen wall and enter the blood stream going on to cause liver abscesses and laminitis. Subacute rumen acidosis may be a larger concern to the beef industry because symptoms are hard to detect and these cattle often have reduced weight gain and gain-to-feed.

Rumen acidosis is often seen as a problem for feedlot cattle, but cattle on pasture also can experience rumen acidosis. There is very little research done in the area of acidosis on pasture. A study from Ireland looking at dairy cattle showed that 11% of cattle were affected with some form of rumen acidosis (O’Grady et al. 2008). Although this cannot be applied to the Canadian beef industry, it does suggest that ruminal acidosis may be a problem for cattle that are on pasture. More research is needed into the prevalence of acidosis on pasture for beef cattle and the effects that this has on production. Dairy cattle on 50:50 forage concentrate rations also experience sub-acute ruminal acidosis that is caused by an increase in short chain fatty acid production (Mutsvangwa, 2003) this type of ruminal acidosis may be more similar to what beef cattle on pasture would experience, but more research is needed into the area of acidosis on pasture before any conclusions can be drawn.

Although no research has looked into the cost of acidosis to the Canadian beef industry, it is suggested that the cost to the individual producers stems more from the loss in production and efficiency when cattle are sub-acutely affected as opposed to the cost of death loss or treatment costs (Hilton, 2014). Digestive disorders are second to respiratory disease for depressed performance and efficiency (Nagaraja, 1998). It is very difficult to measure acidosis under commercial settings, as rumen pH is currently the only reliable indicator. Rumen acidosis studies have, in the past, required cannulated cattle with large numbers of samples being taken, making them difficult to do, and adding to the difficulty in understanding prevalence. New methods to detect ruminal acidosis are needed to get a better understanding on the economics related to acidosis in the beef industry. Evaluating liver abscesses post mortem provides an indication of the incidence of acidosis, but the presence of liver abscesses and rumen acidosis are not mutually exclusive. Cattle can have ***liver abscesses*** but not have had acidosis, or have had acidosis but not have liver abscesses.

Although it is difficult to measure prevalence on an industry basis, past studies have shown that feedlot cattle on average spent anywhere from 3.9-20.9 hours per day with a rumen pH of below 5.6. Recent research by Castillo-Lopez *et al.* (2014) showed lower incidences of ruminal acidosis and suggested that because of the way that data was collected in the past, previous studies could actually be overestimating prevalence of acidosis. Castillo-Lopez *et al.* (2014) suggests that there is an overestimation due to the fact that most past studies looked at cattle fed individually. In this study where cattle were fed in groups, as is standard industry practice, and were allowed to exhibit normal feeding behaviour, they spent on average 3.2 hours per day with rumen acidosis. Another study is currently being conducted on a larger scale and the findings will be useful in determining the true incidences of rumen acidosis in feedlot cattle.

There are currently no Canadian numbers quantifying death loss due to acidosis, but in 2005, the National Health Monitoring System showed that 7% of beef cattle death loss could be attributed to digestive problems in the southeast US. (NCBA, 2006) It is important to note that this number includes acidosis and bloat.

The dairy industry has conducted a lot of research on rumen acidosis and obtaining industry wide prevalence, and economic costs. This data cannot be used to make assumptions in the beef industry due to different management practices and economic structures. Also in most of these studies the primary focus is milk production and not effects on weight gain, calf performance or daily gain, which would be of more value in the beef industry.

Ruminal acidosis is still not clearly understood so most research continues to look into better understanding the digestive disorder. More research is needed for effective prevention strategies. Past research has looked at the use of step up diets and strategies to introduce cattle onto a high concentrate diet, how feeding behavior affects risk for acidosis, the impact of feed processing and how it influences risk for acidosis, and what rumen bacteria are associated with acidosis. Recently, researchers have investigated how adapting the gut may help prevent acidosis. In addition, it has been recognized that external factors like weather and pen conditions may also play a role in predisposing cattle to rumen acidosis. Current research is also looking into feed additives such as buffers, prebiotics, and probiotics.

FEEDLOT BLOAT

Feedlot bloat can be either frothy or free gas bloat. Frothy bloat is usually the result of over processing feed. The small particles of the feed cause the rumen bacteria to release polysaccharides. These, along with polysaccharides released when rumen bacteria cells rupture increase the viscosity of the rumen fluid which means that small gas bubbles become trapped in the rumen fluid, leading to frothy bloat. (Majak W. *et al.* 2003).

Free gas bloat is much less common and more sporadic than frothy bloat. Free gas bloat accounts for approximately 10% of all cases of feedlot bloat and is more likely to affect animals on an individual versus pen basis. Free gas feedlot bloat can be the result of several factors including irregular feed intake, inhibition of the nerves that control contraction of the rumen walls (such as in the case of hardware disease), or any physical obstruction of the esophagus. (Majak W. *et al.* 2003).

For the most part bloat on its own is well understood and currently not a high research priority when it is looked at on an individual basis. Sometimes feedlot bloat is looked at as a measurement in acidosis studies when looking at feed additives, or feeding strategies to reduce acidosis and also prevent bloat.

LAMINITIS

Laminitis (sometimes referred to as founder) is the acute or chronic infection of the hoof that can be caused by severe or prolonged acidosis symptoms. (Alberta Agriculture and Rural Development, 2011) The exact etiology of laminitis is not fully understood but it is hypothesized that when acidosis occurs the rumen bacterial population rapidly shifts from primarily fibre digesting bacteria to primarily concentrate digesting bacteria. As some of these bacteria die they release toxins. If the pH of the rumen was low enough for long enough and the animal had experienced ruminitis where the epithelial lining of the rumen was damaged these toxins are able to enter the blood stream. Once in the blood stream toxins cause small arterioles to dilate and increase the blood pressure in the claw, further damaging the blood vessels. (Greenough, 1997) As a result the blood vessels in the claw swell, and damage the tissues that form the claw. Cattle can experience varying degrees of laminitis. (Alberta Agriculture and Rural Development, 2011) In some cases animals will not show symptoms if they are in well bedded pens. Signs may only become evident when cattle are standing at feed bunks. In other cases cattle may show signs of pain while walking, or even crawl on their knees.

Although laminitis can affect cows on pasture, it is considered more of a disease of feedlot cattle. Because of the short time that cattle are in the feedlot, treatment options are very limited. NSAID's can sometimes reduce symptoms if they are given before laminitis symptoms become acute. Since laminitis is actually damaging the horn of the hoof, little can be done to reverse the damage Treatment normally focuses on relieving pain and in the case of mild laminitis treatment is often not cost effective. (Alberta Agriculture and Rural Development, 2011) In severe cases cattle may need to be euthanized. Trimming the hooves may help to reverse some of the damage but it is not practical in a feedlot situation, it is more of a solution for cows on pasture or dairy cattle.

Although the exact mechanism and exact cause of laminitis is not fully understood very little current research is looking into laminitis on its own. Laminitis research tends to be included in studies that are looking at lameness in feedlot cattle, or as a measurement factor in acidosis studies. Currently a study out of Agriculture and Agri-Food Canada, Lethbridge Research Center is looking at prevalence of feedlot lameness, which will give a better understanding of prevalence of laminitis and how laminitis affects the Canadian beef industry.

Part of the struggle with collecting laminitis data is that it can only be diagnosed post mortem by doing an autopsy on the foot. This may be a contributing factor to why industry prevalence is currently unknown.

RESEARCH PRIORITIES:

Research is needed to define the prevalence of acidosis in Canadian feedlots and to further define how ruminal pH influences animal welfare, such as whether acidosis and/or sub-clinical acidosis are painful for cattle. Also needed is continued research to:

1) identify optimal feedlot transition strategies;
2) identify differences in feeding behaviour, ruminal physiology, metabolism and genetics that lead to individual variations in susceptibility to acidosis;
3) in extremely painful cases/situations there must be focus on decreasing incidence;
4) determine which diets produce the best weight gain and carcass with the least digestive upset.
5) Economic analysis to compare the cost of reduced final weight to the cost of nutritional diseases associated with high concentrate feeding (i.e. drug treatment costs and carcass value losses) is also needed.

PRODUCTION LIMITING DISEASES

BOVINE RESPIRATORY DISEASE (BRD) - *DR. EDOUARD TIMSIT AND DR. CALVIN BOOKER*

Despite numerous advances in bovine infectious disease research, bovine respiratory disease (BRD) remains highly prevalent in Canadian feedlots and contributes to decreased cattle performance. Several areas can be improved to better control BRD. To advance BRD prevention, development of alternatives to on-arrival mass medication with antimicrobials (e.g., probiotics, Nitric Oxide in its gaseous form - gNO, etc.) and development of efficacious vaccines against *M. bovis* (and *P. multocida*) are needed. The cost-effectiveness of preconditioning (in various forms) and cattle acclimation procedures (such as low-stress cattle handling or cattle training) should also be investigated. To enhance BRD treatment response and decrease the impact of BRD, the benefit of health monitoring systems (location tracking devices, IRT cameras installed at a watering system, rumen temperature boluses, etc.) should be evaluated and these systems should be promoted if found cost-effective. Methods to augment chute-side accuracy of the BRD diagnosis (thoracic ultrasonography and lung auscultation) should also be further evaluated. Finally, antimicrobial sensitivity testing of bacteria currently involved in BRD cases occurring in Canadian feedlots is needed to optimize treatment regimes and ensure sustainable use of antibiotics.

ECONOMIC COST

Bovine Respiratory Disease (BRD) is one of the most significant health problems in the beef industry. Despite substantial advances in antimicrobials and vaccines against respiratory pathogens, BRD remains an important cause of morbidity and mortality in beef cattle, causing considerable economic losses (>$500 million per year in North America) and decreasing animal welfare.

Cattle of all ages can suffer from BRD; however, cattle are most affected during the first 50 days following their arrival at the feedlot because they are exposed to a wide range of pathogens (as a result of commingling) at a time when various stresses negatively affect the immune system. Indeed, although BRD is ultimately a bacterial disease, it is a multifaceted problem with host (genetic, immunity, stress), management (weaning, transportation, commingling), and environmental (temperature variation) factors combining to predispose to cattle to respiratory disease.

RESEARCH AREAS

Control of BRD can be divided in two parts: its prevention and its treatment. Because BRD is multifactorial, a holistic approach to prevention is needed aiming at: (1) decreasing exposure to pathogens; (2) increasing host resistance (through vaccination or genetic selection); and (3) reducing or eliminating predisposing factors.

Since its conception, preconditioning has repeatedly demonstrated a reduction in BRD morbidity and mortality in feedlots. However, it can also simply shift health disorders from feedlots to cow/calf producers, where infrastructure and labour forces are often less adapted to treat a large number of animals. In addition, premiums paid do not always cover the costs – making it financially risky for producers. Also all preconditioned calves are not risk free for the feedlot with benefits potentially lost when cattle are comingled.

Comparison of feedlot health performance of preconditioning and conventional calves (1980-1987)

	Preconditioned			Conventional		
Feedlot Location	**# of calves**	**% treated**	**% died**	**# of calves**	**% treated**	**% died**
Alberta	13,567	9.1	0.6	23,180	21.4	1.6
Ontario	2,616	7.9	0.2	3,335	25	0.7

Treatment of cattle with BRD is divided into three steps: (1) detection; (2) diagnosis; and (3) treatment or selection of antimicrobial agent and ancillary therapy. Each step is critical to effective control of BRD.

Cattle with BRD are often **detected** late in the disease process (often a few days after the onset of fever) or not detected at all. Early detection is key to effective BRD control as it enables early treatment; maximizing the opportunities for clinical and bacterial cures, thus decreasing the impact of BRD on cattle performance and welfare. Numerous systems have been recently commercialized to remotely and continuously monitor the physiology (body temperature) and behaviour (feeding behaviour and activity) of beef cattle. Unfortunately, only location tracking systems and IRT cameras installed at a watering station seem feasible for improving BRD detection in commercial feedlots. All other systems are either too expensive (Growsafe) or not practical enough (pedometers, rumen temperature boluses) for commercial use at this time. Further research is needed to (i) better characterize the detection accuracy of these systems in commercial feedlots and (ii) determine the cost-benefit of early BRD detection using these systems. Interestingly, a recent Canadian study estimated that these early detection systems should cost less than CDN$4.06 per steer to be cost-effective.

