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ICASA

A FFAR COLLABORATIVE

International Consortium for Antimicrobial Stewardship in Agriculture (ICASA)

2019-2025 Project Abstracts & Updates

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About ICASA

Antimicrobial Stewardship in Animal Agriculture

Antibiotics are valuable tools for preventing, treating and controlling disease in animal production. Yet maintaining antibiotic efficacy is a highly complex issue that affects both human and animal health. The responsible and judicious use of antibiotics is a top priority in animal agriculture.

ICASA: Collaborative Research for Healthier Livestock

The International Consortium for Antimicrobial Stewardship in Agriculture (ICASA) is a public-private consortium that invests in research to develop practical solutions, such as new technologies and management practices, that promote judicious antibiotic use, produce healthier beef cattle and swine and improve animal welfare.

The Consortium brings together funders and participants from multiple stages of the beef and swine supply chains to ensure funded research is:

- Grounded in commercial, on-farm production systems.
- Scalable and adoptable.
- Delivering value across these industries, not only to individual segments.

ICASA 2019-2025

The Foundation for Food & Agriculture Research (FFAR) established ICASA in 2019 with an initial $7.5 million investment to fund antimicrobial research in beef and swine that promotes targeted antibiotic use, advances animal health and welfare and increases transparency in food production practices. Participants and additional project-level partners matched FFAR funds, resulting in a total investment of $15 million in research advancing antimicrobial stewardship.

Consortium 2019-2025 Participants

ICASA is a research consortium with representation across the U.S. beef and swine supply chains. The Consortium's participants guide decisions on its research direction and project selection. The Consortium's 2019-2025 participants include: Advanced Animal Diagnostics, the Beef Alliance, Cactus Research, FFAR, Genus plc, Hy-Plains Feedyard Research and Education Center, JBS USA, McDonald's Corporation, National Cattlemen's Beef Association, National Pork Board, Noble Research Institute, Pipestone Veterinary Services, Tyson Foods, U.S. Roundtable for Sustainable Beef and Veterinary Research & Consulting Services. Associate participants included Cargill, Production Animal Consultation, Yum! Brands and Zoetis.

ICASA Next Steps

In 2025, FFAR and several partners recommitted to ICASA to fund research that continues advancing antimicrobial stewardship. The Consortium welcomes interest from new participants. Participants will help determine the Consortium's future research directions during its early stages of redevelopment. For more information about joining ICASA, contact Lauren Hershey, FFAR director of strategic partnerships at lhershey@foundationfar.org.

ICASA's Six Working Groups

Liver Abscess in Beef Cattle

Liver abscesses are a significant problem in beef cattle. Recent estimates published in the Journal of Animal Science predict that the U.S. beef industry loses approximately $256 million annually to liver abscesses or $9.07 per animal sold. This condition is also a serious issue for animal welfare. Liver abscesses occur when bacteria cross from an animal's gastrointestinal tract into the bloodstream and accumulate in the liver. To prevent liver abscesses, current control methods involve treating groups of animals with antibiotics simultaneously. As a result, healthy animals are often administered antibiotics, as it is difficult to determine which animals are infected. This method is costly and can increase antibiotic resistance in cattle, making them susceptible to other conditions.

Research Objective

1. Identify a method or methods that allow for the management of liver abscesses in finishing cattle, reducing or omitting the use of shared-class antibiotics while resulting in no detrimental effects to live animal performance, animal welfare or carcass quality.

Beef Stewardship

Beef stewardship helps drive retail and food service sustainability goals through science-based management practices that promote responsible antibiotic use while safeguarding animal health and welfare. This includes advancing antimicrobial stewardship strategies that reduce the need for antibiotics through disease prevention, herd health management and identifying antibiotic use standards and protocols. By upholding high standards of animal care, beef stewardship helps conserve natural resources and supports efficient, productive operations that remain viable for future generations.

NOTE:
To date, the Beef Stewardship Working Group has only funded projects in collaboration with the Liver Abscess in Beef Cattle Working Group. As a result, all awarded Beef Stewardship projects investigate liver abscesses to advance stewardship in beef production.

Research Objectives

1. Identify and assess antibiotic use standards and protocols, including shared approaches and differences, that would inform organizations involved in processing, retail and food services.
2. Support research on antimicrobial stewardship in the beef industry, including the terms currently used to describe use and the rationales for treatment.
3. Support research on the potential impact of alternatives to antibiotics for for treating and preventing different conditions, including the efficacy of various alternatives/best management practices.

Metaphylaxis in Beef Cattle

Metaphylaxis in beef cattle is the strategic, group-level administration of antibiotics to high-risk animals, most commonly upon feedlot arrival, targeting subclinical infections to prevent or control Bovine Respiratory Disease

Research Objective

1. Solicit and support research focused on the use of metaphylaxis treatment practices in cattle and swine to enhance antimicrobial stewardship in food-producing animals. To date, ICASA has funded research projects exclusively on beef cattle.

(BRD) outbreaks. BRD costs ranchers in the United States about $900 million annually due to animal death, reduced feed efficiency and treatment costs. Although metaphylaxis can be effective in reducing illness and death, frequent or routine use raises concerns because it can contribute to the development of antimicrobial resistance, negatively affect animal health and increase costs in beef production. For these reasons, careful and responsible use is essential for the future of the cattle industry.

Late Morbidity in Beef Cattle

In beef production, late morbidity refers to cattle deaths occurring during the final 90 days of the finishing period. Losses at this stage are especially expensive because animals have already incurred most of their feed and labor costs. Common contributors include metabolic disorders such as acidosis, congestive heart failure, heat stress and Bovine Respiratory Disease (BRD). Effectively managing these risks is essential to reducing feedyard mortality, improving animal welfare and strengthening farm profitability.

Research Objectives

1. Qualify and quantify mid-day morbidity and late-day mortality, characterize the topic and define it so there is common understanding of the terms.
2. Identify possible explanations or causes of mid-day morbidity and late-day mortality as well as possible associated factors.

Swine Health

Swine health encompasses the coordinated management of pig welfare with an emphasis on preventing disease, supporting proper nutrition and maintaining strong biosecurity practices to protect both herd health and food safety. Although antibiotics are used to treat, control and prevent diseases, their frequent or routine use can contribute to the development of antimicrobial resistance and increase costs in swine production. For these reasons, careful and responsible use is essential for the future of the swine industry.

Research Objectives

1. Surveillance and characterization of antimicrobial resistance at the farm level;
2. Investigation into epidemiology and control of bacterial pathogens of swine. Specifically: *Streptococcus suis, Haemophilus parasuis* and *Actinobacillus suis*.
3. Projects to improve swine gut health, specifically focusing on the following: neonatal diarrhea and post-weaning diarrhea.
4. Generate a better understanding of the swine microbiome for improved pig health and performance.

Cross-cutting Technologies

Technologies that support animal health play a critical role in strengthening antimicrobial stewardship. By preventing disease before treatment is needed, enabling earlier and more accurate diagnosis and supporting targeted care at the individual animal level, these tools reduce reliance on broad, preventive or herd-wide antibiotic use. Healthier animals require fewer medical interventions overall, reducing the need for antibiotics and limiting the conditions that allow resistant bacteria to develop.

Research Objective

1. Identify and support technologies that improve animal health and the antimicrobial stewardship of animals.

ICASA's Research Projects

ICASA 2019-2025 funded 31 research projects to advance antimicrobial stewardship in beef and swine production. Each project aligns with one of ICASA's six working groups and is at a different stage of completion. The following abstracts for each project were submitted by the respective principal investigators and have been lightly edited for clarity and confidentiality, where necessary.

Information on the following research projects is provided for informational purposes only and, in many cases, reflects work in progress. Project descriptions are shared at a high level; detailed data, methods and results remain the intellectual property of the project teams. Findings from ongoing projects should not be interpreted as final results. Information and findings from ICASA projects, whether ongoing or completed, should not be redistributed or cited without prior authorization from the respective principal investigators and FFAR.

Liver Abscesses In Beef Cattle Working Group

Completed Projects

Liver abscesses in feedlot cattle: Further delineation of the etiology and pathogenesis

PI: Dr. Raghavendra Amachawadi
Primary Organization: Kansas State University
Year Awarded: 2021
Matching Funders: Cargill; Micronutrients Corp.; Phibro Animal Health Corp.
Project Status: Completed

Project Abstract

Liver abscesses (LA), matched with ruminal and colonic epithelial tissue samples from 96 steers and heifers, originating from 15 feedlots, were collected at slaughter, transported to the laboratory and processed within 24 hours. Samples were subjected to anaerobic and aerobic culture methods, including enrichment and selective media for detection and isolation of S. enterica, E. coli, K. pneumonia, P. aeruginosa, and B. fragilis . For each bacterial species, two-sided Fisher's exact test was used to evaluate the association of its prevalence in LA with that in colon and rumen at 0.05 level. Overall, prevalence of subsp. necrophorum, subsp. funduliforme, T. pyogenes and S. enterica in liver abscesses were 86.4 (83/96), 21.8% (21/96), 35.4% (34/96) and 6.2% (6/96), respectively. In ruminal tissue samples, prevalence of subsp. necrophorum, subsp. funduliforme, T. pyogenes and S. enterica were 6.6% (6/96), 40.6% (39/96), 11.4% (11/96) and 4.1% (4/96), respectively. Prevalence of subsp. necrophorum, subsp. funduliforme, T. pyogenes and S. enterica in colonic tissues were 18.7% (18/96), 36.4% (35/96), 0% (0/96) and 7.2% (7/96), respectively. Prevalence of E. coli, Klebsiella spp., and P. aeruginosa in LA samples were 70.8% (68/96), 92.7% (89/96), and 91.6% (88/96), respectively. Prevalence of E. coli, Klebsiella spp., and P. aeruginosa in

rumen epithelial tissue samples were 17.7% (17/96), 50.0%, (48/96), and 15.6% (15/96), respectively. Prevalence of E. coli, Klebsiella spp., and P. aeruginosa in colonic tissue samples were 16.6% (16/96), 24.0% (26/96), and 12.5% (12/96), respectively. Interestingly, the study revealed that the prevalence of F. necrophorum subsp. funduliforme was higher in both ruminal and colonic tissues compared to F. necrophorum subsp. necrophorum, suggesting a differential distribution of these subspecies in different regions of the gastrointestinal tract. Moreover, B. fragilis was not detected in any of the liver abscess samples. In conclusion, E. coli emerged as the second most dominant species detected and isolated from liver abscesses, following F. necrophorum subsp. necrophorum. The higher frequencies of F. necrophorum subsp. funduliforme and S. enterica in colonic epithelial tissues compared to ruminal tissues suggest that the hindgut may also serve as a significant source of pathogens

Final Project Updates & Impacts

Understanding pathogenesis: Detailed insights into the distribution of Fusobacterium necrophorum and other bacterial pathogens in the gastrointestinal tract of cattle, emphasizing the role of the hindgut as a potential source of liver abscess-causing bacteria. Identification of E. coli as the second most dominant species in liver abscesses after F. necrophorum subsp. necrophorum Discovery of a high prevalence of antimicrobial resistance genes among F. necrophorum isolates, regardless of tissue origin.

Contribution to the “Ruminitis-Acidosis-Liver abscess complex”: Reinforcement of the hypothesis linking ruminitis and liver abscesses, highlighting the importance of feeding practices in preventing ruminal acidosis, a precursor to liver abscesses.

Managing gut health: Gut health management through dietary adjustments is pivotal in preventing liver abscesses and improving overall animal health and welfare.

Future research directions: Antibiotic alternatives (probiotics or other dietary supplements), aimed at improving gut health and prevention of liver abscesses. The discovery of antimicrobial resistance in F. necrophorum may lead to the design of new research focused on developing antibiotic alternatives and reducing antibiotic use in feedlots.

Legislation and industry practices: The findings could influence regulatory agencies and industry groups to recommend or mandate specific cattle management practices aimed at reducing the incidence of liver abscesses. Education and training opportunities: The results may be incorporated into training programs for veterinarians, cattle producers, and feedlot managers, emphasizing the importance of gut health management and prudent antibiotic use to prevent liver abscesses.

Reduced incidence of liver abscess: Documented decreases in the prevalence of liver abscesses in feedlot cattle due to the adoption of improved feeding practices and gut health management strategies influenced by the study's findings.

Enhanced overall cattle health and welfare, leading to better productivity and reduced mortality rates in feedlots as a result of targeted interventions based on the research.

