Using Antimicrobials in Feedlot Production Systems: The Feedlot Health Approach to Understanding the Impact on Antimicrobial Resistance

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Presentation Outline

- Introduction to Feedlot Health
- Approach to Understanding the Impact of Feedlot AMU on AMR
- Key Findings to Date
- Current Initiatives
- Summary
Overview

- Feedlot Health is a professional services company providing a full suite of production consulting services and management/execution tools to commercial feedlots and calf grower operations in:
  - Canada
  - United States
  - Mexico

with ongoing business development projects in:
  - South Africa
  - China
  - Russia
Overview

- The company is based just outside of Okotoks, Alberta, Canada and currently provides professional services to beef feedlots and calf grower operations with an annual throughput of approximately 2.5 million beef cattle.
Overview

- Partner companies – Cow/Calf Health Management Services and Dairy Health Management Services provide analogous services in the beef cow/calf and commercial dairy sectors
Mission

- To provide a broad range of world-class consulting and research services, along with management and execution tools, to improve the net profitability of our feedlot and calf grower clients.
Business Principles

Focus on Data Collection and Analysis

- Individual animal data collection, including AMU
- Decision making models based on data collection and analysis, commercial field research programs, and economic modeling

Business Model to Facilitate Sustainability

- Focus and expertise extending beyond animal health to include all aspects of procurement, production, and marketing, including economic, environmental, and ethical sustainability
- Daily veterinary and production oversight of commercial production
Overview

- Our Feedlot Health Team includes
  - 26 member professional services team with expertise in feedlot animal health, epidemiology, pathology, animal welfare, animal production, nutrition, meat science, applied research, statistical analysis, economic modeling, quality assurance and process optimization
  - 40 member support team that includes animal health technologists, project managers, research assistants, administrative personnel, technical assistants, field assistants and technology support personnel
The Feedlot Health Approach

Feedlot Health Resources
Professional Experts, Support Team, Software Tools, & Infrastructure

The Feedlot Health Approach

FH /FHMS, Digital Imaging, dSort, NIR, Carcass, Feeding, & Non-FH Databases
Data Collection, Monitoring, Analysis & Production Oversight

Ongoing Research & Development
- Literature Reviews
- Proprietary Data Modeling
- Pilot Studies
- Large Scale Commercial Feedlot and Calf Grower Field Trials

Bio-economic Modeling
- Morbidity & Mortality
- ADG & DM:G
- Carcass Attributes

Production Consulting Services for Feedlots and Calf Growers
- AH
- FF
- PEPP
- IAM
- PM
- AFC

External Research Ideas & New Products or Technologies

Client Specific Value-Proposition

Modifications to Existing Module Specific Recommendations
Creating Value for Feedlot and Calf Grower Customers

- The Feedlot Health model is based on the ongoing creation of value for our customers through:
  - Continuous research and development to identify and evaluate the most cost-effective methods for sustainable improvement of feedlot and calf grower production systems
  - Daily oversight, monitoring, consultation and input to ensure optimal execution of the animal health and production strategies and protocols used by each feedlot or calf grower operation
“The Feedlot Health ACC will be responsible for ensuring ethical animal research and associated activities based on provincial and federal legislation and CCAC guidelines, policies and documents, and will oversee the care and welfare aspects of all proposed animal research at Feedlot Health”

Feedlot Health Animal Care Committee

Eric Behlke · Sherry Hannon · Calvin Booker · R Kent Fenton · Tracey Greer Kirsh Berndt · Ashley Gaudet · Kelly Roger · Barb Richardet
AH Module – Key Features

- **Veterinarians with Specialization in Feedlot and Calf Grower Operations**
  - Extensive, focused experience managing animal health in feedlots and calf grower operations means Feedlot Health veterinarians have the practical and technical expertise to manage complex health issues.

- **Data Driven Approach to Disease Prevention, Treatment and Control Protocols**
  - Feedlot Health recommendations are based on the results from scientifically valid, large-pen commercial field trials, including cost-effectiveness of different preventive measures, therapies and intervention strategies for cattle with various animal health risk profiles.