Diagnosis of BRD in feedlots is typically based on visual signs of respiratory disease and temperature. However, this diagnostic method is not always accurate, with an estimated specificity of only 63%. Several laboratory tests could enhance the accuracy of BRD diagnosis in feedlots. For example, detection of respiratory pathogens such as *M. haemolytica, P. multocida, M. bovis*, etc. in the lower respiratory tract of cattle could confirm the presence of a lung infection. However, numerous studies have shown that respiratory pathogens can also be found in the lower airways of healthy animals, which raises questions about the specificity of their detection for confirming BRD. Determination of acute phase proteins (APPs) such as serum haptoglobin can also be used to confirm the presence of inflammation and/or infection. However, determination of APP concentrations takes time to complete, which is not compatible with a chute-side decision for treatment. Chute-side examination of the respiratory tract (e.g. thoracic ultrasonography and lung auscultation[12]) needs further investigation along with the cost effectiveness of their use in a commercial feedlot setting.

Treatment of BRD with antimicrobials significantly increases recovery rate and decreases mortality in feedlot cattle. However, all antimicrobials are not equal and the appropriate antimicrobial agent to treat BRD should be selected carefully.

Tulathromycin ranks as the most efficacious antimicrobial treatment of BRD, and the older molecules, such as the ceftiofur formulations, trimethoprim and oxytetracycline are among the least efficacious antimicrobial treatments of BRD (O'Connor *et al.* 2013). Numerous data are available in the scientific literature to select the most appropriate treatment based on cost and expected treatment-response.

Alternative therapy may need to be considered when the percentage of BRD pathogens classified as resistant to any one antimicrobial agent is >25%. Based on this recommendation, antimicrobials such as

[12] Research on dairy cattle does not show a significant connection between the presence of lung lesions and disease or economic impact.

tetracycline (with only 49% of M. haemolytica isolates sensitive to this antimicrobial) and tilmicosin (with only 59% of M. haemolytica isolates sensitive to this antimicrobial) should not be recommended for the treatment of BRD in the Unites States and Canada. However, because there is considerable year-to-year and regional variation (US versus Canada), it is critical to have access to updated and local antimicrobial susceptibilities to decide which antimicrobial to select or reject.

Ancillary therapies (i.e., drugs in addition to the antimicrobial) are commonly used in feedlot cattle. In the US, nearly half the cattle with BRD are vaccinated against a respiratory pathogen (e.g., IBR), one third are treated with vitamin C and 20% receive non-steroidal anti-inflammatory (NSAID) drugs (e.g., banamine, aspirin, etc.) at the time of initial treatment (USDA, 2013. Feedlot 2011, Part IV: Health and Health Management on US Feedlots with a capacity of 1000 or more head). Interestingly, there is no current evidence that adding other products to a single antimicrobial increases treatment response in feedlot cattle. Ancillary therapies can nevertheless substantially increase costs associated with treatment.

CANADIAN

Presently, prevention of BRD in feedlots relies mainly on mass-medication with injectable antibiotics (i.e. metaphylaaxis) at or soon after arrival. Two alternatives are currently being investigated in Canada. One is on-arrival inhalation of Nitric Oxide in its gaseous form with nasal administration. Second, is nasal administration of probiotic products on arrival at the feedlot. There is no research currently being conducted on preconditioning in Canada that we know of.

To the authors' knowledge, only one study (led by Dr Timsit, U of C) is currently investigating health monitoring systems (IRT camera) and BRD detection in Canadian feedlot cattle. No studies are currently being conducted on thoracic ultrasonography and lung auscultation in Canadian feedlots.

Two projects (one led by Drs. Alexander and Timsit and one led by Dr. Ralston from Agriculture and Rural Development [ARD]) are currently being conducted in Western Canadian to study antimicrobial resistance in BRD pathogens.

Given similar production systems, utilizing and building on results found in the United States is necessary.

TECH TRANSFER:

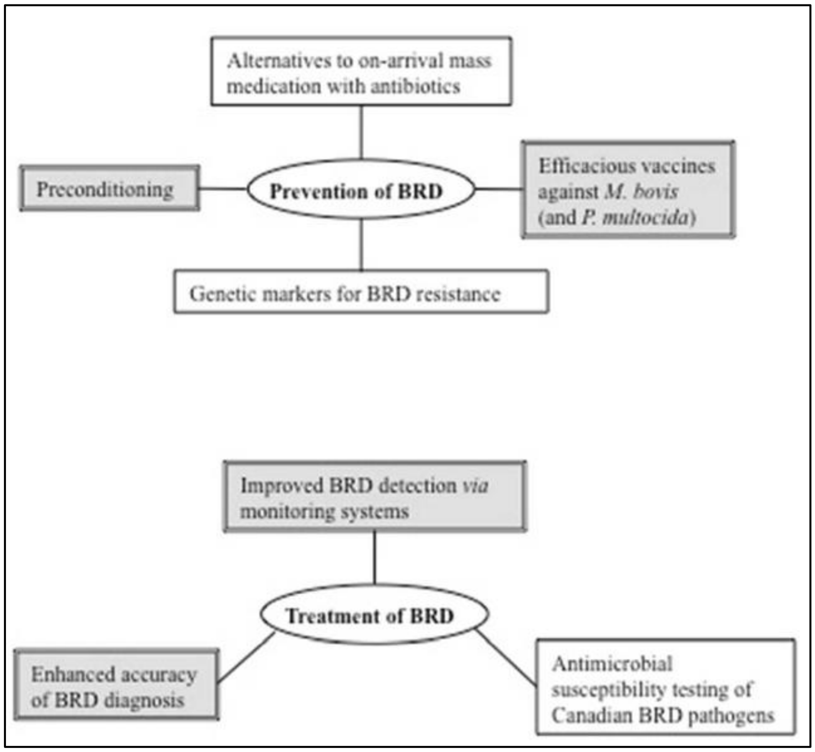
There is plenty of evidence and research showing the health benefits of preconditioning. A calculator that evaluates the economic opportunity for cow/calf producers from preconditioning is available on the Beef Cattle Research Council website. But further research is needed to assess the cost-effectiveness associated with preconditioning for feedlot producers – as they still face production risks with preconditioned cattle impacting willingness to pay and price premiums.

A downloadable spreadsheet that calculates the difference in treatment response necessary to justify an increase in treatment cost can also help in selecting the most cost-effective antimicrobials for a particular feedlot.

RESEARCH PRIORITIES:

The figure shows areas where research is needed to improve Bovine Respiratory Disease (BRD) control in Canadian feedlots. Grey boxes indicate research areas where no research projects are currently conducted in Canada (to the authors' best knowledge).

The full report by Edouard Timsit and Calvin Booker is available upon request.



BOVINE VIRAL DIARRHEA VIRUS (BVDV)

Bovine viral diarrhea virus (BVDv) costs the beef industry through decreased production and increased expenses. When a cow is infected with BVDv in early pregnancy, the offspring may be born persistently infected (PI). PI animals are generally considered to be the primary source for transmission of the virus. According to a study conducted in a Western Canadian feedlot in 1991, the estimated prevalence of PI calves in 5,129 calves was less than 0.1%. Although the prevalence of PI was low, serological tests suggested a high risk of seroconversion to BVDv (Taylor et al. 1995). In the US, data collected from recent surveys of beef cattle indicates that the prevalence of PI animals is less than 0.3% in surveys of beef herds, feedlots and dairies. The apparently low prevalence of BVDv-infected beef herds in the US based on PI animal detection is thought to be underestimated[13] (Van Campen, 2010).

In the U.S., total annual losses have been estimated at $20 million for every million calves when modeling for low-virulent BVDv strains and $57 million when modeling for a high-virulent BVDv strain (Houe, 1999). If we take Canada's breeding herd at 3.9 million beef cows that would put BVD losses here in the range of $78 and $220 million (Clarke, 2014).

Vaccination of feedlot cattle against BVDv antigens is commonly practiced in North American feedlots. Terrell et al. (1999) surveyed feedlot veterinarians providing cattle health and well-being recommendations for feedlot cattle in the United States and Canada and found that all surveyed veterinarians recommended that high-risk cattle be vaccinated with BVDv (types 1 and 2) vaccine, and

[13] Test methods in 2010 did not detect PI fetuses, herd sizes are large and individual testing is not logistically or economically feasible; an estimated 80% of cattle in the US are vaccinated with either inactive or modified live viral vaccines containing BVDv; consequently BVDv seroprevalence is high and the serologic tests are unable to distinguish between vaccinated and naturally infected cattle. In addition, some BVDv infected herds may be misclassified if there is no PI animal alive at the time of testing and as BVDv associated diseases are not reportable there is no data enumerating BVDv associated cases.

95.65% recommended that low-risk cattle be vaccinated with BVDv (types 1 and 2) vaccine. However, very little clinical trial data exist illustrating the efficacy of vaccination at feedlot arrival to prevent BVDv infection and clinical disease associated with BVDv (Larson, 2015).

INTERNATIONAL

Europe – During the 1990s a systematic strategy to controlling BVDv evolved within eradication programs in the Scandinavian countries. This strategy is based on three central elements 1) biosecurity, to prevent introduction of infection into free herds; 2) elimination of PI animals in infected herds to reduce virus circulation; and 3) continuous monitoring of free herds for early detection of reinfection (Lindberg and Alenius, 1999). The model used within the Scandinavian BVDv control schemes has been very successful. As of 2012, all of the Scandinavian countries are free, or almost free from BVDv (Ståhl, K., & Alenius, S. 2012).

An economic analysis on the 10-year (2008-2017) Swiss eradication program estimates that the break-even point was reached in 2012, approximately 4 years after the program began. The economic analysis on the Norwegian eradication scheme shows projected saved losses between NOK$50 and 200 million annually with costs of NOK$52.4 million over 10 years.

US – Research in recent years have shed light to prevalence of BVDv (Wittum et al., 2001; Loneragan et al., 2005, Fulton et al., 2006; O'Connor et al., 2007), economic effects (H. Houe, 1999; Hessman et al., 2009; Smith et al., 2014), cattle performance (Hessman et al.,2009), vaccine efficacy (Fulton et al., 2003) and detection of emerging BVDv subtypes.

Mandatory, systematic BVD control programs similar to those in the Scandinavian countries do not exist in the U.S. (Lindberg et al., 2006). The perception of a low prevalence of BVDv herd infections, the unrestricted sale of PI cattle, lack of economic data, intensive marketing of vaccines, reluctance to accept federal regulations, and a ''gambler's'' attitude among producers are impediments to implementation of a national systematic BVD control program (Van Campen, 2010).

Since 2004, voluntary BVD control programs have been organized in nine states reflecting the recognition of BVD as an important and preventable problem in the U.S. All programs are voluntary, associated with a university and organized in conjunction with other beef or dairy quality assurance programs. Program elements include: (1) education about BVDv transmission and diseases, (2) required testing procedures, (3) documentation of biosecurity practices to prevent the re-introduction of BVDv, and (4) verified use of a vaccination schedule (Van Campen, 2010).

Oceania – Disease surveys in Australia have found that up to 60% of cattle and up to 90% of herds have been infected with BVDv (Department of Agriculture and Food, Australia). The cost to the national industry is estimated to be AUD$57.9 million annually (Lanyon et al., 2014). There is no BVDv eradication program currently available in Australia. The barriers to BVDv control include large (beef) cattle herds and their unique management practices (such as annual mustering), lack of leadership and a lack of certainty about the potential of other species to act as potential reservoir hosts for the virus (particularly in the case of sheep) (Lanyon et al., 2014).