A reduction in the emergence and spread of antimicrobial resistant bacteria in cattle populations due to decreased reliance on antibiotics, informed by the study's findings on resistance genes in F. necrophorum.

Development of a non-invasive model to induce liver abscess formation in cattle

PI: Dr. Rand Broadway
Primary Organization: U.S. Department of Agriculture Agricultural Research Service (USDA-ARS)
Year Awarded: 2021
Matching Funders: Kansas State University; USDA-ARS; West Texas A&M University
Project Status: Completed

Project Abstract

Liver abscesses (LA) in feedlots are costly to the beef industry. At harvest, LA cause an increase in liver condemnations, carcass trimming, and a decrease in quality grade. The objective of this research was to develop an experimental LA model in Holstein steers using an acidotic diet with and without intraruminal inoculation of bacteria involved in LA formation. These data

suggest acidotic diet challenges in conjunction with intraruminal inoculation with F. necrophorum, T. pyogenes, and S. Lubbock were able to induce LA in Holstein steers. The acidotic diet alone caused steers to spend extended periods of time in subacute ruminal acidosis, causing rumenitis observed at harvest. Nonetheless, intraruminal inoculation F. necrophorum and T. pyogenes had a compounding effect on rumen epithelial damage. The addition of S. Lubbock to F. necrophorum and T. pyogenes indicates potential synergism with F. necrophorum as these bacteria were isolated from 57% of the LA. This project sheds some light on liver abscess formation and will ultimately help the beef industry find a way to mitigate or lessen the severity of this costly disease.

Final Project Updates & Impacts

These data are being used and will continue to be used to guide liver abscess research to understand how these abscesses form and will undoubtedly be used as a model to test potential interventions in a controlled system.

Rumen, gut, and nasal microbiome associations with liver abscesses.

PI: Dr. Kristen Hales
Primary Organization: Texas Tech University
Year Awarded: 2021
Matching Funders: Texas Tech University
Project Status: Completed

Project Abstract

Crossbred steers were transported to a feedlot and fed a high-concentrate diet. Nasal, ruminal fluid, and fecal samples were collected following feedlot arrival, 1 week after adaptation to a finishing diet, and the day before harvest.

Livers were collected at harvest and examined for LA, and cattle were subsequently assigned into either control or liver abscess groups. Overall, LA prevalence was 18.7%. The concentration and prevalence of Salmonella decreased in ruminal fluid and increased in feces with days on feed ($p < 0.01$). Conversely, ruminal fluid prevalence of F. necrophorum subsp. necrophorum and F. varium increased with days on feed ($p < 0.01$). Abundance of F. necrophorum subsp. necrophorum was greater in abscessed liver tissue than healthy tissue ($p = 0.03$), although no other differences in bacterial abundance or prevalence were observed in livers. Overall, Fusobacterium and Salmonella prevalence in the nasal cavity, ruminal fluid, and feces were affected by days on feed, but their prevalence and abundance were not indicative of LA occurrence. Nasal prevalence of F. necrophorum ssp. Necrophorum and F. varium did not differ by LA status or sampling period. Conversely, an abscess × sampling interaction occurred, where steers with LA had lesser F. necrophorum ssp. funduliforme prevalence on d 35 than those without a LA. Nevertheless, the number of enumerable F. necrophorum ssp. funduliforme samples did not differ between steers with or without LA or across sampling time. This is the first report of Fusobacterium detection and enumeration from the nasal cavity of feedlot beef steers.

Final Project Updates & Impacts

Overall, Fusobacterium and Salmonella prevalence in the nasal cavity, ruminal fluid, and feces were affected by days on feed, but their prevalence and abundance were not indicative of LA occurrence. Although these data suggest that Fusobacterium species are present in the nasal cavity of finishing beef steers throughout the feedlot period, a direct link between nasal Fusobacterium populations and LA development was not detected tract, respiratory disease prevalence, and LA formation.

Pathogen-host interaction during the development of liver abscesses; local and systemic immune and metabolic responses during Fusobacterium necrophorum challenges

PI: Dr. Vinicius Machado
Primary Organization: Texas Tech University
Year Awarded: 2021
Matching Funders: Texas Tech University
Project Status: Completed

Project Abstract

The objective of the project was to elucidate, through transcriptomics analysis of hepatic tissue and leukocytes, the ways that the bovine immune system responds to the pathogenic challenge during the formation of liver abscesses (LA), and how LA may disrupt metabolism. The original plan was to use LA inducing models involving the administration of Fusobacterium necrophorum subsp. necrophorum into the jugular or portal vein in pre-ruminant calves. The study was performed as 2 experiments according to the inoculation site. Experiment 1 was performed in 18 calves randomly assigned to receive intrajugular infusion of saline (CONIV), or 107 (FUSOIV7), 109 (FUSOIV9), and 1011 (FUSOIV11) of F. necrophorum. In experiment 2, 20 calves were assigned to receive intraportal infusion of saline or 106 (FUSOPV6), 108 (FUSOPV8), and 1010 (FUSOPV10) of F. necrophorum. Liver biopsy samples were collected at 0, 7, and 14 days relative to challenge. Calves were euthanized 14 days after inoculation and examined for liver gross pathology. Contrary to previous reports, intraportal and intrajugular inoculation with F. necrophorum did not produce LA in calves, and we did not perform transcriptomics analysis in the samples collected. Instead, to ensure that the objectives of the project were achieved, we performed another study aiming to perform transcriptomic analysis of hepatic tissues after an experimental model for LA in ruminant calves based on an acidotic diet and oral pathogenic challenge. Fifteen Holstein calves received a diet regimen that alternated cycles of a low-starch and high-starch acidotic diet for 20 days. Then, five calves were randomly assigned as negative controls (CON), and 10 calves received intraruminal inoculation of F. necrophorum (8.00 × 108 CFU) and Salmonella enterica serovar Lubbock (2.67 × 109 CFU). Hepatic tissue samples and blood samples were collected one day prior to inoculation (-1), and at seven, and 14-days post-inoculation. All calves were euthanized on day 14 and the presence of LA was evaluated via gross pathology. Samples had their total RNA isolated and were submitted for RNA sequencing analysis. DESeq2 R package was used for differential gene expression analysis (DEG) considered as $P \leq 0.05$ and $\log2FC \geq 1$. DEGs were evaluated for Kyoto Encyclopedia of Genes and Genomes (KEGG) enrichment analyses. Of the 10 calves inoculated, 3 developed LA, while 7 did not (no-LA). We observed that multiple KEGG pathways were differentially expressed in liver and leukocytes due to LA formation, with many of those pathways being of immunological, metabolic, and tissue remodeling nature. For instance, many of those pathways included the gene BOLA-DQB, which is specifically associated with the MHC II region, expressed by dendritic cells and macrophages that play a role in the initial immune response. Additionally, multiple other genes associated with inflammation and tissue remodeling were upregulated in response to LA formation, while the expression of genes related to metabolism were downregulated due to LA development. These results offer valuable novel insights into key genes regulating LA pathogenesis in bovine.

Final Project Updates & Impacts

Our research is the first one to characterize the immunological response and its progression overtime to a hepatic pathogenic insult, both at the local and systemic levels.

Evaluation of dietary Tylosin intake on incidence and severity of liver abscesses in feedlot cattle

PI: Dr. Todd Milton
Primary Organization: The Beef Alliance
Year Awarded: 2020

Matching Funders: The Beef Alliance
Project Status: Completed

Project Abstract

Tylosin phosphate (Tylosin) is available for use finishing cattle in the United States for reduction of incidence of liver abscesses. Research efforts by the Beef Alliance have focused on judicious use of Tylosin in finishing diets. Those data support the removal of Tylosin from the diet 30 to 40 days prior to harvest without significant increases in the incidence and severity of liver abscesses. These experiments have been conducted feeding 90 mg/head/day of Tylosin and/or 8 to 10 grams/ton of complete feed. Recently, the Center for Veterinary Medicine (CVM) has provided the beef industry written guidance on Tylosin feeding suggesting that Veterinary Feed Directives (VFDs) should be implemented based on a feeding rate of 60 to 90 mg/head/day rather than solely grams/ton of complete feed. A large pen, multi-location experiment was conducted to evaluate the efficacy of Tylosin fed at 60 or 90 mg/hd/d on the incidence and severity of liver abscesses of finishing cattle. Cattle were fed a common level of Tylosin (yard standard) for approximately the first 21 to 30 days on feed while transitioning to finishing diets and then fed treatment concentrations (60 or 90 mg/hd/d) for the remainder of the feeding period until 30 to 40 days prior to harvest. The experiment was conducted at six separate locations, including the Pacific Northwest, Nebraska, Colorado, Kansas, and Texas (two locations). Each location had 6-12 replications of treatment. The experiment consisted of 60 blocks, 120 lots of cattle, and 16,875 head (8,399 head on 60 mg treatment; 8,386 head on 90 mg treatment). Cattle enrolled in the study were selected to be similar starting weight and breed type within block at each location. Cattle days on feed (DOF) ranged from approximately 140-300, covering many different common industry feeding scenarios. No differences were observed between treatments for initial body weight (BW), dry matter intake (DMI), average daily gain (ADG), feed efficiency (F:G) or death loss % ($P \geq 0.20$). Hot carcass weight (HCW) was 4 pounds greater ($P = 0.02$) for cattle fed 90

mg/hd/d compared to cattle fed 60 mg/hd/d, while all other carcass characteristics were not different ($P \geq 0.13$). Total incidence of liver abscesses ($P \geq .29$) and severity (A+, $P \geq .84$) were similar between treatments, with total abscesses averaging 22.1% and 22.8% and A+ incidence 10.65% and 10.73% for 60 and 90 mg/hd/d treatments, respectively. This experiment suggests that control of liver abscesses in finishing cattle can be accomplished when feeding Tylosin between 60 and 90 mg/hd/d. However, there is a potential loss of hot carcass weight when Tylosin is fed at the lowest concentration of 60 mg/hd/d. These data can be used to provide cattle producers, veterinarians, and nutritionist confidence that the incidence of liver abscesses in finishing cattle can be controlled without using the highest approved concentration of Tylosin (90 mg/hd/d) when they are making decisions regarding judicious use of Tylosin.

Final Project Updates & Impacts

The potential outcome of this research is reduction in Tylosin use to control liver abscesses in feedlot cattle. If producers, veterinarians, and nutritionists reduce Tylosin concentration from 90 mg/hd/d down to 80 mg/hd/d this would result in an approximate reduction of 10%. If Tylosin concentration is reduced to 75 mg/hd/d, it would result in approximately a 16% reduction in Tylosin use to control liver abscesses.

Ongoing Projects

Lungs as a potential source and relationships of ruminal, colonic and fecal concentrations of Fusobacterium necrophorum to liver abscesses in feedlot cattle

PI: Dr. T G Nagaraja
Primary Organization: Kansas State University
Year Awarded: 2025
Matching Funders: Cargill; Kansas State University; Yum! Brands
Project Status: Ongoing

Project Abstract

Fusobacterium necrophorum is the primary etiologic agent of liver abscesses. There are two types of F. necrophorum, called subspecies necrophorum and subspecies funduliforme. The subsp. necrophorum is more pathogenic, therefore, more frequently involved in causing abscesses. The central dogma in the disease mechanism is that ruminal wall, damaged by chronic acidity, becomes susceptible to invasion and colonization by F.necrophorum, which subsequently enters portal blood circulation to reach the liver to cause abscesses. We have preliminary data to suggest that besides rumen, hindgut can also serve as a source of F. necrophorum and lung health and liver abscesses may be comorbidities. Therefore, our objectives are: 1. Determine prevalence and concentrations and isolate the three major liver abscess pathogens, F. necrophorum, Trueperella pyogenes and Salmonella enterica, in lung tissues of feedlot cattle with healthy livers or with abscessed livers, and 2. Determine prevalence and concentrations of F. necrophorum subsp. necrophorum and subsp. funduliforme in ruminal and colonic contents and tissues and rectal contents of feedlot cattle with healthy livers or with abscessed livers. Our approach to achieve the objectives are to collect lung tissues, ruminal and colonic contents and tissues and rectal contents at slaughter from cattle with healthy livers or abscessed livers and subject the samples to culture and molecular methods to determine prevalence and concentrations of the pathogens.

Project Updates & Impacts

This project is in its first year, and the first project update is pending.