- **Proprietary Individual Animal Software**
  - Feedlot Health provides its feedlot and calf grower clients with proprietary software (iFHMS©) to record all individual animal production and animal health information. The software has online disease management protocols to facilitate daily execution of health strategies, a full suite of reports that allow feedlot personnel to quickly and efficiently track animal health performance, and seamless data transfer of pertinent information to feedlot administrative software programs.

- **Daily “Real-Time” Monitoring 365**
  - Utilizing iFHMS©, digital imaging (both live animals and postmortem dissections), electronic data transfer, multi-client monitoring/alert database, and daily reporting, Feedlot Health veterinarians continually monitor health events at all production sites.

- **Analysis and Summary of Individual Animal Health Records**
  - The large Feedlot Health database allows for detailed analyses to describe the epidemiology of each disease, build risk categorization algorithms, evaluate animal health outcomes within individual feedlots, and compare feedlots to appropriate aggregated datasets.
Evidence Based Approach

Adapted from Figure 4 – Relative strengths of evidence provided by different methods used in clinical research illustrated diagrammatically in the so-called pyramid of evidence. Strength of association increases from the base to the peak of the pyramid.

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Approach to Understanding the Impact of Feedlot AMU on AMR
Understanding the Impact of Feedlot AMU on AMR

- Basic principles
  - Management of antimicrobial resistance is important for animal and human health
  - There is overlap of the ecological systems shared by humans and animals
  - AMR is very a complex issue and there are no simple solutions
  - Antimicrobials are an important tool for managing animal and human health
THE AMR CHALLENGE

Very complex ecosystem linkages

Hard to find **meaningful and practical** ways to significantly reduce AMR

**BACTERIA, BACTERIA EVERYWHERE**
Understanding the Impact of Feedlot AMU on AMR

- Feedlot Health Approach
  - Establish baseline levels/trends
  - Identify knowledge gaps to shape future research
  - Apply results of current and future research to shape policy, regulations, and education
  - Make progress over time
Understanding the Impact of Feedlot AMU on AMR

- Feedlot Health Approach
  - Collaborate with multi-disciplinary groups to get the process started
  - Solicit industry participation and support
  - Baseline study in 1998-99
  - Follow up study in 2007-2010 to update baseline data and explore knowledge gaps
  - Current project in 2013-2018 to further update baseline data and explore additional knowledge gaps
Understanding the Impact of Feedlot AMU on AMR

- Core Research Group
  - Dr. Patrick Boerlin, Ontario Veterinary College, University of Guelph
  - Dr. Calvin Booker, Feedlot Health Management Services Ltd.
  - Dr. Sylvia Checkley, Faculty of Veterinary Medicine, University of Calgary
  - Dr. Sheryl Gow, Richard Reid-Smith, Public Health Agency of Canada
  - Dr. Tim McAllister, Agriculture and Agri-food Canada
  - Dr. Paul Morley, College of Veterinary Medicine and Biomedical Sciences, Colorado State University
  - Dr. Ron Read, Faculty of Medicine, University of Calgary
  - Graduate students, technicians, feedlot operators and workers....
Understanding the Impact of Feedlot AMU on AMR

- Funding Resources
  - Canada-Alberta Beef Industry Development Fund
  - Advancing Canadian Agriculture and Agri-Food Program
  - Alberta Beef Producers
  - Beef Cattle Research Council, Canadian Cattlemen’s Association
  - Alberta Livestock and Meat Agency
  - Other Provincial and Federal Agencies
Key Findings to Date
Key Findings to Date

- Baseline study in 1998-99
  - Four commercial feedlots with randomly selected pens/animals (2622 individual animals) sampled at arrival, re-handling, and exit
  - 61 feedlot workers
  - Rectal swabs – VRE, Campylobacter, Salmonella, E. coli
  - Nasal swabs – MRSA, P. multocida, M. haemolytica, H. somni
Key Findings to Date