In New Zealand, the prevalence of BVDv and its economic cost to the industry are well defined. It is estimated that at least 65% of beef herds have active virus infections. The annual losses for beef famers are estimated at NZD$3,000-$9,000 per 100 cows in infected herds. The BVD Steering Committee has been promoting BVD control to the veterinary professions and farmer over the country since 2005, and is now exploring the possibility of a national BVD control program.

Global – Recent studies conducted in Europe (Fiammarioli et al., 2015), South America (Silveira, 2015) and Asia (Zhang, 2014) show a high genetic diversity of BVDv in these regions and raises concern related to the emergence and spread of new BVDv variants.

CANADIAN

In Canada the prevalence of PI calves in feedlots populations has not been well established (Campbell, 2004). The Canadian sourced data quoted by most studies today is from the study by Taylor *et al*. (1995) conducted in a single feedlot in western Canada. While there are estimated economic impacts of BVDv in North America, economic analysis focusing on the Canadian beef cattle herd is limited.

There is a lack of scientific literature examining the effects of BVDv vaccination on subsequent health parameters of feedlot cattle. The benefits of prevaccination and preweaning or preconditioning have been demonstrated in a variety of studies, but the effect of BVDv vaccination are not separated from the other vaccines and management procedures in these studies. The use of BVDv vaccines before arrival at the feedlot has not been examined specifically. The effect of prevaccination on BVDv immunity has not been well established, and will require further research (Campbell, 2004).

Two BCRC projects completed in 2007 and 2011 shed light to DNA-based vaccines against BVDv. The research team led by Dr. Sylvia Van Drunen Littel-van den Hurk produced BVD virus Type 1 and Type 2 E2 DNA-based vaccines and developed the TriGrid™ Delivery System which delivers DNA vaccinations using a process called electroporation. Electroporation uses electrical impulses to create pores in cells that make DNA insertion into cells easier. The results show that a DNA vaccine for BVD could be administered to newborn calves via electroporation and provide excellent protection.

Adam Chernick et al. (2014) examined the evolution of BVDv subgenotype 1a in Western Canada from 1999 to 2013. Using 5’UTR and E1–E2 sequence data as well as collection date and locations data obtained from isolates submitted to a diagnostic laboratory in Saskatoon. The study found that the Western Canadian Isolates share a most recent common ancestor dated near 1909. Furthermore, the E1–E2 region shows a median substitution rate about ten times greater than the 5’UTR. The study also found that there are significant gains to be made by utilizing a Bayesian analysis and by incorporating additional types of data beyond the sequence. These include the estimation of most common recent ancestor dates and the precise inference of transmission routes.

RESEARCH PRIORITIES

More precise and current surveillance information would help the industry evaluate the appropriate level of emphasis to place on BVDv research.

Economic analysis on the impact of BVDv in Canadian beef and cattle operations would help to evaluate the feasibility of BVDv control programs in Canada.

Evaluation of current vaccines against BVDv at feedlot and cow-calf levels as well as the development of innovative vaccines is also important.

Assessment on health impact of different BVDv subtypes and detection of new subtypes will have important implication on BVDv control and vaccine development.

GASTO-INTESTINAL PARASTIC NEMATODE INFECTIONS - *DR. JOHN GILLEARD*

Gastro-intestinal nematode (GIN) infections (roundworms) have a negative impact on production through three main mechanisms: (a) appetite suppression reducing feed intake; (b) compromised gastro-intestinal function reducing feed conversion; and (c) diversion of dietary energy and protein away from growth towards the immune response. Appetite suppression is considered to be the most important contributor to production loss. The overall impact of internal parasitism in beef cattle is manifested by reductions in weight gain, feed conversion efficiency, carcass quality and reproductive performance. In addition, there are potential impacts associated with suppression of the immune system, of which clear evidence is still lacking. These include the predisposition to other inter-current (viral, bacterial and metabolic) diseases as well as reducing responsiveness to vaccination programs

The beef industry has relied on the use of pour-on macrocylic lactone drugs (e.g. ivermectin) to control GIN parasites for the last 30 years. These anti-parasitic drugs have provided producers with major production benefits. However, resistances to the macrocyclic lactones, as well as other anthelmintic drug classes, have emerged worldwide and now threaten sustainable control. Although there is limited information from Canadian cattle, preliminary data suggests that ivermectin pour-on treatments often have sub-optimal efficacy. Changes in consumer expectations also need to be considered and it is important that the beef industry is proactive in developing more sustainable approaches to parasite control and that anthelmintic drugs are used in a more evidence-based manner as with other pharmaceuticals.

ECONOMIC IMPACT

The discovery of highly effective broad spectrum anthelmintic drugs in the 1980s transformed parasite control and the routine application of these products over the last three decades has significantly improved the productivity of the North American cattle industry. One of the challenges of determining the economic impact of GIN parasitism is that production impacts vary dramatically between individual herds, geographical regions and from year to year (depending on husbandry practices and climatic conditions). A meta-analysis of over 170 research trials has suggested that the economic benefit of anthelmintic use to the cattle industry of North America is >2.5 times that of growth promoters (Lawrence 2006). This study concluded that eliminating anthelmintics from the entire cow-calf, stocker and feedlot beef production chain would negatively impact breakeven prices by 19%.

It has been estimated that GIN infections cost the US and Brazilian cattle industries over $2 billion and $7 billion per annum respectively (Stromberg and Gasbarre 2006). There is no published analysis for the economic impact on Canadian cattle. However, given the similarity of infection intensities to those seen in the northern US states, the cost is likely to be in the tens of millions dollars per annum as a conservative estimate.

INTERNATIONAL & CANADIAN RESEARCH

Although, anthelmintic resistance has only been recognized in cattle parasites relatively recently, it appears to be widespread. It is now widely regarded as the most important animal health and production problem for small ruminants worldwide.

There are only two classes of anthelmintic available for cattle GIN parasite control in Canada; the macrocyclic lactones (such as ivermectin and doramectin) and the benzimidazoles (such as fenbendazole and albendazole). Over the past twenty years, the macrocyclic lactones have been the most commonly used, largely because they provided coverage against ectoparasites such as lice and cattle grubs (hypoderma species). Although there are no published studies on the prevalence of anthelmintic resistance in Canadian beef herds - recent unpublished data suggests that the situation is similar to that described in the USA. Research by ALMA and Merck indicated many macrocyclic lactone treatments are being applied at sub-optimal efficacy. This is a concern, not only because of the potential production loss, but also because sub-optimal dosing is a major risk factor for the selection of drug resistant parasites.

Benzimidazoles have not been heavily used in Canada so the selection pressure has been considerably lower than for the macrocyclic lactones. Use of benzimidazole drugs is now increasing with the growing awareness of ivermectin resistance. Based on experience with cattle parasites from other countries where benzimidazoles have been more heavily used, it is likely that resistance to this drug class will emerge quite quickly as usage increases. Mutations that can confer benzimidazole resistance have already been identified in *O. ostertagi, C. oncophora* and *H. placei* in a number of countries and detectable field resistance is present in those countries where there has been significant use in cattle.

Efficacy of macrocyclic lactone drugs is suboptimal in many Canadian beef herds and is predominantly *Cooperia* species that survive the drug treatments. Although, resistance to the benzimidazole drugs is apparently less common at present, resistance is likely to emerge as the use of this drug class increases. Of particular concern is the potential of resistance emerging in the highly pathogenic nematode species *Ostertagia ostertagi* which has already shown a propensity to develop benzimidazole resistance in several other countries.

RESEARCH PRIORITIES:

The effectiveness of the macrocyclic lactones has resulted in a lack of investment in cattle GIN parasite research for almost three decades. Consequently, there are a now large number of both basic and applied research priorities. The most urgent of these include:

(1) Obtaining regional information on GIN parasite infection intensities, parasite species distributions, production impacts and on the prevalence of anthelmintic resistant parasites in Canadian beef cattle.
(2) Developing more accurate, accessible and affordable diagnostic tools to measure parasite infection intensities, production impacts and to detect anthelmintic resistance.
    a. Determining what different parasite loads mean for an animal and what is considered "acceptable" in cattle (this is relatively clear in small ruminants[14]).
    b. Determining what different anthelmintic resistance means for an animal and what is considered "acceptable" in cattle.
(3) Elucidating the epidemiology of the major cattle parasite species in Canada and using this information to inform evidence---based control practices.
(4) Investigating producer perceptions and developing policies to maximize the adoption of new technologies and sustainable parasite control programs such as targeted selective treatments[15].

In addition to these urgent research needs, that will have short to medium term benefits, there are also longer term research priorities. These include research into (1) selective breeding of cattle for

[14] The equations/recommendations currently being used are adapted from small ruminants, but it is unclear how this correlates with cattle. Especially considering fecal material in cattle has a much higher liquid content and the relevant FEC may then differ in cattle.

[15] Including Refugia research and which animals should be treated.

resistance/resilience to parasite infections, (2) development of parasite vaccines, (3) development of improved drug delivery methods and (4) new drug classes. These, as well as some of the more immediate priorities, will need a significant investment in genomic resources for the major parasite species such as the development of high quality reference parasite genomes.

The full report by Dr. John Gilleard is available upon request.

ECTO PARASITES - *DR. DOUG COLWELL*

Horn flies (*Haematobia irritans irritans)* cause significant reductions in productivity of pastured cattle through induction of stress, changes in grazing patterns and, in extreme cases, blood loss. Burdens of 200–500 flies will reduce weight gains of beef cattle (up to 14% reduction) and will reduce milk yield (Haufe, 1987). Heavy infestations (over 1000 flies) can cause serious loss of condition and rarely, deaths. Control can result in higher feed efficiency, increased growth rate and increased calf weaning weights. Control of *H. irritans* results in better food intake and conversion, better growth rate and better calf weaning weights. They are also known as vectors of diseases such as anaplasmosis. Virtually all of the cattle on pasture in North America are affected by horn flies with the exception of those kept at higher elevations.

Infestations are controlled by traps, insecticide sprays, back rubbers, dust bags, or eartags impregnated with insecticides. Eartags impregnated with organophosphorus compounds and synthetic pyrethroids have been widely used, but resistance has built up to levels that make this technique highly ineffective. Resistance to diazinon has been reported in eastern Canada and the United States.

There are two species of **Cattle grubs or warble flies** which specifically parasitize cattle: *Hypoderma bovis*, and *H. lineatum*. They are not easily seen because of the rapidity of their flight. Repeated infestation results in an acquired immunity that results in older animals being less severely affected than younger animals. If the fly population is heavy, cattle at pasture may be worried by their attacks which disrupt grazing and breeding behavior. Avoidance behavior, called gadding, may result in injury as cattle run into fences and other natural obstructions. Immunosuppression results from the effect of larval secretions. All larval stages of cattle grubs are very sensitive to macrocyclic lactone compounds. Their widespread use in nematode control programs plays a major role in controlling warble flies, but has become a major issue as resistance to these compounds becomes a larger issue. Advent of the macrocyclic lactone endectocides has greatly reduced the prevalence of the cattle grub species in North America, but they persist in localized areas.

Cattle lice, there are four species of biting lice and one species of chewing lice. Populations begin to increase with cooler temperatures, reaching maximum levels in late winter. Treatments should be timed to coincide with the beginning of population growth (i.e. autumn or early winter). Extremely early treatments often result in spring outbreaks that result from very small residual populations on a few animals. Effective management of lice in a herd requires that new animals be isolated for a period of time sufficient for all lice to be eliminated by treatment. The introduction of one or two lousy animals to a herd leads to a slow build-up of infestation.

Stable flies, *Stomoxys calcitrans*, are the most economically important species affecting confined livestock in North America. This fly has now moved onto pasture where it can affect cattle that are fed from round bales left as a food source. Bites are quite painful and often bleed freely when fresh.

Feeding activity results in stress to the animals through feeding of the flies and the pain they cause and reduced efficiency through reductions in feeding time. When large numbers of flies are present the animals will bunch to reduce biting rates on individuals. At high environmental temperatures the bunching may result in cattle overheating. A localized sensitivity of the forelimbs of cattle may develop and result in the formation of intradermal blisters which coalesce to form bleeding sores. With very heavy infestations some deaths may occur. In confined cattle the fly populations can be assessed by counting the number of flies on the front legs. When the average number exceeds 5–10 per animal significant losses can occur.