Defining the contribution of acidosis to the liver abscess complex using novel challenge model to delineate impacts of diet composition and feeding management on liver abscess pathogenesis

PI: Dr. Kendall Samuelson
Primary Organization: West Texas A&M University
Year Awarded: 2021
Matching Funders: Cactus Research; Tyson Foods; West Texas A&M University
Project Status: Ongoing

Project Abstract

Given the animal performance, health, food safety, economic, and operational considerations associated with cattle liver abscesses, it is important to expand our understanding of liver abscess pathogenesis and evaluate alternatives to replace or reduce the amount of antibiotics used in feedlot cattle diets. The current paradigm for liver abscess etiology indicates ruminal acidosis is a necessary precursor, but the relationship has not been extensively evaluated. Furthermore, the rate of liver abscesses in finishing cattle may be under-estimated using the currently accepted liver scoring system. This study will determine the contribution of acidosis/low pH on liver abscessation in cattle and determine if dietary composition, feed management, or both are more potent instigators of acidosis and the development of liver abscesses. A total of 720 steers will be assigned to treatments in a 2 × 2 factorial arrangement using a generalized complete block design. Treatment pens (n=12/treatment) will consist of control or an acidosis challenge diet fed to cattle receiving either normal feeding management or erratic feed management. Research outcomes will include cattle health, performance, and carcass traits concomitant with continuous rumination, activity, and ruminal pH. The rumen and liver of each animal will be assessed using our unique scoring systems to determine the relationship between ruminal acidosis, rumenitis, and liver abscessation. Validation of a model to induce liver abscesses in feedlot cattle that can be applied in both research and commercial settings will improve future evaluation of management techniques, antibiotic alternatives, and prevention strategies for liver abscesses.

Project Updates & Impacts

The findings from this study have helped illustrate the variability that can be observed in parameters relating to gastrointestinal health and have highlighted the needs for further research. We believe that this is the largest and most complete study to date investigating this topic.

Beef Stewardship & Liver Abscess Working Groups

To date, the Beef Stewardship Working Group has only funded projects in collaboration with the Liver Abscess in Beef Cattle Working Group.

Completed Projects

Modeling for genomic, blood, and microbiological markers for liver abscesses in fed beef cattle

PI: Dr. Dale Woerner
Primary Organization: Texas Tech University
Year Awarded: 2022

Matching Funders: ABS Global (Genus plc); Hy-Plains Feedyard; Texas Tech University; Veterinary Research & Consulting Services, LLC
Project Status: Completed

Project Abstract

Liver abscesses represent a major health and economic concern in fed beef production and are believed to be related to normal rumen function. Liver score and corresponding carcass data were collected from 1,984 beef × dairy heifers, with a subset of 200 animals sampled for blood, rumen, and liver tissue morphology, histology, blood chemistry, and microbial prevalence. The first objective of this study was to use phenotypic factors from individual animal data to model the condition of liver abscesses, by comparing abscessed versus non-abscessed subjects, as well as comparisons of the severity of the liver abscess condition. Overall, decreases in carcass value were associated with increased liver score ($P < 0.01$); rumen characteristics indicated a thinner keratin layer surrounding papillae but greater surface area ($P < 0.05$). Blood chemistry profiles were able to predict the presence of liver abscesses using a LogitBoost model with 80% accuracy ($P < 0.01$). Furthermore, higher prevalence of Trueperella pyogenes and Salmonella enterica was found in cattle with severe liver abscess (A+; $P < 0.01$). The

second objective was to assess the heritability associated with liver abscesses. The liver abscess condition was not found to be heritable ($h2 < 0.01$). The findings of this study demonstrated that liver abscesses continue to result in economic losses in beef × dairy cattle as a result of morphological changes in the rumen, allowing for bacterial translocation. Further work should emphasize rumen health interventions and management strategies to reduce disease incidence and reliance on antimicrobials.

Final Project Updates & Impacts

In a comparison of outcomes between cattle with and without liver abscesses, carcasses from cattle with liver abscesses were economically worth less. Papillae of cattle with liver abscesses had a thinner protective layer but a larger surface area, potentially facilitating the translocation of bacteria to the liver. Machine learning algorithms were also capable of predicting which cattle had abscesses with 80% accuracy. Based upon the genomic analysis, it was reported that liver abscesses are not strongly influenced by genetics, suggesting they are more likely caused by environmental factors rather than inherited traits. These findings show that liver abscess negatively impacts rumen morphology and increases economic losses in beef × dairy heifers. Future strategies should focus on management practices that support rumen health and overall animal well-being.

Associations between feeding and management practices of beef-on-dairy cattle from birth to harvest with liver abscesses

PI: Dr. Raghavendra Amachawadi
Primary Organization: Kansas State University
Year Awarded: 2022

Matching Funders: Animal Welfare Consulting; Cargill; Deer Creek Feeding, LLC; Hy-Plains Feedyard; Syracuse Dairy, LLC; Tyson Foods; Veterinary Research & Consulting Services, LLC
Project Status: Ongoing

Project Abstract

The use of beef cattle semen to breed dairy cows to produce calves, called beef-on-dairy crosses, for beef production has greatly increased in the past five years. The practice increases the value of calves produced from dairies, but a major limitation is the high incidence (60 to 80%) of liver abscesses and associated economic losses. The reason for the high incidence is not known. The lifecycle of beef-on-dairy cattle, although varies among calf ranches, typically includes three phases: phase 1 is from birth to weaning, approximately 75 days, with calves housed individually in hutches and fed milk or milk replacer with access to dry feed, phase 2 is group housing in pens and typically fed a diet with varying proportions of roughage and grain, and phase 3 is cattle are transported to a feedlot and fed a finishing diet before shipment to harvest. Our principal objective is to conduct a comprehensive analysis of feeding and management practices, including data on morbidity and mortality, from birth to harvest to determine their associations with liver abscesses, timing of their development and bacterial community composition. We have identified several calf ranches and feedlots that raise and finish beef-on-dairy cattle willing to provide mortality, incidence of liver abscesses, animal, feed and management data; therefore, we will be able to follow individual animals with differing management styles from birth to

slaughter. Bacterial community composition analysis of liver abscesses, collected from all three phases, will be based on culture-dependent and culture-independent methods.

Project Updates & Impacts

Objective 1:

Outcomes to date: We have completed 243 necropsies of beef-on-dairy calves at four calf ranches with the plan to continue to collect data through January 2025 to provide 12 months of data. We have had one liver abscess case out of 243 necropsies. We have completed 110 necropsies of beef-on-dairy cattle at eight feedyards with the plan to continue to collect data through summer 2025. We have had two liver abscess cases out of the 110 necropsies. To complete this objective, we will compile these data to evaluate the relative risk of having liver abscess in the calf ranch compared to the feedlot phase of the production system.

Objective 2:

Outcomes to date: We have collected data on management practices from 15 calf ranches spanning Kansas, Texas, New Mexico, California, Indiana, and Ohio. These data are being published in a scientific journal. We have completed collection of liver abscess data on 349 lots of beef-on-dairy cattle at harvest from nine feedyards with liver abscess prevalence ranging from 10 to 92%, which should provide adequate range to identify associated risk factors. We will be collecting liver abscess data on 60 additional lots of beef-on-dairy cattle at beef slaughter plants in November and December 2024. We also have acquired historical data on liver abscess at plants on 134 lots of beef-on-dairy cattle from four feedyards with liver abscess prevalence ranging from 7 to 88%. We have acquired historical liver abscess data from plants on 460 lots of beef-on-dairy cattle from four feedyards with liver abscess prevalence ranging from 0 to 60%. To complete this objective, we will collect feedyard management data from participating feedyards and match that with calf ranch management practices and liver abscess data at harvest. We will use logistic regression techniques to determine the risk factors at the calf ranch and feedyard level associated with liver abscess at harvest.

Objective 3:
We just started working on bacteriological analysis of liver abscess collected at slaughter. After completion, we will evaluate the bacterial community composition of liver abscesses by metagenomics sequencing.

Metabolomic analysis of blood plasma to identify unique biomarkers indicative of liver abscesses

PI: Dr. T G Nagaraja
Primary Organization: Kansas State University
Year Awarded: 2022
Matching Funders: Kansas State University; United Health Corp
Project Status: Ongoing

Project Abstract

Liver abscesses in cattle are a silent infection because no clinical signs are exhibited and are detected only at slaughter. Liver function tests, serum chemistry and serological tests have not shown to be specific to liver abscesses. Our objective is to utilize metabolomics, a technique to analyze metabolites, to determine a comprehensive ‘biochemical fingerprinting’ in the plasma of blood of cattle with or without liver abscesses. We are proposing to conduct two studies to analyze blood metabolomics associated with liver abscesses. In study 1, liver abscesses will be induced experimentally, and in study 2, samples will be collected from naturally-occurring liver abscesses in feedlot cattle at slaughter. The experimental model will allow us to relate metabolomics to liver abscesses alone, not confounded with any other pathology and a nutritional model with ruminal acidosis and ruminitis. The data generated from experimentally-induced liver abscesses will be used to focus on selected metabolites in cattle with naturally-occurring abscesses. In addition to gaining insight into the pathogenic process, unique biomarkers in the blood of cattle will aid in the diagnosis in with liver abscesses. The biomarker will be a major fill in the knowledge gap to detect the onset and progression of liver abscesses in cattle before slaughter. Although early diagnosis could aid in management decisions to decrease the impact of liver abscesses on animal health and animal performance, a major application of an antemortem diagnosis may be in studies designed to evaluate novel interventions to prevent liver abscesses.

Project Updates & Impacts

Due to an unavoidable delay, the study began later than anticipated and the update for this project is pending.

Understanding liver abscess pathogenesis and risk-factors of feedlot cattle reared in conventional beef versus dairy management systems

PI: Dr. Kendall Samuelson
Primary Organization: West Texas A&M University
Year Awarded: 2022
Matching Funders: West Texas A&M University
Project Status: Ongoing

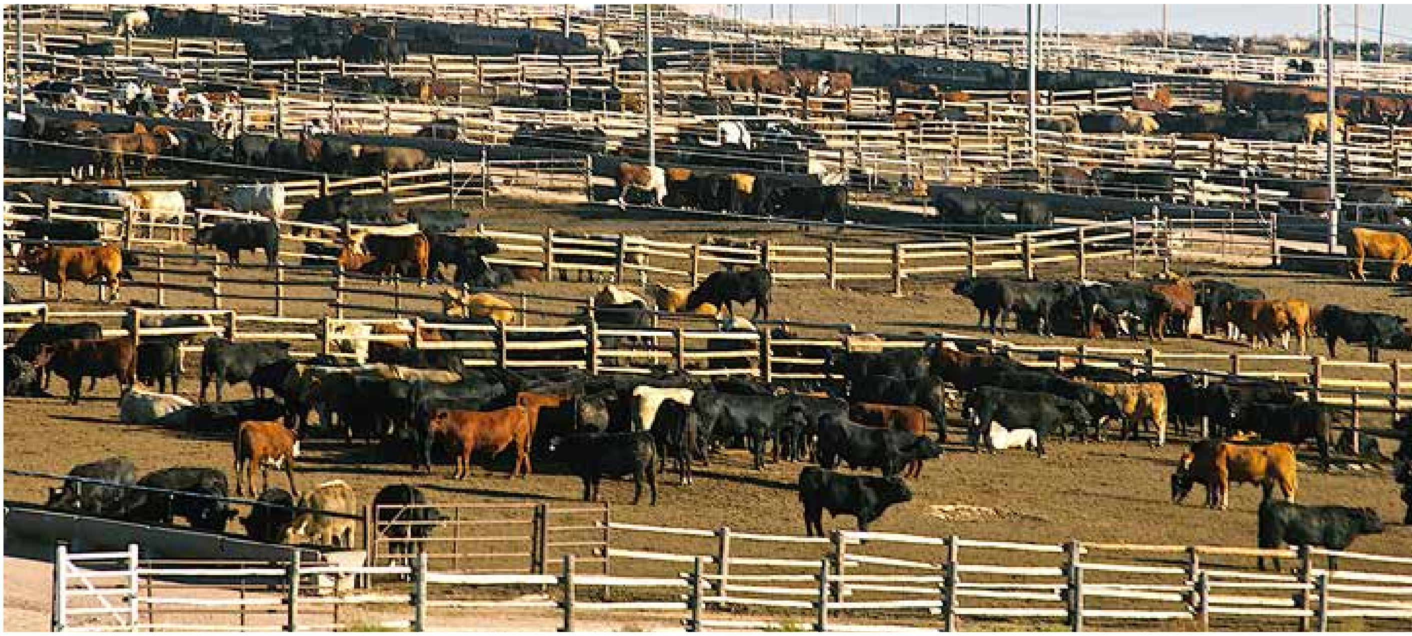
Project Abstract

Liver abscessation in beef × dairy crossbred cattle is two to three times greater than beef breeds. Because management practices before feedlot arrival are drastically different for beef versus dairy calves, early life management and nutrition may influence liver abscess prevalence independent of the animal's genetic composition. Therefore, the objective of this study is to evaluate the impacts of the calf management system rather than genetics on feedlot performance, carcass characteristics, liver abscess prevalence, rumen buffering capacity, blood composition, and rumen and liver microbiome in beef calves raised in beef versus dairy systems. To address this objective, 128 calves will be used in a randomized complete block design. Calves resulting from beef embryos from the same mating will be received at the feedlot and allocated into treatment pens based on the previous calf management system: 1) beef or 2) dairy. Calves born to beef cows will be reared using conventional practices for beef cattle, whereas calves from the dairy system will be separated from the dam within 48 hours and transferred to a calf-raising facility. Within each pen, six calves will be selected to quantify rumination, activity, and ruminal pH. At feedlot arrival and before shipment for harvest, blood and rumen fluid samples will be collected for analysis of complete blood count, serum chemistry, blood transcriptomics, and bacteriological analysis. At harvest, the rumen will be scored, and a sample collected to evaluate papillae morphology and histology. Liver scores will be recorded and when present, liver abscesses collected for bacteriological analyses.