Stable flies are mechanical vectors for a number of diseases including anthrax, bovine viral diarrhea, and surra. They are intermediate hosts for a nematode parasite of horses, *Habronema majus*, which may cause an allergic dermatitis.

Effective management of stable flies requires removal of high moisture, rotting organic matter from the environment. Edges of silage pits, manure, and compost piles should be kept dry and manure-contaminated bedding should be removed regularly. Insecticide treatments must be applied to all exterior surfaces (i.e. barn sides, fences, and exterior of feed bunks). Diflubenzuron 0.5 g/m2 sprayed in a cow barn completely inhibited breeding of the stable fly. Spraying of fixtures and walls, particularly sunlit walls where the flies often remain unnoticed, with long-acting compounds reduces infestations for 2 weeks or longer.

INTERNATIONAL & CANADIAN RESEARCH

In the past few years the majority of **horn fly** research has occurred on cattle in the southern hemisphere but there is some research on control in North America and the microbiome. Research could be pulled from international sources but many insecticides are not registered in Canada. However there is still significant information on the biology and the impact that must be developed in Canada for our conditions. In particular there is a lack of information on the impact and the threshold that must come from Canadian conditions and the variation that will occur as the problem is surveyed across the country.

Cattle grubs or warble flies - Vaccination of cattle using crude larval extracts has reduced both the number of warbles in the back and the number of larvae that could pupate. Results of vaccination studies with recombinant antigens have been variable, but show promise although there has been no commercial development. Recent efforts on cattle grub have not been evident in the majority of northern latitudes except for the occasional report on molecular results (Weigl et al. 2010). Much of the relative information on cattle grubs simply does not exist as reported in review by Sandeman et al. (2014). Although because grubs remain of importance to label claims and label requirements they continue to be reported at low levels in some studies

There is very little information available on **biting and chewing lice** in both literature from Canada or from abroad. A small amount of information on the occurrence of lice is available in Canada but most is outdated (Colwell et al, 2002). Research on sucking lice is largely limited to occasional efforts into louse control although some recent efforts have redefined aspects of louse biology (Colwell 2014). Aspects of **louse** occurrence (Colwell et al, 2001) and the effect of alternate controls (Briggs et al. 2006) as well as studies of the impact of immunity (Colwell & Himsl-Rayner, 2002) are under control.

A great deal of the material on fundamental research on **stable flies** can be obtained from international literature. However there is still significant information on the biology and the impact that must be developed in Canada for our conditions. In particular there is a lack of information on the impact and the threshold that must come from Canadian conditions and the variation that will occur as the problem is surveyed across the country.

TECH TRANSFER NEEDS:

Technology transfer is not common and is largely related to control options.

RESEARCH PRIORITIES

Fundamental research on **horn flies** and **stable flies** biology and the impact on beef cattle in Canadian environments. In particular there is a lack of information on the impact and the threshold for Canadian conditions including the variation across the country.

The full report by Dr. Doug Colwell is available upon request.

REPRODUCTIVE EFFICIENCY

Reproductive failure is the most common reason associated with culling cows from the breeding herd. According to the 2015 Western Canadian Cow-Calf Survey, open rates were 7% in cows and 10% in heifers. The conception rate for all females at 92.8% was down from 95.6% in 1998 (Western Beef Development Centre, 2015). The expense of an open cow to a producer is not only the lost value of a calf, but also the cost of maintaining the cow for a year – having a direct impact on the per unit cost of production and an operations profitability.

Many factors can lead to reproductive failure, including poor cow nutrition, mineral imbalance, bull infertility, and other diseases. However, 25% of reproductive failures in Western Canadian herds go undiagnosed; thus the relative impact of each factor is not completely understood (Hendricks & Campbell, 2015). Nutrition is probably the most important factor that influences cow fertility. Cows deficient in energy (indicated by body condition) or trace minerals preferentially partition these nutrients to maintenance rather than reproduction (Hendricks & Campbell, 2015).

Large-scale studies of the economic cost of non-pregnancy in cow-calf operations have been limited due to the many different management strategies employed by producers and the large quantity of epidemiological and economic data required. Bellows *et al.* (2002) estimated reproductive failure cost the US cattle industry $441-502 million per year in 1999. This included female infertility, abortions/stillbirths, dystocia, retained placentas, and metritis/pyometra with economic losses coming from decreased production, delayed reproduction, treatment and prevention measures. This estimated cost was six times higher than the cost of respiratory diseases. Three quarters of the cost of reproductive disease and conditions were attributed to female infertility, dystocia and the failure to produce a healthy calf that will survive the first 24 hours of life *(see neonatal disease section).*

RESEARCH AREAS

Heifer Development - Lardner et al. (2014) evaluated the effects of target breeding weight and development system on beef heifer reproductive efficiency in western Canada. The study shows that a $58 development costs can be reduced by $58 for heifers developed to 55% compared with 62% of mature body weight without a loss in reproductive performance. This study also suggests developing heifers in an extensive bale grazing system can be a viable alternative to reduce development costs. Nevertheless, environmental conditions (e.g., snowfall, temperature) may limit forage intake in winter bale grazing systems. Therefore, careful management and supplementation practices must be considered when using extensive grazing systems during the winter season in western Canada.

Herd Management & cow characteristics - Waldner et al. (2013) identified several risk factors for non-pregnancy including Body Condition Score (BCS), age, length of the breeding season, use of vaccines, and previous reproductive history. This study provides evidence to support the recommendation that adequate body condition at calving and controlled loss immediately after calving are critical to optimize fall pregnancy rates. In addition, it demonstrated the importance of vaccination for herds using communal grazing pastures.

Cow Nutrition - Waldner and Hendrick (2010) evaluated the relationship between trace mineral and vitamin status with reproductive efficiency. The research found that there was no association between levels of selenium, molybdenum, vitamin A or vitamin E and pregnancy status. Copper concentrations were more often below normal than the other micronutrients, and lowered copper levels did increase the risk of open cows younger than 10 years of age. *Cow nutrition research areas and priorities are discussed in the "Cow Nutrition, Water Quality and Mineral Supplementation" Fact Sheet.*

Disease – Viral, venereal and bacterial diseases can cause abortions (e.g. Vibrio, Trich, IBR). Metritis and pyometra[16] can lead to greatly reduced fertility, prolong the interval to uterine involution and first ovulation by 20 or more days (which may increase calving interval 16 to 36 days), and delay conception. While more common in the dairy industry prevalence and incidence are thought to be under-reported in the beef herd.

Bull Evaluations - Waldner et al. (2010) reported larger scrotal circumference (SC) measurements were associated with a higher frequency of cows diagnosed as pregnant by palpation and to a lesser extent with shorter intervals from first bull contact to calving.

TECH TRANSFER

Body Condition Score (BSC) is an important indicator of how to manage their rations to maximize beef cow productivity, especially reproduction. A summary about the relationship between BSC and beef cow reproductive efficiency can be found in the BCRC Fact Sheet "Productive Issues with Over- and Under-Conditioned Cows Relationship". Calculators that estimate the value of weaned calves based on BCS, and the feed cost to improved BCS are also available on the BCRC website.

An economic model was developed by Muzzin et al. (2015) for cow-calf producers in western Canada to determine the **cost-benefit of pregnancy-testing**.

RESEARCH PRIORITIES

Research on reproductive efficiency frequently has overlaps with research on **diseases** such as Bovine Viral Diarrhea (BVD) and Infectious Bovine Rhinotracheitis (IBR). Basic and applied reproductive research may not always be disease prevention related, but may include more basic reproductive research into **hormones**, how reproductive cycles can be manipulated (e.g. nutrition) and looking at evaluation of reproductive success (e.g. body condition scoring, bulls, bull testing).

Economic analysis is also needed to assess the loss associated reproductive failure caused by specific diseases and other reproductive issues or pathogens, as well as the economic feasibility and practicality of applying certain management methods.

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[16] Metritis is an infection in the uterus; puerperal metritis is a severe infection that causes systemic illness; and pyometra is an accumulation of pus in the uterus with a corpus luteum (CL) present, but does not have to be associated with infection. Pyometra will cause fertility problems, but does not make cattle sick (as compared to cats/dogs).

Welfare Evaluation - While many studies have illustrated the link between Body Condition Score (BCS) of cows and pregnancy rate, relatively little research has applied BCS as an indicator of animal welfare. Retailer and industry welfare assessment schemes include BCS as an outcome measure, but face the challenge of determining a threshold of acceptability, though Canada's Code of Practice for the Care and Handling of Beef Cattle (National Farm Animal Care Council, 2013) requires prompt corrective action to improve body condition of cattle with a score of 2 or less (out of 5). The scientific basis for such cut-offs is unclear. In future research, if body condition scores are used as an outcome measure in welfare assurance schemes, additional research is needed to understand the when body condition score reaches an unacceptable threshold (Tucker et al. 2014).

The 2012 National Beef Research Strategy calls for:

- Reduced incidence of reproductive failure through improved nutritional management, diagnostic tests, vaccination and biosecurity by 2016.

NEONATAL DISEASES – *DR. CHERYL WALDNER*

One of the most important production factors influencing the economics of the beef cow calf farm is the calf crop percentage. This is defined as the percentage of cows exposed to the bull that raise a calf to weaning. In order to achieve this, a cow must become pregnant, successfully carry the calf through to term, give birth to a live calf and raise it to weaning age. Many factors can influence the calf crop percentage including reproductive management as well as calf losses through abortions, stillbirths, and other mortalities. A number of studies have demonstrated the importance of perinatal and neonatal losses in beef cattle in affecting the calf crop percentage.

Research suggests that over 8% of the calf crop is lost after the cow becomes pregnant. A large research study on Western Canadian cow-calf herds provides an overview of the reasons for calf losses. The results give a snapshot of what the 'normal' level of calf losses are in Western Canadian cow-calf herds. The study found that during that breeding and calving season:

- 1.6% of the pregnant cows aborted
- 2.6% of the calves were stillborn
- 4.0 % of the calves born alive died before reaching weaning age

These numbers are similar to what has been seen in other studies in other parts of North America.

For the average beef producer, most calf losses occur between birth and the first 7 days of life. A number of factors can contribute to these losses including: dystocia (calving difficulty), maternal nutrition, maternal behavior, climate and infectious agents and environment.

AREAS OF RESEARCH

Minimizing abortion losses: infectious disease (BVDv, neospora, leptospirosis, IBR, bovine genital campylobacteriosis, trichomoniasis), effectiveness of vaccines, and cow nutrition (micronutrient status and supplementation).

Losses at or near the time of birth: breeding management to decrease dystocia risk, management of cow Body Condition Score (BCS) during gestation, cow micronutrient nutrition during gestation, better understanding of behaviour around the time of calving so producers are more comfortable with when/if they should intervene.

Neonatal mortality: beneficial management practices (BMPs) for colostrum supplementation and cow nutrition during gestation.

Calf disease and mortality: enteritis (scours), pneumonia, best management practices to minimize exposure to infectious disease, vaccination of the cow during gestation to maximize colostral antibodies, neonatal vaccination.

Animal welfare: BMPs for castration, pain control strategies for painful procedures, evaluation of pain and stress in calves.

Antimicrobial use and resistance: evaluating current AMU practices in calves and cows near calving, current levels of AMR in calves, impact of changing recommendations for AMU in the livestock industry.

INTERNATIONAL & CANADIAN RESEARCH

While international research on best practices for infectious disease could provide useful insights, cow-calf operators in Canada face unique environmental and nutritional challenges. Research from Canada is needed to inform appropriate and evidence-based management recommendations.

The Western Canadian Cow-Calf Surveillance Network based out of the Western College of Veterinary Medicine is working with a cohort of 120 cow-calf producers from Alberta, Saskatchewan, and Manitoba to address a range of questions related to improving calf health and decreasing mortality.