Project Updates & Impacts

There were several goals for the year 1 reporting period which included: producing embryos, transfer of embryos to recipient cows, and management of the calves resulting from these matings. Embryos were produced and transferred into recipient cows in the beef herd in June 2023. For the dairy cows, embryos were produced and transferred in July and August 2023. Calves were born from April to May of 2024. Within 24 hours of birth, calves born on the dairy were transferred to a commercial calf raising facility, where they are currently being housed and cared for. The calves will remain at the calf raising facility for approximately 150 days of age. Calves born to beef cows on pasture will remain with the dam until weaning at approximately 6 to 7 months of age. Over the next project period, all calves will be transferred to the West Texas A&M University Research Feedlot, thus beginning the data collection portion of the study. The research objectives for Year 2 include:

- Wean conventional beef calves
- Receive both beef and dairy produced beef calves at the West Texas A&M University feedlot and complete cattle feeding portion of the study
- Collect intake, health, and growth performance data
- Collect blood and rumen fluid samples
- Collect carcass, rumen, and liver data
- Collect rumen and liver samples
- Complete laboratory analysis of biological samples



Metaphylaxis In Beef Cattle Working Group

Completed Projects

Development of a science-based management strategy to reduce the use of antimicrobials in high-risk beef cattle

PI: Dr. Kristen Hales
Primary Organization: Texas Tech University
Year Awarded: 2020
Matching Funders: Texas Tech University
Project Status: Completed

Project Abstract

The objective was to provide an updated profile of the bovine acute-phase response to include recent advancements in technologies and expanded hematological, cytokine, and serum chemistry variables. Beef steers (n = 32) were fitted with indwelling jugular catheters 1 d before lipopolysaccharide (LPS) administration. Rectal temperature was measured using indwelling probes, and ocular temperature was measured using infrared thermal imaging. Pearson correlation of rectal temperature and ocular infrared temperature was 0.61 ($P < 0.01$) and the Spearman correlation coefficient was 0.56 ($P < 0.01$). Body temperature differed by method at hours 0.5, 2.5, 4.5, 7.5, 12.5, 36.5, and 47.5 ($P < 0.01$), but were not different otherwise. All variables of serum chemistry and complete blood count were influenced by LPS administration, except creatinine, serum glucose, and percent basophils ($P \leq 0.02$). Alanine aminotransferase and alkaline phosphatase peaked at hour 2 relative to LPS administration, returned to baseline at hour 12 and continued to decrease below the baseline value at hour 48 ($P < 0.01$). Total protein concentration decreased 3% in response to LPS ($P = 0.01$). Serum cortisol concentration increased 294% relative to baseline at hour 1 followed by a sustained decrease and return to normal concentration at hour 4 (P <

0.01). Additionally, circulating cytokine concentrations changed with time in response to the LPS challenge, excluding aFGF, bFGF, IGF-1, IL-2, IL-4, MCP-1, and ANG-1 ($P \leq 0.08$). Data presented herein add to existing works to understand the endocrine and immune responses of beef steers administered exogenous LPS, and incorporate recent technologies, additional biomarkers, and an expanded cytokine profile that can be used as referential data in future research.

Final Project Updates & Impacts

The use of targeted metaphylaxis based on measures of body temperature can decrease the proportion of animals administered antimicrobial metaphylaxis while maintaining expected clinical health and growth performance outcomes, but more research should be conducted in this area and especially in populations of feedlot cattle with greater bovine respiratory disease (BRD) morbidity.

Findings and Recommendations. The acute phase response is a component of innate immunity initiated by infection, inflammation, or tissue damage. Characteristics of these host responses can be emulated by administration of exogenous endotoxin and closely studied in controlled settings to understand the response to inflammatory diseases that are commonplace in livestock production. Beef steers were administered exogenous lipopolysaccharide, and responses of body temperature, serum chemistry, complete blood count, cortisol, and cytokines were quantified. A moderate correlation of body temperature measured via rectal probe or ocular infrared temperature was observed, but both methods had a similar temporal response and were sensitive to changes in body temperature. Response of serum chemistry variables highlighted the links between metabolism and the inflammatory response. The initial inflammatory response was initiated by cortisol and pro inflammatory cytokines at hour 1 and tempered by anti-inflammatory cytokines at hours 3 and 4. Therefore, these data offer an expanded view to our understanding of the bovine acute phase response.

Predictive model development to promote science-based, strategic metaphylaxis administration in beef operations

PI: Dr. Brad White
Primary Organization: Kansas State University
Year Awarded: 2020

Matching Funders: Five Rivers Cattle Feeding, LLC (Beef Alliance); Hy-Plains Feedyard; Innovative Livestock Services (Beef Alliance); Veterinary Research and Consulting Services, LLC
Project Status: Completed

Project Abstract

Antimicrobial stewardship is important in the beef industry and determining which animals should receive metaphylaxis (treatment of an entire cohort of animals with antimicrobial) is challenging. The project objective was two-fold: 1) create an econometric framework to evaluate expected cattle welfare and performance differences based on metaphylaxis decision, and 2) assemble multiple data sources to generate predictive models identifying optimal strategic metaphylactic techniques. For the first objective, cohorts (n=12,785; 13 feedyards) were used to create economic models and determine model-adjusted probability of a cohort benefiting from metaphylaxis. Most (72%) cohorts did not economically benefit from metaphylaxis and cattle cohort demographics influenced the probability benefits would be observed. For the second research aim, data from 16,368 cattle cohorts (20 feedyards) were used to build four predictive models: boosted decision tree, logistic regression, neural network, and random forest. Area under the Receiver Operating Characteristics curve (AUC-ROC) was used to evaluate model performance. The same algorithms were used to compare adding origin and external economic data to the baseline models. Model performance was high with AUC-ROC values ranging from 0.80 to 0.93 in the baseline models. Adding external economic variables increased performance (AUC-ROC=0.92-0.94), while origin data resulted in poorer performance (AUC-ROC=0.79-0.89). Overall findings indicated value of metaphylaxis differs by cattle demographics and predictive models can be used to augment current metaphylaxis decision processes. Further research utilizing these predictive models in field settings to evaluate validity and value would be useful.

Final Project Updates & Impacts

In the beef industry, antimicrobial stewardship (responsibly using antibiotics) is crucial, but it's difficult to decide which groups of cattle should receive preventive treatment. This research aimed to solve that problem in two ways: 1) developing a system to predict how cattle health and performance could improve with preventive treatment, and 2) creating models to help beef producers make better decisions about when to use this treatment.

Researchers analyzed data from thousands of cattle across many feedyards. They created economic models to see if giving antibiotics to entire groups of cattle was beneficial. They found that in most cases (72%), the treatment didn’t provide economic benefits, and factors like the cattle’s age or health played a big role in whether it would help.

Next, the team built four types of predictive models using data from 16,368 cattle cohorts. These models helped predict when preventive treatment would work best. The models were very accurate, with performance scores ranging from 0.80 to 0.93. The models worked even better when additional economic data was included, but including data about where the cattle came from made the models less effective.

These findings show that using preventive antibiotics work best in specific situations, and the benefits depend on the type of cattle. By using these models, beef producers could make strategic decisions about when to use antibiotics, improving cattle welfare and the efficiency of beef production. Future research should test these models in real-world settings to make sure they work as expected.

Promoting antimicrobial stewardship through improved knowledge on the subset of feeder cattle in which the value of metaphylaxis-use is most uncertain

PI: Dr. Natalia Cernicchiaro
Primary Organization: Kansas State University
Year Awarded: 2022

Matching Funders: Cactus Research; Five Rivers Cattle Feeding, LLC (Beef Alliance); Hy-Plains Feedyard; Innovative Livestock Services (Beef Alliance); Veterinary Research and Consulting Services, LLC; Zoetis
Project Status: Ongoing

Project Abstract

Antimicrobials are one of the most significant interventions for reducing the deleterious health and economic effects of bovine respiratory disease complex (BRDC), the most important disease in the U.S. feedlot industry. The success of mitigation strategies, such as metaphylaxis administration, is often tied to expected BRDC incidence within the population, but without reliable data for accurately classifying BRDC risk, the decision to use metaphylaxis is often based on subjective assessments. An improved understanding of the perceptions, reasons, and/or information used to classify lots based on BRDC risk and make subsequent antimicrobial use decisions is warranted. The objectives of the study include 1) to assimilate knowledge from industry stakeholders on the current practices, information gaps, and development of subsequent metaphylaxis research that is relevant to, and could be implemented by, commercial cattle feeders, and 2) gather and interpret data and information from cattle feeders, through the implementation of a survey of feedlot managers, veterinarians and other decision-makers, to establish what type of qualitative and quantitative information is used (or not used) in classifying BRDC risk, with a particular focus on medium or moderate risk groups in which the metaphylaxis decision is most uncertain. Obtaining data on perceptions and behaviors through direct industry partnerships, can be used to comprehensively assess health risks and interventions, and in turn, optimize health management strategies for specific cohorts within heterogeneous cattle populations. Our research outcomes will have direct impact on cattle producers who strive to improve animal management, promote health and well-being, price-differentiate cattle based on health risks, efficiently utilize sparse labor resources, and importantly - prudently use antimicrobials.

Project Updates & Impacts

The veterinary consultants' survey was distributed through the listservs of key organizations, including the American Association of Bovine Practitioners (AABP), the Association of Veterinary Consultants (AVC), and prominent veterinary consultant groups (PAC, TELUS, VRCS). The survey aimed to capture detailed insights on feedlot characteristics, including size, location, management, cattle demographics, and the factors influencing the risk assessment for bovine respiratory disease (BRD) in incoming cattle. Additionally, it explored the time and personnel involved in metaphylaxis decision-making.

Statistical analyses were conducted to distill the criteria used to classify BRD risk — identifying who makes the decision, when, and how it informs metaphylaxis use — while also pinpointing knowledge gaps in the administration of metaphylaxis for cattle at uncertain risk. Responses from 21 veterinary consultants, representing 560 U.S. feedlots and 8.7 million cattle across 32 states in 2023, provided a broad industry perspective. The primary factors influencing the assessment of BRD risk for cattle at uncertain risk were cattle in-weight (58%), commingling (53%), distance traveled (53%), weather conditions (53%), and cattle history (47%).

On average, metaphylaxis decisions for 20% of pens (median 10%, range 0–80%) were made before cattle arrived at the feedlot, suggesting that for most at-risk cattle, decisions are finalized post-arrival. Visual assessments — such as body condition score, gut fill, behavior, and clinical signs — were highlighted as key indicators guiding these decisions at the feedlot level.

The findings provide crucial insights for industry stakeholders, shedding light on metaphylaxis decision-making for cattle with uncertain BRD risk. By clarifying current practices and identifying gaps in knowledge, this study contributes to promoting responsible antimicrobial use and sustainability within the U.S. beef industry.