TECH TRANSFER NEEDS:

Most information transfer to cow-calf producers on neonatal health currently happens through features written for industry magazines and papers such as the Western Producer. Producer information nights organized by local veterinary clinics provide additional information. There is some Canadian information available on provincial government websites. Organizations such as the Beef Cattle Research Council and Alberta Beef Producers have worked hard in recent years to provide timely access for producers to research highlights through their websites along with regular webinars on a variety of research findings.

- There is a need for improved technology to assist capturing on-farm health and production outcomes to inform management decisions and surveillance.
- There is a need for a variety of information products tailored to the different needs of large commercial cow-calf producers, pure-bred producers, as well as the many operations where the cow-calf herd is not the only source of family income.

RESEARCH PRIORITIES:

Cow-calf herd size is increasing and management strategies are evolving to adapt. Research is needed to provide evidence-informed advice on the best practices to balance economic outcomes, animal health and welfare.

Neonatal diseases that continue to challenge producers include pneumonia and enteritis (calf scours). There are outstanding needs for vaccine research, evaluation and treatments for important neonatal diseases in beef herds.

Better information on current antimicrobial use and resistance in cow-calf herds is urgently required to address growing international concerns. This will also enable appropriate treatment of neonatal diseases.

Big data is a growing topic in other areas of livestock production. Does the cow-calf industry have the on-farm information and data collection tools to take advantage of advances in big data and machine learning and genetic information in minimizing calf losses and optimizing calf health?

Our understanding of the importance of fetal programming is growing in all areas of livestock production. There are very real opportunities to pursue this knowledge gap in cow-calf production.

WELFARE & STRESS

The objective of animal welfare research is to develop a scientific base for best management practices and assist in effectively communicating current industry practices to consumers. The cattle industry is being increasingly pressured to demonstrate the impacts of current practices on animal welfare and address consumer perceptions. Being able to provide scientific information that explains the impact of practices used by the industry would be beneficial in advancing best management practices, identifying areas of priority, as well as supporting industry and public communications.

Animal welfare is closely linked with animal health. Overall, understanding how multiple stressors affect the animal and determine the least stress alternatives will inform industry decisions. For example, should treatments be separated to reduce animal stress or does the additional handling create even more stress? Hence, does doing everything at one point provide the least overall stress on the animal? Welfare is primarily concerned with transportation practices and pain control (castration, dehorning).

PAIN MITIGATION - *TARA MULHERN DAVIDSON, AAG*

Pain mitigation in beef cattle is becoming increasingly important. A number of standard animal husbandry procedures that are performed cause pain, even though many procedures such as dehorning, may provide net welfare and production benefits through reduced animal injury or carcass bruising.

Consumers and the public take an interest in pain mitigation as it relates to animal welfare therefore it is prudent for Canada's beef cattle value chain to take a proactive approach. In 2013, the National Farm Animal Care Council released a Code of Practice for the Care and Handling of Beef Cattle, outlining several best practices for mitigating pain during common procedures such as castration, dehorning and branding. Requirements regarding the use of pain control in consultation with veterinarians will be phased in effective January 1, 2016.

The age at which the procedure is performed has been identified as being important. The younger an animal is when they are castrated, dehorned and/or branded, results in a faster recovery and experience fewer production setbacks than older animals or animals that are already stressed or otherwise compromised.

Pain experienced by beef cattle is measured using *physiological* and *behavioral* methods. Accurately assessing acute and chronic pain attributed to procedures in beef cattle is challenging given the extensive nature of working cattle operations. Sample collection alone can elevate animal stress when monitoring physiological responses such as heart rate, cortisol levels or thermography. Similarly, assessing behavioral characteristics, such as tail flicking, stride length or chute activity may cause stress or pain that may be difficult to separate from procedural stress.

Pain mitigation in beef cattle can be accomplished with *anesthetic* or *analgesic* drugs or a combination of both. Anesthetic drugs may be topical or injectable and cause a temporary loss of feeling. Analgesic drugs, or pain-relievers such as non-steroidal anti-inflammatories (NSAIDs), may be injected or administered orally, including oral meloxicam, which was recently licensed for use in Canada.

While pain mitigation measures are available in Canada, the following challenges need to be addressed:

- availability of products and knowledge of veterinarians and producers
- the extra-label usage of drugs known for but not registered for use in pain mitigation
- timing between drug administration and when procedure is performed
- degree of pain control and duration of effect in real world situations

- the requirement for specialized on-farm training and skills development
- a need for additional animal restraint to administer anesthetics and analgesics
- increased costs due to time, labour and drugs

ROUTINE PAINFUL MANAGEMENT PROCEDURES COMMON IN BEEF CATTLE

Castration: male calves are commonly castrated using surgical or non-surgical means through banding (i.e. elastrator) or burdizzo crushing. According to results from the recent Western Canadian Cow-Calf Survey[17], 94% of respondents castrate early, and 76% of respondents indicate they use the elastrator method. All methods cause pain and ideally procedures are performed within the first week of life. For older animals, evidence shows that using a combination of anesthetic and analgesic drugs achieve the greatest reduction in pain. Immuno-castration, while effective, requires numerous injections, poses a risk to animal handlers and is not currently registered for use in Canada.

Dehorning: according to Canada's most recent 2010/11 National Beef Quality Audit, approximately 12.5% of fed cattle had some presence of horns. The use of polled genetics is a non-invasive method of removing horns from cattle. Dehorning and disbudding by cutting, burning or cauterization continue to be common invasive husbandry practices. Dehorning or disbudding preferably takes place on young calves before 2-3 months of age when horn development is still at the bud stage. Results from the Western Canadian Cow Calf Survey indicated that 80% of respondents dehorn their calves early.

Branding: While there are several methods of animal identification, branding remains the only permanent method of marking cattle. Branding may be required in certain circumstances including live export, proof of ownership, or if cattle are reared in comingled pastures or open range situations. Brands are applied using hot or cold techniques (i.e. hot branding or freeze branding). Both methods are considered painful. According to the 2011 National Beef Quality Audit, 9.8% of fed cattle and 24.75% of non-fed cattle had brands in Canada. This is a significant decrease from 20 years ago; the situations where branding is required should be continually evaluated to determine if there are less painful ways of permanent identification. Brands must be applied carefully to dry hides only, the size of brand must be appropriate to size of animal and re-branding is discouraged.

Other painful procedures or conditions: Wattling, ear notching, and heifer spaying are other painful procedures that sometimes occur on beef cattle operations. Pain control may also be evaluated as it relates to conditions including: calving, lameness, injury, arthritis, mastitis or other disease that affects beef cattle welfare[18]. While priority has been placed on conducting research and providing recommendations for more common painful procedures, these conditions should not be overlooked.

INTERNATIONAL RESEARCH

Immunocastration, the use of Gonadotropin releasing factor (GnRF) immunization of *Bos indicus*-based breeds is common in Latin American countries. Evidence from Brazil shows immunocastration is welfare-friendly and anan effective method of castration that does not cause detrimental effects on carcass and meat quality. *Bos indicus*-based breeds are more receptive to immunocastration than *Bos taurus* breeds, however it may be useful to review research and review applicability to Canada.

[17] Western Canadian Cow Calf Survey Aggregate Results, Western Beef Development Centre, June, 2015

[18] Research on dairy cattle could be applied as there is more information available on these topics

The use of topical anesthetic during on-farm castration is showing promise following studies in Australia. Use of topical anesthetics in Canada for similar purposes has been identified as a research gap.

Internationally, there has been a lot of research regarding pain mitigation for dehorning and disbudding cattle particularly dairy calves. Until a comparative analysis of beef and dairy dehorning research is performed which considers differences in frequency and type of animal handling between the two systems, this research is presumed relevant to the level of pain experienced by beef cattle.

Recent research related to single administration of an NSAID following hot iron branding was published from University of California. The study demonstrated that it took almost 8 weeks for brands to heal and that the NSAID was not effective. Other research also carried out at University of California evaluated a post-brand application of cooling gel, determining that it did not aid in pain mitigation and possibly compromised healing time. Further studies may be required to establish effective analgesic use for branding.

CANADIAN RESEARCH

Due to differences in drug testing, approval and labelling, there is a need for pain mitigation research that is specific to Canada. The recent approval of oral meloxicam for use in analgesia in cattle in Canada provides opportunities for determining practical on-farm use for a variety of scenarios in consultation with veterinarians.

Economic evaluations of pain mitigation, including the use of oral meloxicam, may be useful to help increase implementation and adoption of recommended practices by producers.

Cow-calf operations are managed under generally extensive conditions in Canada. Painful procedures, such as branding, dehorning, and castrating, are often performed concurrently when calves are at a very young age. There is currently ongoing research taking place in Canada to assess pain and mitigation of concurrent routine procedures (i.e. pre-weaning branding and castration). This research will be valuable and may initiate further studies that take into consideration practical cattle management scenarios.

RESEARCH PRIORITIES & INFORMATION GAPS

There are gaps remaining in research and information related to pain mitigation as a whole including:

- Use of multiple administrations of NSAIDs to control chronic or long-term pain
- Effect of stress from restraints used for procedure as well as pain mitigation administration
- Cumulative effect of performing several procedures at once (i.e. castrating, dehorning, branding simultaneously)
- Relationship between post-procedural inflammation, pain, tissue trauma and growth rate and performance of beef cattle
- Cost-benefit economic analysis investigating expenses associated with administering pain drugs and the production benefits associated with pain mitigation
- Effect of social behaviour of herdmates on pain and recovery associated with painful procedures (i.e. social dominance, nurturing from dam)

The following information gaps exist for **castration**:

- Research on practical and effective chronic pain mitigation, given evidence that pain endures into post-castration period particularly for banded cattle

- Research investigating castration pain experienced by very young beef calves (i.e. 0-2 months of age)
- Practical use of topical and local anesthetics to mitigate pain during on-farm castration procedures
- Optimum drug dosages specific to castration method
- No single method of castration is definitively preferable than another, in spite of extensive research on various methods

The following information gaps have been identified for **dehorning**:

- Post-procedural chronic stress and pain in dehorned cattle, particularly after sensitization returns post-anesthesia
- Practical methods of administering anesthetic on extensive beef operations and reducing window of time required between administration and procedure

The following information gaps are acknowledged in relation to **branding** for identification:

- Use and effect of analgesics at time of branding
- Practical methods to mitigate pain during branding
- Practicability of implementing non-invasive cattle identification methods including biometrics (i.e. retinal scans)

TECHNICAL TRANSFER OPPORTUNITIES

There are several key technical transfer opportunities that will contribute to implementation of recommendations related to pain mitigation during routine husbandry practices. These extension opportunities will also improve consumer perception of the beef industry.

- Increase communication of recommendations outlined in the Beef Cattle Code of Practice related to pain mitigation in beef cattle
- Inform veterinarians and producers of their roles regarding pain mitigation for beef cattle
- Provide education regarding animal age at time of procedure
- Increase awareness of pain mitigation methods including cost and availability of drugs, and administration techniques (i.e. pre-dehorning corneal nerve block)
- Provide awareness to producers on branding best practices, including using one iron, avoiding rib brands and unnecessary brands
- Provide producers with economic cost-benefit rationale for mitigating pain
- Improve information exchange between researchers, veterinarians, and producers related to use of pain mitigation measures
- Improve consultation with veterinary drug manufacturing sector to help exchange information with researchers and develop and implement effective and practical anesthetics and analgesics
- Share positive, science-based evidence regarding Canada’s commitment to pain mitigation with the public to increase consumer confidence in this potentially sensitive issue

RESEARCH & INDUSTRY CAPACITY

There is currently a benchmarking study also conducted through the University of Calgary that is quantifying the frequency of common painful procedures that take place on farms and understanding producer perceptions of pain mitigation. There is a project through the University of Calgary and AAFC assessing pain associated with castration in conjunction with branding. Pain mitigation research is also taking place at the Lethbridge AAFC Research Station, the Western College of Veterinary Medicine and the Ontario Veterinary College (focused on dairy cattle).