After gathering feedback from multiple stakeholders and completing pre-testing, we have now launched the feedlot managers' survey through influential channels such as the National Cattlemen's Beef Association (NCBA), Kansas Livestock Association (KLA), Texas Cattle Feeders Association (TCFA), Feedlot Magazine, and direct outreach to key feedlot leaders.

Acoustic Monitoring to Support Mass Treatment Decisions

PI: Mr. Tom Darbonne
Primary Organization: Ergense
Year Awarded: 2021

Matching Funders: Cactus Research; Ergense; Five Rivers Cattle Feeding, LLC (Beef Alliance); Veterinary Research and Consulting Services, LLC
Project Status: Ongoing

Project Abstract

One of the most critical decisions made for every cattle truck arriving at the feedlot is whether to mass treat the lot with antibiotics. This decision has ramifications for acquired antibiotic resistance in humans – with the obvious goal that treating the minimal number of cattle will translate to fewer people acquiring antibiotic resistance. The standard procedure is to place each lot of cattle into a receiving pen for at least 24 hours to let them settle, and then to make a decision about whether the entire pen should receive a metaphylactic course of antibiotics. This mass treat decision is made on multiple factors including transportation, shrink, body weight, visual appraisal of body condition, and sounds from the receiving pen. The decision can be very subjective. There is an opportunity for audio to help tease out more information on the condition of the incoming lot by listening to the animals and then pulling out statistics based on machine learning which can influence the mass treatment decision. Acoustic signatures of specific animal vocalizations can be an important determinant for the automatic detection of disease or stress. Because the audio analytic process can continuously listen during night and day, it offers clues to the animal's condition when they are not guarding their physical condition. This body of evidence can be made available before the mass treat decision is made.

Project Updates & Impacts

The update for this project is pending.

Late Morbidity In Beef Cattle Working Group

Completed Projects

Identifying potential causes of late-day bovine respiratory disease in high-performing feedyard cattle

PI: Dr. Myriah Johnson
Primary Organization: Noble Research Institute
Year Awarded: 2020
Matching Funders: Five Rivers Cattle Feeding, LLC. (Beef Alliance); Hy-Plains Feedyard; Veterinary Research and Consulting Services, LLC
Project Status: Completed

Project Abstract

The overall goal of this project was to identify potential causes of bovine respiratory disease (BRD) in high-performing cattle. One portion of the study provided observations related to BRD in high-performing cattle during the mid-portion of the feeding period (MFP), describing the occurrence, timing, and population. Data from a feedlot in Kansas were evaluated for temporal occurrence of BRD in high-performing and high-risk calves on a lot level. High-performing calves were categorized based on performance potential and carcass characteristics. High-risk calves were categorized based upon administration of a macrolide at arrival processing. The cumulative percent of BRD for the high-performing and high-risk categories at 45 days on feed (DOF) was 33.7% and 67.2%, respectively. Morbidity caused by BRD in high-performing cattle is greater than expected. Incidence for BRD occurred at ≥ 45 DOF in all three feedlots evaluated. Additional research is needed to identify potential causes for BRD morbidity during the MFP.

Another portion of the study provided preliminary observations on 4,346 cattle related to BRD morbidity in high-performing cattle related to cow-calf

operations, number of modified-live viral (MLV) vaccines received prior to the feedlot, viral and bacterial presence in the nasal cavity during the mid-feeding period, and rate of gain related to incidence of BRD. First treatment for BRD was associated with the number of times cattle received MLV vaccine prior to the feedlot ($P= 0.02$). Cattle administered MLV vaccine three times prior to the feedlot had a greater first treatment for BRD (21.32%) compared to cattle vaccinated one time (9.56%; $P=0.06$). Cattle which developed BRD had lower ($P < 0.01$) ADG through the first 30 DOF compared to clinically healthy cattle. Preliminary nasal swab polymerase chain reaction results show common respiratory viral or bacterial pathogens were not identified in BRD during the midfeeding period. There is great variability in BRD morbidity between cow-calf operations. Additional research is needed to further evaluate the entire host, environment, and pathogen triad for development of BRD.

Reticulorumen pH was monitored in 60 beef feedlot steers to evaluate the pH during ration transitions and relationship with liver abscess. Transition from starter to intermediate ration resulted in increased amount of time reticulorumen pH ≤ 5.6 and 5.2 compared to the transition from intermediate to finish ration. Steers with an A+ liver abscess spent a greater ($P < 0.01$) amount of time with reticulorumen pH ≤ 5.6 and ≤ 5.2 compared to steers without an A+ liver abscess. The steers first exposure to highly fermentable carbohydrates resulted in increased time of reticulorumen pH ≤ 5.6 and ≤ 5.2 compared to transition from intermediate to final ration. Efforts to reduce the amount of time reticulorumen pH below 5.2 may result in decreased liver abscesses. Two convening events were held in conjunction with this project. Industry leaders, researchers, and consultants all participated. These convenings helped to identify and develop common language and experience around mid to late day morbidity as well as provided input to needed research projects in the area.

Final Project Updates & Impacts

Cow-calf producers have selected for high-performing cattle over the years. These high-performing cattle have the ability to obtain high average daily gain (ADG), improved feed conversion, and yield a valuable carcass consisting of carcass weight, yield grade and quality grade. Increased incidence of bovine respiratory disease (BRD) has been observed in high-performing cattle at approximately 45-90 days on feed. The timing of disease occurs much later in the feeding period compared to traditional disease incidence. This is a major issue, as animals have been selected for improved performance using EPDs for years. However, the high morbidity detracts from the advantages of genetic progress and results in antibiotic use for prevention or treatment. Even through advancements in technology and genetics, morbidity and mortality continue to increase in the feedlot. The work from this grant resulted in intermediate outcomes. The results from our studies as well as the information coalesced at the convening event have been widely used by all other current researchers in this area. Additionally, some have cited our work in order to apply for further grant money. This work has been fundamental in launching research in this specific area.

Determining risk factors for mid- and late-day bovine respiratory disease morbidity and mortality

PI: Dr. Brad White
Primary Organization: Kansas State University
Year Awarded: 2020

Matching Funders: Five Rivers Cattle Feeding, LLC. (Beef Alliance); Hy-Plains Feedyard; Veterinary Research and Consulting Services, LLC
Project Status: Completed

Project Abstract

Bovine respiratory disease (BRD) is the most frequent and economically important disease in the beef cattle industry. The timing of BRD can influence both disease impact and outcome, and recent reports have identified more frequent BRD later in the feeding phase. The objective of this research was to conduct a series of projects to more completely understand BRD later in the feeding phase. This research was completed in conjunction with ICASA collaborators including data sharing and access to facilities. Observational retrospective projects were conducted to more accurately identify potential differences in timing of BRD. Initial work developed expectations for timing of individual cases of BRD throughout the feeding phase and the frequency of cohorts to suffer from late day BRD. These projects developed baselines allowing U.S. beef producers to set reasonable expectations for disease timing. Subsequent work identified late day BRD more frequently in heifers arriving in the second quarter of the year allowing producers to further refine expectations. A prospective observational project was conducted evaluating feedyard mortalities and this work identified several key pulmonary syndromes in cattle with differing epidemiologic patterns. This work illustrated the importance of necropsy to accurately identify contributing factors to mortality. This project benefited the U.S. food and agricultural systems by providing more refined case definitions for mid- and late-day BRD, identifying key risk factors, and categorizing specific pulmonary pathologies.

Final Project Updates & Impacts

Specific research outcomes and impacts are listed in detail below. The findings of this study resulted in several intermediate outcomes which can be utilized to improve decision making and provide a baseline for improved management of mid- and late-day BRD. These outcomes include:

- Refined case definitions for mid- and late-day BRD at both the individual and cohort levels.
- Descriptive analysis of expected timing of BRD treatments during the feeding phase.
- Determining the frequency of cohorts with late day BRD through clustering and identifying key performance and health differences based on BRD temporal patterns.
- Identification of key risk factors of individual animals and cohorts more likely to suffer from mid- and late-day BRD.
- Evaluating feedlot mortalities to identify key pulmonary syndromes including reporting on a syndrome with both bronchopneumonia and interstitial pneumonia.
- Determining key epidemiologic differences based on category of pulmonary pathology identified in feedlot mortalities.
- Evaluation of machine learning as a potential tool for necropsy digital photographic evaluation.

Development of metrics to identify cattle predisposed to feedlot heart disease

PI: Dr. Scott Speidel
Primary Organization: Colorado State University
Year Awarded: 2021
Matching Funders: ABS Global (Genus plc); Cactus Research; Hy-Plains Feedyard; Veterinary Research and Consulting Services, LLC
Project Status: Ongoing

Project Abstract

Beef cattle have been selected over time for increased production levels (growth and fatness) to meet consumer demand. These changes have corresponded to increases in individual animal morbidity and mortality stemming from increased pulmonary hypertension. Incidence of congestive heart failure (CHF) in feedlot cattle has paralleled these increases in production levels. This CHF that occurs in feedlot cattle has been termed feedlot heart disease (FHD) and manifests itself in either subclinical performance losses or death due to heart failure. Additionally, feedlot cattle suffering from FHD tend to exhibit symptoms similar to respiratory illness which is traditionally treated with antibiotics. Animals experiencing FHD in the absence of any respiratory illness, however, would not respond to antimicrobial treatments resulting in the ineffective over-use of antibiotics.

Project Updates & Impacts

In this second year, as a direct result of the funds received from the grant, the goal of objective 1 was to collect an additional 1,500 heart scores. Additionally, we collected pulmonary arterial pressures on another 200 head, measured twice, both at the beginning and end of the feeding period (n = 400 phenotypes in total). Also collected in this year's efforts, in addition to the heart scores and pulmonary arterial pressures, was carcass information that

In this second year, as a direct result of the funds received from the grant, the goal of objective 1 was to collect an additional 1,500 heart scores. Additionally, we collected pulmonary arterial pressures on another 200 head, measured twice, both at the beginning and end of the feeding period (n = 400 phenotypes in total). Also collected in this year's efforts, in addition to the heart scores and pulmonary arterial pressures, was carcass information that included back fat, ribeye area, marbling score, carcass weight, and yield grade. These carcass measures were collected on all individuals receiving heart score measures. We also measured average daily gain and average daily dry matter intake on a subset of these same individuals. The reasoning for the subset of animals with intake measured is again the lack of a sufficient number of pens available to measure individual intake on all animals.

Again, similar to the first year, data collection occurred in two locations. The first group of individuals targeted for data collection was a set of Angus-influenced beef cattle. A second group of cattle were targeted for data collection. In this second group, we are evaluating the incidence of Heart Failure in Beef x Dairy cross cattle. Even with the disparity among the two populations (beef x beef and beef x dairy), all cattle with data collected in this project were sired by Angus and Sim-Angus bulls obtained from ABS Global (DeForest, WI, a grant cooperator). The original goal of the project was to collect Heart Scores on 750 individuals at each location. This year, however, we had some modifications to those numbers and took advantage of projects being conducted, specially at Feedyard 2, and obtained heart scores on a much larger group of cattle than originally projected.

In terms of the data collection numbers for year 2, we obtained 388 individual heart scores on the cattle from Feedyard 1. This is short of the 750 originally projected in year 2, but if we look at the combined numbers for both years 1 and 2, we currently have collected 1,634 heart scores which is greater than the projected 1,500 heart scores listed in the project proposal. Of these 388 collected in year 2, 200 received two PAP measures. Additionally, these 200 also had individual feed intake measured. All of these 388 individuals received carcass phenotypes.

In terms of data collection numbers for year 2 from the Feedyard 2, 1,888 heart scores were collected. With the addition of year 2 animals, the total number of heart scores currently sits at 2,324 individuals. This number is 824 individuals, greater than the projected total originally targeted in the project proposal. All of these individuals have received carcass measures.

Per goal or objective 2 in year 2, we were to continue the data analysis to begin to understand the phenotypic relationships amongst all of the data or traits being collected. This year, we began these efforts, but the timing of the cattle harvest in conjunction with the efforts to assemble the data from the various collaborators (Feedyard 1 – carcass data, feed intake; Feedyard 2 – carcass data, feed intake; ABS – pedigree and genotypes) complete data sets were not compiled until recently. We are currently farther along in the analysis of the Feedyard 1 recorded data as these animals were harvested in February of this year, whereas the Feedyard 2 data collection did not finish until the end of April.