LAMENESS - *STACEY DOMOLEWSKI*

Simply defined, lameness is any leg or foot pain that affects how cattle move. There are many different types and causes of lameness, and often it is a symptom of other diseases. Lameness is not only a welfare concern, but it also affects growth, performance and profit because cattle may go off feed, or be too sore to stand at the feed bunk, or to drink water. There is also the added cost of culling animals that are chronically lame.

Cattle of all ages and at all stages of production can be affected by lameness, but the type of lameness often changes depending on the age and stage of production. Since lameness is a welfare concern very visible to the public, and has a large impact on economic returns, it is an area that considerable research has been done and is continuing to be done.

One of the biggest problems with lameness is that it is not easy to **diagnose**, it is often easy to see that an animal is in lame and in pain, but a true diagnosis can often only be obtained after a necropsy of the hoof post mortem. The fact that a true diagnosis is hard to obtain means frequency of the different causes of lameness is not well documented in Canada. A study is currently underway out of Agriculture and Agri-Food Canada's Lethbridge research center that is looking at lameness in feedlot cattle. The research team is hoping to determine incidence of lameness along with a case definition for the types of lameness that are observed. This study will help to determine what types of lameness are most prevalent in Canada and where there are gaps in research.

One of the biggest challenges with lameness research is that lame cattle show similar symptoms, but all lameness is not the same and therefore cannot be treated the same. Often differentiating the kind of lameness is difficult to do. Most times cattle that are lame are treated for foot rot, as most handling systems are not designed to give a proper view of the hoof, or with proper restraints to allow for adequate inspection and analysis of the foot.

AREAS OF RESEARCH

Lameness is not only a problem by itself, but it is also a symptom of many diseases of beef cattle. Lameness can broadly be broken up into 4 categories: Genetic (i.e. sand cracks), Nutritional (i.e. laminitis), infectious (i.e. foot rot, digital dermatitis, toe abscesses, joint ill), and physical (i.e. injection site lesions, handling systems). These categories can stand alone, but more often they interact to cause lameness. Often one of the factors predisposes the animal to another cause of lameness.

- Most conformation and other **genetic** factors (i.e. heritability) are well understood. Research is not a priority.
- **Sand cracks** are the most commonly seen hoof problem but very few actually result in lameness.
- **Nutritional** causes of lameness are most commonly seen in the feedlot with **Laminitis** being the most prevalent. Because of the short time in the feedlot, treatment options are limited. Most research is done in coordination with acidosis.
- There are many different types of **infections** that can cause lameness but the most prevalent is **foot rot**.

  - **Foot rot** is an infection that is very prevalent in both cattle on pasture and feedlot cattle. The cost stems from the cost of treatment and loss in potential gains as well as added feed costs.
  - **Digital dermatitis** is usually associated with dairy cattle but is also found in feedlots. It is often misdiagnosed and therefore prevalence is unknown. There is currently no research on this but anecdotal evidence suggests it is present, especially in feedlots. Current recommended treatments are impractical in the feedlot situation.
  - Injection site lesions
- **Physical injury** is one of the less researched aspects of lameness, as it is often more of an 'accident' than a researchable disease. A study of feedlot cattle in Alberta showed that 1.6% more cattle showed signs of lameness after processing as compared to before processing. This suggests that improving processing and **handling procedures** (especially upon arrival) may be able to help reduce incidences of lameness in the feedlot.

INTERNATIONAL & CANADIAN RESEARCH

An American study indicated that 13% of feedlot animals were treated for health problems. Of these, about 16% of cattle were treated for lameness and contributed to 5% of feedlot deaths. The same study found that lameness contributed 70% of culling non-preforming cattle (Griffin et al. 1993). Although current Canadian numbers are unknown, they are expected to be similar, contributing to huge economic losses for the feedlot industry. Updated Canadian numbers would help to identify priority areas for lameness research.

Lots of research has been done in the dairy industry regarding lameness. Although the general pathology or etiology of specific diseases is similar or the same as in beef cattle, prevalence, and predisposing factors may be very different due to large differences in management styles and genetics of cattle. Most of the research and extension efforts to do with Lameness have been focused in the dairy industry. In the beef industry, more focus has been placed on feedlots as compared to cow/calf operations.

Although currently there is little Canadian research being conducted looking at lameness specifically, lameness (e.g. laminitis) is often measured as a symptom in other studies such as in acidosis studies. Current research has looked into treatment options for lameness (Coetzee et al. 2014), changes in housing (Brscic et al. 2015; Cozzi et al. 2013), and digital dermatitis (Sullivan et al. 2013). Quality audits have also been completed in the US to help to determine prevalence of lameness (Griffin et al. 1993). Past research has been successful at determining specific symptoms and causative agents of most types of lameness, but there is still the challenge of providing a definitive case study for different types of lameness based on symptoms that don't involve a post mortem exam.

TECH TRANSFER

Joint ill (infectious Arthritis) is the primary cause of infectious lameness in young calves. Past research has been very thorough in determining the cause and progression of the disease. There are many extension articles to help fully explain how to manage this problem, most focus on the dairy industry but the information can easily be used by beef producers as well.

Injections can damage the muscle, resulting in lameness. Most injection site lesion lameness can be prevented by proper injection procedures. There are numerous extension resources for both the beef and dairy industries that provide adequate instructions and advice on proper practices to reduce injection cite lesions. The Canadian Beef Quality audit showed that injection site lesions have decreased to 0.56% from 7.34% in previous year (NBQA. 2011).

Zinpro Corporation's International Bovine Lameness Committee has produced a new "Cattle Lameness" book, which is an electronic resource available at http://www.zinpro.com/lameness/beef. The book begins with general background on lameness, prevention and determination of prevalence, economics, causes and risk factors. Next it covers the anatomy and key structures of the bovine foot as they relate to lameness risk. It then details non-infectious and infectious lesions, with numerous photos of each to aid in diagnosis and treatment. Their "Step-Up™ Management Program for Beef Cattle" outlines locomotion scoring, lesion identification and digital dermatitis.

RESEARCH PRIORITIES

The Beef Cattle Code of Practice identified the following research needs (May 2013):

- Risk factors, prevalence, characteristics, and management of lameness in Canadian feedlots.
- Cause of toe tip necrosis
- Frequency of pen cleaning required to prevent foot rot as well as economic analysis of the benefits of pen cleaning.

The full report by Stacey Domolewski is available upon request.

WEANING - *TARA MULHERN DAVIDSON, AAG*

Weaning is a natural part of the life cycle of a beef animal however it is one of the most critical and challenging periods during an animal's life. Weaning involves removing milk from a calf's diet, although it is often coupled with other stressors, including the abrupt loss of contact with the dam, transportation to a foreign environment, commingling with unfamiliar animals, introduction to different feed types and water sources, and animal handling for purposes of sorting or vaccination. All of these stressors can reduce the welfare of the calf, leading to potential animal health issues including disease, poor performance, and even death. The effect of weaning on a calf's propensity to develop bovine respiratory disease (BRD) is of particular concern.

Weaning calves from cows varies across Canadian production systems; however there are three typical methods:

Abrupt weaning: Calves and cows are suddenly, physically and visually removed from one another. With this weaning method, transporting calves to a new environment where they may be comingled with other unfamiliar animals is a common outcome. Abrupt weaning is considered to be a *traditional* method of weaning.

Fence-line weaning: calves and cows are suddenly and physically separated however still maintain visual or auditory contact through a shared fence-line in an adjacent pen or field. Cows and calves may share a water source and a similar diet. Fence-line weaning is considered a *low-stress* method of weaning.

Two-stage weaning: a two-step process where mother's milk is removed from the calf's diet through initial application of a nose paddle, which prevents calves from suckling. Calves are returned to their mothers. During the second step, the nose paddle is removed and the mother and calf are physically separated. Two-stage weaning is considered to be a *low-stress* weaning practice.

Natural weaning: is when the calf and cow are left together until the cow no longer allows the calf to nurse or her milk supply comes to an end. While natural weaning is not a common husbandry practice, it is considered a *low-stress* method.

There are numerous animal health and production benefits associated with low-stress weaning that demonstrate low-stress animals eat and rest more, and pace and vocalize less. In spite of this research, the majority of cow-calf producers wean calves using a traditional/abrupt method. Results from the 2014 Western Canadian Cow-Calf Survey[19] show that 70% of respondents wean their calves traditionally[20], and 30% use low-stress methods of fence-line, two-stage, or natural weaning, reported at 22%, 6% and 3% respectively.

Preconditioning calves is a method of preparing calves for a successful post-weaning (i.e. feedlot) experience approximately 30-60 days prior to weaning. Preconditioning practices include administering vaccinations aimed at reducing BRD, *Clostridial* diseases and others; gradually introducing ration changes or water transitions; and/or ensuring painful procedures are appropriately performed well in advance of weaning calves from their dams.

INTERNATIONAL RESEARCH

Research has been conducted across North America on the effects of traditional versus low-stress weaning methods on animal health and production, particularly in the past decade. Most of the research supports low-stress weaning practices to improve welfare and reduce morbidity and mortality of beef calves.

In the EU and Australia, there is conflicting information regarding best practices for weaning, although there is not an abundance of research that looks at low-stress weaning. The structure of beef production systems in these jurisdictions is also much different and the timing of weaning in Australia may be guided more by extreme weather (i.e. drought) than by other factors.

In Latin America, temporary weaning, or separation of calves from dams for a short period during lactation, is a production practice often used to initiate rebreeding in postpartum cows. There has been research performed to demonstrate the role of nose paddles during both regular and temporary weaning practices. A recent study was conducted in Uruguay and built upon Canadian research that looked at the appropriate amount of time calves must have nose paddles in place prior to weaning.

CANADIAN RESEARCH

There has been research conducted on low-stress weaning techniques such as fence-line weaning and two-stage weaning, particularly through the Western College of Veterinary Medicine as well as Agriculture and Agri-Food Canada at the Lethbridge Research Centre.

The “Quietwean” nose paddle, a plastic nose tag used in two-stage weaning, was developed and is currently manufactured in Saskatoon by JDA Livestock Innovations.

RESEARCH PRIORITIES & INFORMATION GAPS

Canadian and international research evaluating low-stress and traditional weaning practices has been conducted however there remain a few research and information gaps including:

- *Effect of weaning method on maternal health and welfare including udder and reproductive health*
- *Effect of parity and annual stress of weaning on maternal health*

[19] 2014 Western Canadian Cow-Calf Survey Aggregate Results, Western Beef Development Centre, June 2015

[20] Further investigation is needed to determine if the use of traditional weaning is due to economics and the lack of facilities or if there are other barriers to changing weaning method.

- *Employing new techniques of assessing cognitive and emotional response of animals in relation to weaning*
- *Effect of weaning strategy on calf health, particularly as it relates to respiratory health and reducing incidence of BRD*
- *Fully understanding effect of weaning strategy on calf growth rate*
- *Effect of weaning strategy on animal transport outcomes and successes*
- *Understanding barriers to adoption to low-stress weaning methods by producers*

TECHNICAL TRANSFER

There are numerous technical transfer opportunities that can contribute to implementation of practices to reduce stress during weaning.

- *Increase communication and awareness of low-stress weaning practices to cow-calf producers.*
- *Demonstrate economic benefits that may be derived due to lower incidence of disease (particularly due to BRD) and increased productivity from calves weaned through low-stress techniques.*
- *Increase awareness among veterinarians and extension personnel regarding low-stress weaning methods.*
- *Engage producers in discussions regarding two-stage weaning by providing producers with a free nose-paddle sample.*
- *Conduct a survey of producers to better understand barriers to practical adoption of low-stress weaning methods.*

Provincial agriculture departments may have an interest in beef cattle weaning practices and cooperate in information dissemination.