Feedyard 1: In total, the data we have collected is from 883 steers and 751 heifers, representing 88 unique sires. The average heart score was 2.10 and ranged from 1 to 4. Scores 1 & 2 are considered variations of normal, while scores 3 & 4 are considered to be hearts from individuals experiencing heart failure. In these data, 27% of the individuals measured had a heart score of 3 or 4, suggesting that more than ¼ of the animals observed are in some form of heart failure at harvest. One item worth mentioning is the lack of a score of 5. The grading scale for hearts ranges from 1 to 5. In these data, we have not observed any heart scores of 5 in the pacing plant, and this is due to the fact that these individuals simply do not make it to harvest.

Phenotypically with regard to the relationship between heart score and carcass traits, heart score had a significant impact on hot carcass weight, ribeye area, marbling score, and 14-month pulmonary arterial pressure measures. In these analyses, higher heart scores were associated with linear 43decreases in marbling score and curvilinear relationships with ribeye area and hot carcass weights, where the peak phenotype was observed for heart score 3 and then significant decreases for those individuals with a heart score of 4.

This year, we also began genetic analyses to determine the heritability of each of the traits, and genetic correlations amongst all of the traits. For the Feedyard 1 data, the heritability of heart score was found to be 0.28 +/- 0.10. This suggests that 28% of the differences we observe in heart score, phenotypically, are due to underlying additive genetic mechanisms. This estimate is considered to be moderate in size and is of similar magnitude to many traditionally recorded metrics that receive selection pressure in today's beef industry (pulmonary arterial pressure, weaning weight, carcass traits, etc.). This estimate suggests genetics plays a crucial role in whether or not an individual experiences heart failure and that it is possible to select sires whose progeny are resistant to the development of heart failure. In terms of the genetic correlations between heart score and the aforementioned traits, the correlations of the largest magnitude were found to be between heart score and 14-month pulmonary arterial pressure (0.94 +/- 0.17), hot carcass weight (0.63 +/- 0.20) and ribeye area (0.27 +/- 0.22). The genetic correlation between heart score and back fat was 0.15 +/- 0.24, and between heart score and marbling was 0.07 +/- 0.24.

Feedyard 2: For the beef x dairy cross cattle, the average heart score was 1.73 (minimum = 1; maximum = 5). In terms of the percentage of the affected hearts, 10.8% of the hearts were considered to be abnormal or undergoing some form of heart failure.

Phenotypically, we are observing similar trends in this population as we did with the beef x beef population. Here, we are observing linear decreases in marbling score with increases in heart score. We are also observing curvilinear relationships between heart score and ribeye area, and carcass weight. In both instances, the highest performing individuals, phenotypically, were those with a heart score of 3. Individuals with a heart score of 4 are experiencing decreases in both ribeye area and carcass weight. Genetically, we have estimated a heritability of heart score in this population of 0.11. This is much lower than the estimate obtained in the beef x beef population. While considered lowly heritable, this does suggest that genetic improvement in heart score in this population is plausible.

Decreasing pulmonary-associated mortality in feedlot cattle using refined case definitions and predictive analytics: emphasizing acute interstitial pneumonia and late day bovine respiratory disease (BRD)

PI: Dr. Brad White
Primary Organization: Kansas State University
Year Awarded: 2024

Matching Funders: Colorado State University; Five Rivers Cattle Feeding, LLC. (Beef Alliance); Innovative Livestock Services (Beef Alliance); Kansas State University; Mississippi State University; Nanostring; Texas A&M University; Veterinary Research and Consulting Services, LLC
Project Status: Ongoing

Project Abstract

Feedlot mortalities due to late-day pulmonary disease (LDPD) represent significant welfare challenges and cost the industry approximately $190 million annually. Research on bovine respiratory disease typically focuses on disease early in the feeding phase; however, this project focuses on syndromes occurring later in the feeding phase such as acute interstitial pneumonia (AIP). The central tenant of this research is a better understanding of disease process resulting in mortality will enhance our ability to promote appropriate prevention and therapeutics including antimicrobial stewardship. The overall project goal is to generate information to mitigate negative impacts of LDPD in feedlot cattle and this will be achieved through three objectives. Objective 1 will determine frequency, timing and risk factors for LDPD, and objective 2 will create a refined case definition for LDPD based on gross, histopathological, and molecular features from systematic necropsies. Objective 3 will identify high risk pens using predictive analytics and determine optimal diagnostic intervention plans through econometric models. Knowledge gaps exist in understanding late day mortalities and this proposal is the most comprehensive assessment of risk factors and pathological characteristics of LDPD ever reported. Results from this project will be valuable to the beef industry and cattle health providers.

Project Updates & Impacts

Several areas of broader relevance have been identified in the first year of research on late day mortality with a focus on acute interstitial pneumonia.

First, in the projects relative to AIP risk and the expected sequalae to AIP morbidity both projects identified BRD morbidity as a relevant risk factor. For the AIP cohort level risk study, a level of BRD morbidity over 5% was associated with increased risk of at least one AIP mortality in the cohort, and in work on individual AIP morbidities if those individuals had previously been treated for BRD they were more likely to succumb to mortality following AIP. Previous researchers have speculated on the relationship between these two syndromes, but this research is some of the first to quantify the relationship between these two syndromes. It is still unknown if there is a true causal link based on the nature of these retrospective studies; however, further investigations may be useful to evaluate the relationship between the diseases.

Second, in cattle interstitial pneumonia has been referred to as Acute Interstitial Pneumonia (AIP). Our necropsy work with consistent histopathology and classifications has identified that a more chronic form of interstitial pneumonia is relatively common (in both cases classified as bronchopneumonia with an interstitial pattern and cases identified grossly as acute interstitial pneumonia). This is relevant when considering potential prevention and interventions as previously the presumption has been the disease process was very acute. Chronicity of interstitial pneumonia is further augmented by findings in the necropsy project illustrating enlarged /misshapen hearts were more common in cases with interstitial pneumonia than bronchopneumonia. Further research is ongoing, but this directly addresses the second grant objective focused on refining the case definition.

Swine Health Working Group

Completed Projects

The IMAGINE Project: Years 1-4

Pipestone Research's IMAGINE Project aims to bridge the gap in farm-level antimicrobial resistance (AMR) data by collecting and analyzing surveillance data alongside antibiotic use. This initiative will help the U.S. swine industry lead in responsible antibiotic use and AMR surveillance, tracking resistance patterns in both human and pig health-related pathogens. ICASA initially funded this project in 2020 and renewed it in 2021, 2022 and 2025. The 2025 project is currently in progress.

Developing a model protocol for tracking antibiotic use and AMR surveillance for the swine industry

PI: Dr. Scott Dee
Primary Organization: Pipestone Research
Year Awarded: 2020
Matching Funders: National Pork Board; Pipestone Research
Project Status: Completed

Project Abstract

Antibiotic use in livestock is often pointed to as the source of antimicrobial resistance (AMR) in humans, despite a lack of data to support the hypothesis. As of this writing, there has been no attempt to conduct AMR surveillance across a large-scale swine production system and compare it in real time with its respective on-farm antibiotic use. This project will facilitate the development of a model protocol to both track antibiotic use and conduct surveillance for evaluating AMR at the level of the swine farm environment and the level of the pig. We hope to develop a protocol for application across the U.S. swine industry in order to address these issues and propel our swine industry to the forefront of responsible use at the global level.

Final Project Updates & Impacts

Major activities included training and sampling as described, along with validation of the sampling process, data transfer and data integrity. Preliminary analyses (descriptive) were conducted as well. The ability to conduct AMR surveillance and track antibiotic use at the farm level is of tremendous value to agriculture. Besides our focus on analytics and data integrity, we have organized an external advisory panel, which will assist with project critique, evaluation of approaches to data analytics.

Developing a model protocol for tracking antibiotic use and AMR surveillance for the swine industry-Renewal

PI: Dr. Scott Dee
Primary Organization: Pipestone Research
Year Awarded: 2021

Matching Funders: National Pork Board; Pipestone Research; U.S. Department of Agriculture Animal and Plant Health Inspection Service
Project Status: Completed

Project Abstract

Monitoring antimicrobial use (AMU) and antimicrobial resistance (AMR) on farms is recognized as an important component of antimicrobial stewardship yet the process can be resource intensive. This project has completed 2 years of a collaboration across government, academia, and a private sector veterinary practice focused on swine production in the Midwestern U.S. This work was supported by farmers and the swine industry. Twice-annual collection of samples from pigs and the environment, along with AMU monitoring, occurred on 138 swine farms. As the longitudinal monitoring project continues, it may serve as a model for future efforts to monitor AMU and AMR. This project represents one of the first attempts to monitor AMU as

well as AMR in both swine and public health pathogens on a large-scale commercial swine system in the United States. As the project is scheduled for a 5+ year period, final results are not yet available. Preliminary results are reported.

Final Project Updates & Impacts

The threat of Antimicrobial Resistance (AMR) is a major concern to human medicine, veterinary medicine, public health and livestock agriculture, and global society. Even though agriculture is often considered the source of AMR in humans, no data support this hypothesis. To complicate the matter, while AMR data are being tracked by the National Antimicrobial Resistance Monitoring System (NARMS) at the level of the meat case (FDA), the harvest facility (USDA) and across cases of human foodborne illness (CDC), no such effort exists at the level of the swine farm. Therefore, the US swine industry must be proactive and begin to collect these data across pathogens of food safety significance and veterinary significance from swine farms using standardized approaches based on NARMS standards and correlate this information with antibiotic usage data for participants. This project will be the first attempt to accomplish this goal at the level of a large-scale commercial swine production system. It provides a platform for on-farm analysis, as well as lays the foundation for similar analyses to be applied at the processing plant.

Developing a model protocol for tracking antibiotic use and AMR surveillance for the swine industry-Renewal

PI: Dr. Francisco Cabezon (who took over from Dr. Scott Dee)
Primary Organization: Pipestone Research
Year Awarded: 2022
Matching Funders: National Pork Board; Pipestone Research; U.S. Department of Agriculture Animal and Plant Health Inspection Service
Project Status: Completed

Project Abstract

The threat of Antimicrobial Resistance (AMR) is a major concern to human medicine, veterinary medicine, public health and livestock agriculture, and global society. Even though agriculture is often considered the source of AMR in humans, no data support this hypothesis. To complicate the matter, while AMR data are being tracked by the National Antimicrobial Resistance Monitoring System (NARMS) at the level of the meat case (FDA), the harvest facility (USDA) and across cases of human foodborne illness (CDC), no such effort exists at the level of the swine farm. Therefore, the U.S. swine industry must be proactive and begin to collect these data across pathogens of food safety significance and veterinary significance from swine farms using standardized approaches based on NARMS standards and correlate this information with antibiotic usage data for participants. This project will be the first attempt to accomplish this goal at the level of a large-scale commercial swine production system. It provides a platform for on farm analysis, as well as lays the foundation for similar analyses to be applied at the processing plant.

Final Project Updates & Impacts

The Imagine project has been underway for three years, with notable achievements in building public/private partnerships, collecting data from farm sites, and isolating targeted pathogens. Our efforts have also included preliminary statistical analyses on antimicrobial use (AMU) and antimicrobial resistance (AMR), using both phenotypic and genotypic methods to evaluate AMR. Continuous improvements to the study protocol have been made based on insights gained from the first two years. A key partnership with the USDA and NAHMS has provided additional funding and expertise in data analysis.

Preliminary findings show that sampling across enrolled sites has been completed, with similar recovery rates of targeted bacteria in both pigs and their environments. No significant differences in AMR were found between sick and substandard pigs in breed to wean sites. Whole genome sequencing revealed high diversity in E. coli and Salmonella genomes, indicating no endemic strains, but additional sampling over another year is necessary to expand the database. We are also beginning to identify outliers—farms with high AMU or a higher prevalence of monophasic Salmonella Typhimurium. To fully understand these observations, factors such as farm health, animal flow, building design, and disease challenges must be explored. With continued sampling, we aim to identify causes, apply interventions, and measure outcomes to improve farm health and control AMR.

Antimicrobial resistance and use tracking through swine production flows on farms in the upper Midwest of the United States-Renewal

PI: Dr. Francisco Cabezon
Primary Organization: Pipestone Research
Year Awarded: 2025

Matching Funders: Merck Animal Health; National Pork Board; PIC (Genus plc), Pipestone Research
Project Status: Ongoing

Project Abstract

Three years of an antimicrobial resistance monitoring (AMR) program has provided the scientific community information on the types of resistance seen on Midwestern swine farms in the United States. This approach tested breed-to-wean (BTW), wean-to-market (WTM), and breed-to-market (BTM) enterprises twice per year and described the isolates AMR patterns and relationships with purchased antibiotics. Two papers have been submitted for peer-review at this point and two others are being finalized for peer-review. Yet this approach did not provide veterinarians or farmers information on the temporal resistance trends or timelines. The latter is needed to inform antimicrobial stewardship.