TRANSPORTATION & ANIMAL-HANDLING - *TARA MULHERN DAVIDSON, AAG*

Cattle transport in Canada is a multi-factorial process, and many circumstances can impact animal health and well-being, and consequently meat and carcass quality from start to finish. The World Organization for Animal Health has identified transportation as a major animal welfare concern. The consuming public and retail sector in Canada and North America have also taken interest in cattle transportation and handling as it pertains to welfare. Scientific evidence and sound policies supporting Canadian beef cattle transport and handling regulations are increasingly valued by the industry in order to support agriculture's social license to operate.

Cattle are generally transported between one and five times in their lives, therefore practicing appropriate beef transport protocols, including pre- and post-transport handling, can improve animal health and welfare and advance production and profitability in all parts of the beef value chain.

There is a Canadian Code of Practice for the Transport of Animals[21] as well as regulations pertaining to the livestock transport industry, however the sector is relatively self-governed with the exception of trailer weight restrictions. There are also resources available to ensure livestock transporters are properly trained in order to mitigate welfare concerns during transport.

[21] Recommended code of practice for the care and handling of farm animals – Transport. Canadian Agri-Food Research Council. 2001. http://www.nfacc.ca/pdf/english/Transportation2001.pdf

AREAS OF RESEARCH

Animal temperament and handling: temperament, pre-sort handling, loading procedures, transporter experience, and post-transport handling affect animal welfare and transport.

Ambient conditions: weather conditions at time of handling, loading or unloading, during active transport and during periods when the vehicle remains stationary impact animal welfare and meat quality. Extreme ambient conditions may also increase potential for emergency accident transport scenarios, of which handling may compromise animal and human welfare and safety.

Transport duration, space allowance and ventilation: Transport duration and space allowance impacts ventilation, may vary among trailer compartments, class of animal transported, as well as whether vehicle is in active transport or remaining stationary. These factors may affect meat quality.

Type of animals being transported: The type or class of animal being transported effects animal welfare and subsequent carcass quality. Higher risk groups of animals, including cull cows and young calves, need to be identified and managed appropriately to reduce rates of morbidity, mortality and non-ambulatory status; as well, load density and space allowance can vary among class of cattle which may or may not be an animal welfare challenge.

Trailer design: Cattle trailer design, compartment and ramp configuration, and perforation pattern varies between manufacturers and can impact animal welfare and carcass quality. Trailer design also factors in with use (or non-use) of perforation-controlling slats or boards to affect air flow and ventilation or mitigate ambient conditions.

Arrival conditions and antemortem handling: Feed and water is typically restricted during transport, therefore transportation duration remains a factor for shrink and dehydration. Feed and water access prior to transport and following arrival at destination can play a key role in recovery and meat quality as does unloading wait times and handling leading up to slaughter.

INTERNATIONAL RESEARCH

International research and evidence-based recommendations regarding cattle transport and handling provide useful insights however they may not be applicable in many cases as they do not reflect transport and ambient conditions experienced in Canada. There is a need for scientific information considerate of Canadian circumstances that can be used to guide best practices.

The European Food Safety Authority has published a science-based opinion paper on transport of livestock, including cattle, however findings related to transport duration and space allowance (i.e. load density) are largely not applicable to North America. The World Organization for Animal Health has a Terrestrial Animal Health Code, including a chapter on Transport of Animals by Land, however again, the factors outlined are not specific to Canadian conditions. Both previously mentioned documents may be relevant to Canada specifically regarding identifying animals unfit for transport.

CANADIAN RESEARCH

Due to the long transport distances, the extensive Canadian live export market, and unique and at times extreme ambient conditions, cattle transport research specific to Canada is imperative. The Canadian beef sector requires studies that are reflective of practical situations as well considerate of existing Canadian recommendations. These studies should be used to inform pragmatic regulations and address concerns related to animal health and welfare.

A useful benchmarking study was published in 2012 that assessed standard industry practices for long haul transport of cattle in Alberta[22]. The study looked at norms and extreme Canadian cattle transport situations, including crossing international borders. The benchmarks established demonstrated that most practices aligned with current recommendations and regulations and provide a framework for future investigation into specific Canadian transport issues.

RESEARCH PRIORITIES & INFORMATION GAPS

There appear to be numerous gaps in research and information related to Canadian beef cattle transport and animal handling, including:

Cumulative transport impacts: animals being sold and re-sold several times resulting in numerous consecutive transportation events; as well as transportation origin (i.e. auction mart, feedyard, or ranch).

Space allowance: there is a lack of North American-based scientific evidence behind load density regulations, as well as impact of space allowance relative to position in trailer (i.e. compartment), impact on carcass bruising, and effect of horned/polled cattle.

Transport duration and unloading delays: there is useful data related to transport duration however more research could be done on the impact that unloading delays or stationary periods play on animal health and welfare during transport during normal and extreme ambient conditions.

Bedding: few studies have assessed the use of trailer bedding (i.e. straw or sand) and its impact on animal welfare and meat quality in Canada. This is an area of interest as the Canadian Code of Practice recommends transporters provide bedding during transport when temperatures are below 10°C.

Pre-transport handling: few studies have looked at pre-transport animal handling although it is logical that handling conditions can have an impact on temperament, loading conditions and therefore animal welfare and consequently meat quality.

High-risk animals: while there has been research looking at identification of critical animals unfit for transport as well risk factors that may compromise animal health and welfare, the effect of transport conditions as well as transport duration on high-risk animals (i.e. young calves and cull cows) could be further examined.

Trailer design: the impact of trailer design and its effects on animal welfare and meat quality could be further examined in North America. Future studies on ramp, compartment design and perforation pattern, as well as consultation with manufacturers may be useful.

TECHNICAL TRANSFER OPPORTUNITIES

There are several key technical transfer opportunities within the beef cattle transport sector that will contribute to the implementation of recommended practices and improved consumer perception of the beef industry.

- Improve communication of rules and regulations governing livestock transport to commercial drivers, on-farm producers, the public, the Canadian Food Inspection Agency, law enforcement and other relevant stakeholders.

[22] Gonzalez, L.A., K.S. Schwartzkopf-Genswein, M. Bryan, R. Silasi, and F. Brown. Benchmarking study of industry practices during commercial long haul transport of cattle in Alberta, Canada. 2012. J. Anim. Sci. 90: 3630-3639.

- Improve information exchange between researchers, transporters and producers related to use of trailer ventilation control (i.e. perforation boarding), bedding, transport durations and load densities.
- Improve consultation with trailer manufacturing sector to help exchange information between researchers and implementation of effective trailer design.
- Improve awareness among producers, auction marts, feedyard staff and transporters regarding appropriate pre-transport conditions to reduce hazards to animal welfare (i.e. feed and water restrictions)
- Improve uptake in Canadian Livestock Transporter training by both professional and on-farm transporters. One study showed that the likelihood of compromised animals during transport decreases with the experience level of the transporter, however experience may be subjective and is not equal to training. It would be beneficial to the beef value chain to provide transporters with high levels of training through programs that are validated.
- Improve communication related to emergency transport situations and ensure recommended practices are readily available to emergency personnel.

RESEARCH & INDUSTRY CAPACITY

There is an Agriculture and Agri-Food Canada scientist at Lethbridge AAFC Research Station dedicated to this topic and currently studying transport and animal handling, including a current project related to the use of electric prods. There is also ongoing beef cattle welfare and meat quality research taking place at the Lacombe Research Centre.

EXTREME WEATHER AND HOUSING CONDITIONS - *TARA MULHERN DAVIDSON, AAG*

Beef cattle in Canada are raised in a variety of conditions depending on their production status and age. Cattle may be confined *indoors*, in barns, stalls or pens; or kept *outdoors*, either in confinement or in extensive systems. Examples of outdoor *confinement or intensive* systems include pens, corrals, or feedlots, and *extensive* production systems may include pastures, fields or rangeland.

The ability of an animal to withstand extreme weather conditions depends on its body condition score, health status, hair coat, stress level, and access to feed, water and shelter, among other factors. Production status and age also affect an animal's ability to adapt. For example, a newborn calf may have a higher risk of not surviving an extremely cold period than a feedlot animal whose developed a hair coat and can use the herd to maintain heat. Extreme weather can compromise weight gains and feed intake, reduce milk production and fertility, cause illness and even death. Examples of extreme weather are:

High humidity and temperature: exposure to high heat and humidity can cause cattle to experience physiological symptoms such as panting, increased body temperature, drooling, and sweating. Cattle also exhibit behavioural adaptations to heat and will seek shade and spend a disproportionate amount of time near or standing in water. Cattle require more water during extreme heat and must have natural or man-made shade made available to them. Cattle handling should be minimized or avoided and in feedlot settings, water may be sprinkled on the animals and in the pens.

Extreme cold: exposure to extreme cold can result in cattle shivering, having a reduced body temperature, and frostbite. Cattle require more energy during prolonged cold periods to maintain their metabolic functions and additional feed is required. In addition man-made, natural, or topographical shelter must be available and if possible, bedding should be provided to reduce animal body contact with cold, wet conditions.

Muddy and wet conditions: cattle exposed to mud for prolonged periods of time can have welfare, production and food safety implications. Cattle may have depressed weight gains, require more energy to balance thermoregulation, and have a reduced ability to walk to obtain feed and exhibit normal behaviour. Diseases such as footrot and lameness have been attributed to muddy conditions and udder health may also be compromised. Mud and manure “tags” on hides reduces the value of the hide and can contribute to carcass contamination during meat processing. Cattle should be managed so as to have access to dry areas that are free from standing water, and bedding must be provided to reduce tag and enable proper thermoregulation.

Housing Conditions: Cattle must be free to exhibit normal patterns of behaviour (i.e. walking, lying, and diurnal patterns) regardless of what circumstances they are housed in. Beef cattle welfare can be affected by type of housing and shelter provided, pen flooring, and bedding methods (i.e. deep pack or shallow pack). Studies evaluating type of housing and flooring demonstrate conflicting results, with some studies suggesting cattle perform better under a roof compared with open lots, and others suggest open lots with shelter afford better performance. Bedding can and should be used to improve cattle comfort, often mitigating cold and wet weather impacts. A deep bedding pack may also release heat during extremely high temperatures however, and can also contribute to ammonia emissions. Numerous factors must be considered when producers choose to adopt a type of housing including construction costs, manure and nutrient management, and regional climatic variability. Housing conditions for beef cattle vary across Canada.

Cattle reared in extensive systems, such as on rangeland, still require access to feed, water and shelter resources. Extreme cold and particularly wind chill exposure may reduce an animals’ ability to forage for grass, impacting their thermoregulatory behaviour. Cattle wintered extensively may use snow as a water source without compromising their welfare only as long as there is an adequate amount of clean, loose snow and the cattle are carefully monitored to ensure their basic needs are met.

Stocking density, group size, and social behaviour can impact production and cause welfare implications. Agonistic behaviour, such as aggression or displacement, can increase with decreased bunk space. In young calves, studies show this occurs irrespective of group size however in adult cattle, agonistic behaviour also increases as group size increases. There are no firm space requirements for housing cattle in Canada however it is recommended that stocking density be managed so as to allow for proper weight gain and adequate lying time.

Buller steer syndrome occurs when a steer (i.e. the buller) is repeatedly mounted by other steers to the point that production is reduced and animal welfare is compromised through injury or even death. Buller steer syndrome is a multi-factorial problem, and housing conditions, animal weight, hormonal fluctuations, weather and natural social dominance order all play a contributing role. It is estimated that buller steers occur at a rate of 2-4% in feedlot situations and group size and pen size may have more of an effect on the incidence of bullers than pen density. The role that growth hormones may play in buller steer syndrome has been studied however conflicting results have been found. Bullers can be managed through prompt removal from the problem pen. Preventative measures, such as placing a maximum number of 200 cattle per pen, may also help to reduce the problem.

INTERNATIONAL RESEARCH & EFFORTS

There has been some useful research conducted across North America on the effects of extreme high and low temperatures on beef cattle welfare, as well as housing conditions, however due to the diversity and complexity of environmental conditions, not all research is comparable to Canadian conditions. Early research that was conducted often used environmental simulations and therefore may not be reflective of practical conditions.