Controlling the impact of recent antibiotic treatments and age are needed to remove confounding associated with these findings. As a result, a novel approach was developed to track AMR across three ages of pigs at five sites for each age monthly: weaned pigs, one month after placement in the grow-finish segment, and one month prior to harvest. Resistance could then be trended through the lifecycle of pigs to assess the resistance's relation to age, time since last treatment, and antibiotic used.

Final Project Updates & Impacts

This project is in its first year, and the first project update is pending.

Fecal microbiota transplant to reduce post-weaning diarrhea and antibiotic use

PI: Dr. Timothy Johnson
Primary Organization: Purdue University- Calumet
Year Awarded: 2021
Matching Funders: Elanco; Indiana Soybean Alliance; Purdue University
Project Status: Completed

Project Abstract

Fecal microbiota transplantation (FMT) is an emerging strategy for modulating the gut microbiome to improve animal health and productivity, particularly as an alternative to antibiotics in livestock. However, administering FMT at large scale via oral gavage is impractical. We evaluated the effectiveness of alternative FMT delivery methods in two animal studies. In experiment 1, forty weaned piglets were administered FMT by oral, rectal, or in-feed administration. Pigs in the FMT groups had higher average daily weight gain (ADG) from day 0-2 post-weaning. The recipient microbiomes shifted towards the donor in all FMT groups, beginning on day 5. On day 4, an increase in villus length was only observed in the in-feed FMT group. The oral group had the highest microbial colonization (15.12%) but was 13.82% and 11.78% in rectal and in-feed groups, respectively.

In Experiment 2, 240 pigs were assigned to no treatment, antibiotic, or one of three FMT groups (oral, in-feed FT1, or double-dose FT2) to assess growth, gut morphology, and microbiome responses under weaning and transport stress. During the first post-weaning week, all FMT and antibiotic groups showed increased feed intake and reduced diarrhea. However, pigs in the antibiotic group exhibited superior weight gain after the first week. Prevalence of fecal enterotoxigenic E. coli F18 was highest in in-feed FMT groups and lowest in the antibiotic group. These findings suggest that while FMT may partially alleviate the effect of weaning stress, its efficacy remains

limited compared to antibiotics under severe conditions.

Final Project Updates & Impacts

Raising pigs with fewer antibiotics is a growing interest for farmers, scientists, and the public. Overusing antibiotics can contribute to antibiotic resistance, which makes it harder to treat infections. One possible alternative is fecal microbiota transplantation (FMT)—a method that uses healthy gut bacteria from donor animals to help support young pigs' health during stressful times, like weaning.

This study looked at how well FMT works when given in different ways: by mouth, by rectum, or mixed into feed. In the first part of the study, researchers gave FMT to 40 young pigs and watched their growth and gut health. All FMT groups grew faster right after weaning, and their gut bacteria started to resemble that of the donor pigs within a few days. Pigs that got FMT in their feed showed early changes in their gut lining, which may help absorb nutrients better.

In the second, larger study involving 240 pigs, researchers compared FMT to antibiotic treatment and no treatment at all. All FMT and antibiotic groups ate more and had less diarrhea during the first week after weaning. But after the first week, only pigs that received antibiotics kept gaining more weight. Also, pigs given antibiotics had fewer harmful E. coli in their feces than the FMT groups.

These findings show that FMT can help reduce stress and illness during weaning, but it still doesn’t work as well as antibiotics under tough conditions. More research is needed to improve FMT as tool for raising pigs without antibiotics.

Risk factors for lameness in finishing pigs

PI: Dr. Meghann Pierdon
Primary Organization: University of Pennsylvania School of Veterinary Medicine
Year Awarded: 2021
Matching Funders: University of Pennsylvania; PIC (Genus plc)
Project Status: Completed

Project Abstract

Little is known about the incidence and causes of lameness in growing pigs. Management factors have been shown to be risk factors in sows, but no studies have been performed in growing pigs. Our aims were: 1) determine the incidence of lameness in pigs at different stages of their growing life, 2) investigate farm-level risk factors for lameness, and 3) examine farm treatment records to assess antimicrobial use. We visited 53 finishing farms at 2 ages and quantified the prevalence of lameness. We gathered PRRS status, feed information, antibiotic records, farm characteristics and Mycoplasma hyosynoviae on oral fluids to assess the association farm-level factors on the proportion of lame pigs on the farm. We found the prevalence of lameness at visit one was 21% with 1% severe. At visit two, the prevalence increased to 34% total lameness with 2% severe. Farm characteristics, disease status, and feed analysis have been done, and analysis is underway. We found 64.2% had paper medication records and 16/34 records were compliant with FDA guidelines. These findings indicate there is a need to understand if the recorded factors influence the prevalence of lameness. We recommend working to improve medication record keeping compliance on swine farms. We intend to do risk factor analysis and examine gross, histological, and culture results for lame pigs and non-lame pigs that were collected from these farms. For antimicrobial use, we intend to follow up with the National Pork Board on our findings to develop record keeping tools for swine farmers.

Final Project Updates & Impacts

Lameness—a condition that makes pigs struggle to walk or stand—is a common problem in adult breeding pigs, but little research has explored how often it occurs in younger pigs or what causes it. Since healthy pigs are essential for strong farms and food production, researchers set out to better understand lameness in growing pigs and find ways to reduce it. To do this, they visited 53 farms where pigs were raised for meat. They checked how many pigs had signs of lameness at two different stages of their growth. At the first visit, 21% of pigs showed some degree of lameness, with 1% suffering severely. By the second visit, the numbers had risen to 34%, with 2% experiencing severe issues. The study also looked at possible reasons behind the problem, such as farm conditions, feeding practices, and disease presence. The researchers collected data on medication use and record-keeping, finding that while many farms kept paper records, not all were following FDA guidelines properly. These findings highlight the need for better tracking of medications and farm practices to improve pig health. Next, the researchers plan to analyze the collected samples to identify specific risk factors and work with the National Pork Board to create tools that help farmers keep better medical records. This research could lead to healthier pigs, more efficient farms, and better food production for all.

Improving the efficacy of vaccination against mycoplasma hyosynoviae by identifying optimal application times

PI: Dr. Maria Pieters
Primary Organization: University of Minnesota
Year Awarded: 2021

Matching Funders: Boehringer Ingelheim; Newport Laboratories; Pipestone Research; Tyson Foods; University of Minnesota
Project Status: Completed

Project Abstract

Mycoplasma hyosynoviae (M. hyosynoviae) is a commensal bacterium that can induce lameness in growing pigs, which contributes to welfare issues in swine. Currently, there are limited preventative and treatment options to control M. hyosynoviae-associated lameness. Although commercial vaccines for M. hyosynoviae are not available to date, autogenous vaccines can be used in an attempt to reduce lameness in downstream pigs. Therefore, the objective of this study was to investigate production and clinical outcomes following vaccination against M. hyosynoviae in commercial settings. A herd with a history of M. hyosynoviae lameness in downstream pigs was selected for the trial. The sow farm housed ~9,000 dams, and 11 of the downstream sites were included based on the production schedule. Dams (n=1,208) were randomly allocated into two treatment groups, vaccinated or non-vaccinated. Vaccinated dams were intramuscularly inoculated at ~5 and ~3 weeks prior to farrowing. Piglets born to enrolled dams were followed from birth until finishing age (n=12,377). Piglets were randomized into the following treatment groups: unvaccinated or vaccinated twice varying in application time (three different groups). Weights were collected from all enrolled piglets at birth and weaning, and subsets of pigs were conveniently weighed at growing (n=2,911) and finishing age (n=2,182). The proportion of lame pigs were analyzed through a mixed-effect logistic regression model based on final live animals at the end of the trial. Individual weights were evaluated through linear mixed models. All statistical analyses were conducted in R, and results were considered significant at $p > 0.05$. Results showed a lower risk of developing lameness in vaccinated piglets when compared to unvaccinated piglets regardless of sow vaccination status. Finishing weights, average daily gain (ADG) at weaning, growing, and finishing did not differ between treatment groups. Under the conditions of this investigation, piglet vaccination regardless of application time, resulted in significantly fewer lame pigs when compared to unvaccinated piglets born to unvaccinated sows. Moreover, vaccination either of the sow or the piglet, did not appear to affect weights close to market age. Regarding clinical presentation of lameness, similar results have been reported after the application of a one-dose autogenous vaccine in commercial settings. Further analyses will be performed to determine the optimal piglet vaccination time.

Final Project Updates & Impacts

Vaccination against M. hyosynoviae decreased the likelihood of growing pigs to develop clinical lameness. Swine professionals and producers can refer to the first evaluation of the use of an autogenous vaccine for the prevention of a bacterial lameness in pigs. In addition, the profile of natural antibodies in commercial pigs offered insights into the host response against the bacterium M. hyosynoviae. Potentially, pharmaceutical companies can dedicate efforts to the development of commercial products to prevent the development of lameness in pigs. The application of the autogenous vaccine contributed to the decrease in clinical lameness in pigs.

Cross-Cutting Technologies Working Group

Completed Projects

A rapid chute-side antibiotic resistance detection tool to improve antimicrobial stewardship and optimize risk management while controlling bovine respiratory disease (AMR protein detection)

PI: Dr. Morgan Scott
Primary Organization: Texas A&M AgriLife Extension Service
Year Awarded: 2020

Matching Funders: Cactus Research; Five Rivers Cattle Feeding, LLC. (Beef Alliance); NG Biotech; Texas A&M University
Project Status: Completed

Project Abstract

A chute-side lateral-flow immunoassay (LFIA) that can speed the detection of antimicrobial resistance (AMR) elements prevalent in bacterial pathogens would significantly improve the management of bovine respiratory disease (BRD). The objective of the study was to assess the sensitivity (Se) and specificity (Sp) of two rapid diagnostic tools targeting (1) extended-spectrum beta-lactamase (CTX-M)/mobilized AmpC (CMY-2) proteins (duplexed) and (2) overall 3rd generation cephalosporin (cefotaximase) activity in the feces of feeder cattle. The objective was achieved using Bayesian latent-class models (BLCM) for novel LFIA comparisons against conventional microbiological endpoints. A total of 400 beef cattle were included in a randomized field trial across two major U.S. beef cattle feed yards. On Day 0, 200 individual fecal samples were collected per rectum on each operation, after seven days, 200 post-treatment fecal samples were collected and matched on animal IDs. Antibiotic metaphylaxis for BRD resulted in an increase in the prevalence of

beta-lactam resistance elements and enzymatic activity on Day 7 compared to pre-treatment on Day 0. Based on this difference, BLCM analysis indicated an increasing Se of the duplexed assay, rising from 81% at 10^2 CFU/g feces to 99% at 10^5 CFU/g. Meanwhile, assay Sp decreased from 93% to 89% over the same range of bacterial counts. The cefotaximase activity assay initially showed lower Se across the same range of coliform CFU (40-75%); however, Sp remained constant at 100% across the same range. Pen-side rapid assays can inform AMR stewardship decisions regarding BRD metaphylaxis. Implementing these tools requires additional equipment and training.

Final Project Updates & Impacts

Scientists wanted to test two fast, on-the-spot tools that could help detect signs of AMR in cattle. These tools check for special proteins or activities in the bacteria found in cow manure, which signal that the bacteria might resist important antibiotics. They tested 400 cattle across two U.S. feedlots. Manure samples were collected from each cow before and after they were given antibiotics. The researchers then compared the results of the new tools to traditional lab tests using advanced computer models to judge how well the tools worked.

Key Findings:

- One tool (the “duplexed assay”) became more accurate as bacteria levels increased—detecting AMR signs in up to 99% of cases at high bacterial counts.
- The other tool (the “cefotaximase assay”) was slightly less sensitive but very accurate when it said a sample was negative.
- Antibiotic use increased the presence of resistant bacteria after just seven days.on BRD temporal patterns.

These portable tests could help farmers and vets make smarter decisions about antibiotic use right at the feedlot, helping fight AMR. However, using them requires some extra equipment and training. Future research can help make these tools more accessible and effective.