During the years following BSE, many extension efforts were focused on low-cost cow-calf production and several studies and economic analyses have been performed on extensive winter management for cow-calf operations. Low-cost does not necessarily equate to high profitability or necessarily always provide for the welfare of the animal, however, therefore the information needs to be interpreted accordingly.

As Latin American countries such as Brazil have shifted more towards feedlot production systems, research interest related to animal housing pertains mostly to emissions and nutrient management as opposed to welfare.

Research conducted in Europe has generally covered housing conditions for livestock, particularly dairy cattle, measuring air ventilation and temperature, as well as ammonia emissions. Some evaluations have been done related to feedlot aggression and social stress, although not all of the information may not be relevant to the Canadian beef industry.

While there has been interest and extension efforts on buller steer syndrome around the world, including Australia, much of the work cited has taken place in North America, particularly Western Canada.

CANADIAN RESEARCH & EFFORTS

There is not a lot of research being done related to heat and cold stress and beef cattle welfare in Canada in a practical context by either federal or provincial organizations. Many feedlot operators and management companies conduct their own applied research related to temperature, stress, pen size and groupings. Current research may largely be performed by industry and results may be retained in-house.

The Western Beef Development Centre in Saskatchewan has undertaken winter site management pertaining to cow-calf operations, where animal condition, performance, and environmental implications (i.e. nutrient management) were assessed, although the impact on animal welfare was not clearly delineated.

The Western College of Veterinary Medicine was involved in buller steer research over a decade ago however current research on the topic is not readily apparent.

RESEARCH PRIORITIES & INFORMATION GAPS:

There remain several gaps in current research and information available regarding the effect of extreme weather on cattle under a variety of housing conditions including:

- Effect of shade or other heat abatement strategies in feedlots and on cow-calf operations to mitigate environmental stress.
- Potential heat mitigation strategies and their effectiveness in a variety of production systems.

- Results of provision of bedding during winter conditions.
- Optimal time and strategies (i.e. bedding, shelter) at which protection from winter weather is required to preserve welfare of animals in feedlot and cow-calf settings.
- Identify effect of wind on beef cattle welfare in common Canadian production systems
- Identify how and when to provide wind breaks and overhead shelter.
- Investigate the welfare implications of cattle grazing extensively for the winter.
    - Evaluate an animal's ability to use snow as a water source and cumulative effect of using snow while exposing animals to cold temperatures and/or high wind chills.
    - Identify when snow as a source of water may be a limitation for welfare and production.
- Evaluate welfare issues caused by muddy conditions in Canadian feedlot and cow-calf operations.
    - Evaluate effects of providing of dry areas for lying (i.e. mounds, pen hygiene, adjust stock density) and these effects on short-term behavioral responses and longer-term health, production and welfare outcomes in feedlots and cow-calf operations.
    - Identify threshold for excessive mud.
- Investigate effect of climate change and frequency of extreme weather on animal welfare.
- Evaluate relationship between body condition score, energy requirements, and cold weather.
- Investigate modelling methods and different techniques for assessing emotional responses to better understand how cattle respond to cold.
- Investigate effect of short-term exposure to extreme cold on long-term welfare and health parameters (i.e. lameness, fertility problems showing up later in animal's life).

There are some key information and research gaps related to social interactions of cattle within a variety of housing and production systems including:

- Best management strategies for grouping unfamiliar animals.
- Optimal group size or space allocation of key resources (i.e. bunk space and water) to better manage social interactions in beef cattle.
- Effectiveness of devices, including overhead barriers, to prevent or reduce buller steer syndrome.

TECHNICAL TRANSFER OPPORTUNITIES

There are numerous technical transfer opportunities that can contribute to implementation of practices to reduce stress due to environment and housing conditions:

- Increase communication and awareness of extreme weather mitigation strategies, including:
    - Heat abatement practices, such as providing shade, improving ventilation, and/or sprinkling water in pens.
    - When and how to provide shelter for wind and extreme cold.
    - Bedding strategies and best practices for cold and wet conditions.
    - Avoiding handling or moving animals in extreme temperatures.
    - Ensure stressful or painful procedures are not performed during or immediately prior to extreme temperatures.
- Increase awareness of when snow may or may not be an appropriate source of water.
- Demonstrate economic benefits to implementing weather mitigation practices such as providing shade, windbreaks, and bedding.
- Demonstrate economic benefits derived from reducing mud in pens.

- Provide information to producers regarding body condition scoring and its usefulness as it pertains to maintaining animal welfare during extreme weather.

The following are technical transfer opportunities that relate to social interactions of animals during confinement or housing situations:

- Engage producers with knowledge of best practices for grouping unfamiliar animals.
- Communicate optimal group size information, space allocation per animal (i.e. bunk space, water access) and pen density recommendations.
- Improve knowledge of buller steer syndrome and practices that may diminish its effect on animal welfare.
- Increase awareness among veterinarians and extension personnel regarding best practices for supporting positive social interactions among cattle housed in confinement situations.

RESEARCH & INDUSTRY CAPACITY

There is little current research related to environmental stress and housing situations as they pertain to beef cattle welfare. There may be research looking into disease or production issues that touch on aspects of animal welfare, however there is no single institution or organization focused on this topic.

GROWTH ENHANCING TECHNOLOGY (GET)

Several technologies are commonly used for either health or management reasons in beef cattle.

1. **Antibiotics** (48% of US feedlot cattle) are fed to both prevent and treat illness and to improve weight gain,
2. **Ionophores** (90% of US feedlot cattle) are used to reduce sub-acute ruminal acidosis by altering ruminal fermentation and feeding behavior,
3. **ß-adrenergic agonists** (57%) are fed in the latter stages of the finishing period to increase average daily gain, improve feed efficiency, and maximize lean muscle growth.
4. **Hormonal implants** are used to increase average daily gain and improve feed efficiency in cattle (84%). Melengestrol acetate (MGA) is fed to 85% of heifers to both improve feed efficiency and suppress estrus in feedlots.

The economic impact of these products is significant. In terms of animal health and performance they include avoiding or minimizing: mortalities, reduced feed intake, reduced weight gain, decreased feed efficiency, and decreased carcass yield. In addition, productivity improvements mean the beef industry uses less land and feed to produce more pounds of beef; thus reducing its environmental footprint. However the use of these products raises questions related to social license and the potential impact on human health.

Canada's beef industry has very limited data on antimicrobial use (AMU). The most current data available was collected from several thousand cattle in four feedlots between 2006 and 2011. Research priorities around AMU, antimicrobial resistance (AMR) and alternatives will be addressed by a BCRC workshop scheduled in December 2015.[23]

[23] Liver abscesses represent a major economic liability to producers, packers, and ultimately consumers. Five antibiotics (i.e., bacitracin methylene disalicylate, chlortetracycline, oxytetracycline, tylosin, and virginiamycin) are approved for prevention of liver abscesses in US feedlot cattle. Tylosin is the most effective and the most commonly used feed additive. Tylosin feeding reduces abscess incidence by 40 to 70%.

AREAS OF RESEARCH

Historical research on GET has primarily focused on the **health** and **performance benefits** of these technologies (including impact on grading performance), while the effects on animal welfare has received some, but relatively less attention.

Animal Welfare - Until recently, ß-adrenergic agonists have not been well studied from an animal welfare perspective. Observations both in non-ruminants and ruminant species indicated administration of ß-adrenergic agonists (βAA) is associated, albeit somewhat inconsistently, with elevated heart rates, body temperature, physical activity, lameness or foot lesions and aggression. Some of the unintended consequences such as elevated heart rate might or ought to be expected with βAA administration. Anecdotally, hoof problems with cattle were reported in August 2013, resulting in Zilmax (i.e. zilpaterol hydrochloride) being removed from the market. High doses of ßAA (ractopamine) in pigs have been associated with increased prevalence of non-ambulatory animals, aggression in gilts and hoof cracking; the label clearly states that non-ambulatory animals may be more common. In characterizing the evidence from August 2013, similarities were found with fatigued pig syndrome (FPS) and bovine stress syndrome (BSS) although differences were also noted.

Using implants in summer, when faster-growing animals might be more susceptible to heat, result in no change or an increase in physiological indicators of heat stress such as panting score or body temperature compared to animals without implants.

Behaviour - Use of implants is thought to either increase (estrogen) or decrease (androgens) buller steer syndrome. Implants either have no effect or decrease aggression and/or sexual behavior. Only a single study found that implants (Synovex-S) increased mounting behavior in females. The majority of these studies have examined Zeranol, an estrogenic implant. These results are likely dependent on the type of implant used, the age and sex of the animal implanted, the dose as well as aspects of experimental design, such as sample size. Zilpaterol has been associated a slight increase in speed when cattle entered the squeeze chute. High doses of ßAA (ractopamine) have been found to make pigs more difficult to handle or show a more marked stress response to aggressive handling compared to untreated controls.

Mortality - βAA have been associated with increased likelihood of death in feedlot cattle during the exposure period. Note the increase while statistically significant is from a very small mortality incidence in the control group. The month of slaughter, a proxy for weather, consistently modified the association found particularly in the warmer months of the year. If a relationship exists between βAA administration and increased risk of mortality, it ought to stimulate discussion of the pros and cons of the use of drugs approved purely to improve the efficiencies of production yet offer no offsetting health benefits to the animals.

RESEARCH PRIORITIES:

Research is needed to understand the more nuanced effects of both hormones (implanted and fed) and ß-adrenergic agonists on beef cattle welfare. The challenge with getting research done on zilpaterol, is that no packing plant will take the cattle. In addition, studies need very large numbers as prevalence appears to be very small and impacted by multiple stressors.

CANADIAN INFRASTRUCTURE AND POTENTIAL RESOURCES

Research can be pulled from international sources in some cases. US research is often applicable in Canada and Australian is occasionally used. Basic immunology, vaccinology, pain mitigation and animal welfare research can be used from a variety of sources including Europe. But the beef industry needs local research for topics like disease surveillance, biosecurity, parasitological, and nutrition (as minerals and toxins are impacted by the local environment).

There are five veterinary colleges in Canada that all would have varying degrees of capacity for beef cattle health and welfare research. In addition there is some significant research through Agriculture Canada and the Canadian Food Inspection Agency that would apply to this field. VIDO at the University of Saskatchewan provides significant capacity in terms of immunology and vaccinology.

Capacity exists in the private sector including private veterinary practices that do a great deal of contract research, publicly funded research, as well as their own private research. In addition, a significant amount of capacity is found within the pharmaceutical and biological companies[24] that market vaccines, antimicrobials and parasite control products.

Professional groups within Canada who may be involved in dissemination of animal health and welfare information include: provincial agriculture departments, the Canadian Council on Animal Care, the Canadian Veterinary Medical Association, the Canadian Association of Bovine Practitioners, and the Canadian Council on Animal Care and the Western Canadian Association of Bovine Practitioners.

Providing animal care during extreme weather is a primary responsibility of producers. As such, provincial organizations focused on animal welfare and incident reporting, such as Alberta Farm Animal Care, Ontario SPCA and Humane Society, or the Saskatchewan SPCA, may play an active role in disseminating information regarding extreme weather mitigation strategies, as well as data collection related to welfare problems.

[24] Health Canada is responsible for drug licensing through the Veterinary Drugs Directorate. Health Canada evaluates and monitors the safety and effectiveness of drugs including analgesics and anesthetics in beef cattle. Drug companies, such as Alberta Veterinary Laboratories, Boehringer, Merial, Modern Veterinary Therapeutics, Vetoquinol, or Zoetis, who wish to register products must follow procedures outlined by Health Canada.

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Additional Resources:

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Additional information:

- http://veterinaryextension.colostate.edu/menu2/Cattle/Lameness%20rules%20of%20thumb.pdf
- http://www.thebeefsite.com/articles/2869/lameness-in-beef-cattle/
- http://www.meristem.com/feature_articles-fac/2014/fa_2014_28.php