Field-deployable biosensors for antibiotic stewardship (chute-side detection of AMR genes in beef cattle)

PI: Dr. Mohit Verma
Primary Organization: Purdue University - Calumet
Year Awarded: 2020

Matching Funders: Cactus Research; Five Rivers Cattle Feeding, LLC. (Beef Alliance); McDonald's; Purdue University; Tyson Foods
Project Status: Completed

Project Abstract

Bovine respiratory disease (BRD) is a multi-pathogen syndrome that carries an annual economic burden of approximately $1 billion in the United States. Due to the numerous infectious etiologies, the management of BRD is inherently complex. The treatment protocols are further complicated by the emergence of antibiotic resistance in BRD pathogens. A major gap exists in the ability to rapidly and affordably determine the causative agent of BRD, characterize the antibiotic resistance profile, and design optimal antibiotic treatment regimens. This project aimed to overcome these challenges by building and optimizing a new pen-side DNA-based biosensor to detect antibiotic resistance (goal 1). The team also developed a machine-learning model to determine which genetic markers predict the effective antibiotic to use (goal 2). The biosensor incorporated loop-mediated isothermal DNA amplification on a microfluidic paper-based analytical device to enable pen-side use by producers and veterinarians. When tested at two different feedlots in over 400 animals, the biosensors demonstrated 80-100% specificity in detecting seven different antimicrobial resistance genes. In addition, when the genes were detected in the field, their estimated levels were within two orders of magnitude to lab-based quantitative polymerase chain reaction methods. The use of these biosensors in feedlots is expected to improve the management practices by refining the treatment regimen for BRD. The reliability of the biosensors can be further improved by combining newly discovered genetic markers that improve the accuracy of genotypephenotype concordance compared to only relying on known antimicrobial resistance genes. The susceptibility of 100 Pastuerella multocida isolates to six antibiotics used to treat BRD could be predicted with an average of 93% accuracy. This is a marked (40% better) improvement from

past antibiotic susceptibility predictions. Improvements were due to more precise pairing of resistance genes and specific antibiotics. In the long-term, since the biosensor is a platform technology, it can also be applied to other diseases and host species for improving animal health and guiding antibiotic usage.

Final Project Updates & Impacts

The findings from this project have the potential to significantly improve the management of BRD and other diseases within the U.S. beef industry. One of the major potential outcomes is the widespread adoption of the pen-side biosensor technology by veterinarians and feedlot operators. The biosensor's ability to detect antimicrobial resistance (AMR) genes with high specificity and accuracy allows for faster, more informed decision-making in the field. By enabling rapid on-site identification of resistant pathogens, the biosensor has the potential to minimize the use of ineffective antibiotics, thereby improving treatment outcomes, reducing costs, and promotingresponsible antibiotic use.

The machine-learning model also presents potential outcomes that could transform the management of BRD. By leveraging genetic markers to predict the most effective antibiotics, the model represents a shift towards precision medicine in veterinary care. This technology has the potential to greatly improve treatment success rates, as it moves away from the "one-size-fits-all" approach traditionally used in feedlots. Additionally, the model's ability to predict effective treatments based on genetic markers could be adapted to other livestock diseases, expanding its impact across the agricultural sector.

The platform nature of the biosensor technology suggests further potential outcomes beyond BRD. The biosensor can be modified to detect other pathogens or AMR genes, making it applicable to a variety of infectious diseases in different livestock species. This adaptability offers the potential for improving the management of animal health across the entire livestock industry, ultimately leading to healthier herds, reduced disease outbreaks, and more sustainable production practices. In addition, researchers were trained in the ability to conduct field-based assays and improve the technology to provide insightful results that are valuable to the producers and veterinarians. This experience was helpful to improve the approach for developing the biosensor and it is also guiding the next steps for commercialization. PI

Verma's startup company, Krishi Inc., is now taking the findings from this project and working on developing a commercially viable product. This commercialization process will help translate the findings into practice so that veterinarians and producers in the cattle industry can use these state-of-the-art technologies.

The technologies have not yet been implemented on a wide scale in clinical settings and thus, have not yet contributed to reductions in morbidity. This evaluation could be done in future studies.

Ongoing Projects

Antimicrobial use monitoring and benchmarking in U.S. feedyards

PI: Dr. Michael Apley
Primary Organization: Kansas State University
Year Awarded: 2021

Matching Funders: Cargill; Kansas State University; Tyson Foods; Yum! Brands
Project Status: Ongoing

Project Abstract

Antimicrobial stewardship includes evaluation of use by individual stakeholders in relation to their peers as well as the more general summary reporting of antibiotic use in the interest of transparency. This reporting is only helpful if the reported metrics are standardized and based on high quality data, and data reporting and the resulting feedback is available to all stakeholders.

Currently, there are major challenges in the ability to efficiently capture and analyze antibiotic use data from multiple beef feedlots across a wide variety of record systems. This proposal seeks to use a model data capture, analysis, and reporting system to support discussion of characteristics of data structures which support efficient data analysis, followed by the optimal

reporting metrics to convey the results of this analysis to both beef feedlots (benchmarks) and to the customers of beef processors (transparency).
To facilitate industry-wide participation in the discussion of standards for data quality, data structure, and antibiotic use reporting metrics, a symposium will be held with brings together a wide array of expertise and experience. The results of these deliberations will be reported to the industry and begin the establishment of standards so that all beef feedlots, software developers and providers, beef processors, and beef product providers will have clear targets on which to base their efforts.

Project Updates & Impacts

Year 1 goals:

Receive data from cooperating beef feedlots then initiate data analysis and preparation of antibiotic use metrics.

- Data in hands of study team. This has been hindered by speed of providing data related to purchases by cooperating feedlots. However, the data structure is complete and populated with data already received.

Year 2 goals:

- Provide reports to cooperating beef feedlots and beef processors. Facilitate interactions between multiple stakeholders to establish initial uniform standards for data quality, data structure, and antibiotic use metrics.
- Provide summary data reports to cooperating beef processors and gather feedback from the processors and processor-selected customers on the utility of these reports in providing transparency.
- Provide antibiotic use benchmark reports to cooperating beef feedlots and collect feedback on the most useful components.
- Host a symposium with targeted facilitation and recording of discussions aimed at establishing standards in beef feedlot data reporting.
- Publish consensus-driven proposed standards for further discussion and incorporation into antibiotic use monitoring programs.
- The format and data structure for providing summary data reports to cooperating beef processors and feedlots is created and in place, populated by existing data. Only the receipt of a few final data sets hinders the provision of results to cooperators. A push to get the final data pieces needed is underway.

- The symposium will be scheduled for fall 2025 at Kansas State University.

Year 3 goals:

- The facilitation of input on data format and presentation will occur at the symposium and the initiation of a consensus process on guidelines will begin immediately. Publication of these consensus guidelines may not be complete by the end of the funding period but will be concluded by first quarter 2026.
- The modeling of economic effects or alterations in antimicrobial use will begin as soon as we have the final data set in early 2025. Our target is to be able to present this modeling at the symposium followed by input and then publication.

The real-time pen-side detection of bovine respiratory disease by chemical analysis

PI: Dr. Adam Reid Rivers
Primary Organization: U.S. Department of Agriculture Agricultural Research Service
Year Awarded: 2020

Matching Funders: McDonald's; Veterinary Research and Consulting Services, LLC; VOC sensor company
Project Status: Ongoing

Project Abstract

Bovine respiratory disease complex (BRDC) is an economically important complex of diseases caused by bacterial and viral pathogens often brought on by the stress of transporting animals. It is a primary reason for metaphylactic antibiotic use in feeds lots. Antibiotic use could be reduced with better tools to identify animals at risk for BRDC when they arrive at the feedlot and tools to rapidly diagnose BRDC in sick animals and determine if infections are bacterial. This work proposes to analyze the volatile organic compounds (VOCs) in exhaled breath to detect early-stage pulmonary immune response and specific pathogen metabolites during feedlot processing and diagnosis when symptoms are present. The VOCs will be detected by a Proton Transfer Reaction mass spectrometer and analyzed to develop supervised machine learning methods. Once these models are developed, they can be used for the real-time sorting of cattle into risk groups and for detecting acute infection and degerming if the infection is bacterial.

Project Updates & Impacts

The aims of the project in year 1 were to design a system for breath sampling of Cattle and collect pilot data from sick and healthy cattle for an initial comparison of the breath profiles of the animals.

In year one we have iterated through 3 designs of breath collection masks and 3D-printed prototype masks with flexible polymers. Our current design uses a 12mm tube connected to a bull ring with a polymer nare plug. This collector is attached directly to our gas sampling bags for collection and analysis. This design is sufficient for breath collection and will be used for our large-scale experiments.

We have collected breath samples from 4 diseased and 4 heathy cattle and analyzed with the PTRMS using two ionization sources (H3O+ and O2+). We are planning to analyze these data in the next month. Results will inform our large-scale acute illness experiment.

Development of artificial intelligence, machine vision and internet of things for livestock health monitoring

PI: Dr. Timothy Robertson
Primary Organization: Precision Livestock Technologies
Year Awarded: 2020

Matching Funders: Alltech; Bennett Data Science; Five Rivers Cattle Feeding, LLC. (Beef Alliance); Iowa State University; JBS USA; Veterinary Research and Consulting Services, LLC
Project Status: Ongoing

Project Abstract

Precision Livestock Technologies (PLT) specializes in applying artificial intelligence, machine vision, and other techniques to develop new sources of actionable intelligence in the livestock industry. In partnership with other companies and top researchers in the livestock field under the auspices of the ICASA grant, PLT will leverage its machine vision platform to increase the capacity and ability of livestock managers to identify and treat sick animals. Specifically, we will monitor feedlot cattle in receiving pens, in the sorting process, in home pens and when treated in hospital pens, to develop automated methods for detecting Bovine Respiratory Disease (BRD) and other common illnesses that are typically treated with antibiotics.

Studies on detection of disease are often undertaken on small numbers of animals in controlled settings. The latest machine vision and artificial intelligence technologies present an opportunity to create an unprecedented amount of new data in production environments. This data will be used to create a new class of animal health monitoring and intervention recommendation tools that lead to a paradigm shift away from herd management and towards the care of individual animals. The benefits from individual animal management include earlier intervention and reduction in the spread of infectious diseases, reduction in unnecessary medical treatments, better animal welfare, less reliance on highly trained individuals in harsh environments, improved meat quality, more efficient consumption of feed, and higher profits for producers.

Project Updates & Impacts

The primary technology development objective of Phases 1 and 2 was to train machine vision algorithms to recognize visible signs of morbidity in cattle. In addition, data on feeding behavior was to be gathered to see if changes in feeding behavior and/or comparison in feeding behavior between low and high-risk cohorts could be used to predict or observe illness.

The most significant positive result from the work during this period is the development of the machine vision algorithms noted above - both the algorithms that dynamically recognize, segment and classify body parts, and the algorithm that combines results from the classification into a prediction of overall health. From the initial success of this work, we have a high level of confidence that continuing with the project will yield more complete and more accurate algorithms in support of the stated goals for the project.

While not a negative finding per se, the differences between high and low risk cohorts were of too small an effect size (38 sick cattle in the high risk vs. 13 in the low-risk group) to yield interesting results for machine learning. Similarly, neither home pen experienced metabolic upsets that would be germane to an analysis of feeding behavior to predict or indicate the same.

ICASA

A FFAR COLLABORATIVE

Thank You:

As ICASA marks six years of progress, FFAR is grateful for our ICASA participants, researchers and co-funding partners. Your participation and collaboration are advancing science-based, practical solutions that strengthen antimicrobial stewardship in beef and swine production. We look forward to continuing this shared commitment in the years ahead.

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International Consortium for Antimicrobial Stewardship in Agriculture

ICASA is a public-private partnership created by the Foundation for Food & Agriculture Research (FFAR) to advance research on antimicrobial stewardship in animal agriculture. ICASA's research promotes the judicious use of antibiotics, advances animal health and welfare and increases transparency in food production practices.

Foundation for Food & Agriculture Research

FFAR builds public-private partnerships to fund bold research addressing big food and agriculture challenges. FFAR was established in the 2014 Farm Bill to increase public agriculture research investments, fill knowledge gaps and complement the U.S. Department of Agriculture's research agenda. FFAR's model matches federal funding from Congress with private funding, delivering a powerful return on taxpayer investment. Through collaboration and partnerships, FFAR advances actionable science benefiting farmers, consumers and the environment.

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