- Baseline study in 1998-99
  - No VRE or MRSA identified in cattle or workers
  - No *Salmonella* species (resistant or non-resistant) recovered from cattle or workers
  - Negligible levels of resistance to fluoroquinolones, gentamycin, or meropenem were observed in *Campylobacter* species from cattle
  - No ciprofloxacin-resistant *E. coli* identified in cattle or humans
Key Findings to Date

- Baseline study in 1998-99
  - Resistance to ampicillin was detected commonly in *E. coli* from cattle and a subset of these isolates exhibited resistance to extended-spectrum cephalosporins
    - Possible linkage to feedlot AMU
    - No evidence of transmission of CMY-2 or other AmpC strains to human workers
  - Very low levels of resistance to tetracyclines and macrolides in bovine nasal pathogens
Key Findings to Date

- Follow up study in 2007-2010
  - Study conducted from September 2007 to May 2010 (140 weeks) in 4 feedlots
  - Two stage random sampling
    - 30% of pens
    - 10% of animals
  - Pens and animals selected from approximately 1,000 pens and 180,000 animals over the study period
Feedlot Pilot Surveillance
Sampling & Data Collection

INDIVIDUAL ARRIVAL
5,489

GROUP ARRIVAL
310

INDIVIDUAL >60 DOF
5,489

GROUP > 60 DOF
>310
Feedlot Pilot Surveillance
Laboratory-Individual Samples

1,804 animals
98% recovery
1,773 animals

3 MH Isolates
4,542 isolates

15%
1,804 animals

Culture MH

PCR Pos. MH

Corresponding Fecal Sample

5,525 isolates
3 E. coli Isolates

Susceptibility Testing
Molecular Testing

INDIVIDUAL ANIMAL SAMPLE PROCESSING

500x335

Molecular Testing

3 MH Isolates

Culture Fecal

1,804 animals
Key Findings to Date

- Follow up study in 2007-2010
  - Susceptibility Testing
    - Biomic
    - Sensititre
  - Molecular
    - Integrons
    - Tet resistance genes
    - Extended spectrum beta-lactamases (ESBLs)
Key Findings to Date

- Follow up study in 2007-2010

Figure 2: Prevalence of antimicrobial resistance in *E. coli* isolated from composite samples
Key Findings to Date

- Follow up study in 2007-2010

*Figure 3: Prevalence of antimicrobial resistance in M. haemolytica isolated from individual feedlot cattle*
LINKAGE OF AMU AND AMR

- MH recovered from ~15% of animals

- 47.5% of those animals received a
  parenteral (not related to digestive system) AM during the study period
  - usually at initial processing for BRD prevention
  - 21% tetracyclines
  - 23% macrolides

- Parenteral β-lactams, quinolones, phenicols and sulfonamides each given to < 2% of study cattle

LINKAGE OF AMU AND AMR

- Parenteral AM exposure
  - individual: associated with decreased MH recovery
    OR 0.2, 95% CI 0.02 - 1.20
  - pen mates: associated with increased MH recovery
    OR 1.5, 95% CI 1.05 - 2.20

- AM exposures not associated with resistance to any single drug

- AM exposures in pen mates were associated with an increased odds of recovering multi-resistant *MH*  OR 23.9, 95% CI 8.4 - 68.3

Key Findings to Date

- Follow up study in 2007-2010
  - Virtually no *Salmonella* species (10 isolates from 2 composite samples) recovered during the study
  - No ESBL producing *E. coli* detected in the isolates from the study
  - Resistance to AM drugs classified as very important to human medicine by VDD/HC were either absent or rare in *E. coli* and *M. haemolytica* isolates from this study
Key Findings to Date

- Follow up study in 2007-2010
  - AMU data reported to establish baseline levels
  - Substantial numbers of *E. coli* and *M. haemolytica* isolates stored for future use
  - 5 graduate students were supported by the study and obtained degrees based upon their work contributed in this study
  - At least 12 peer-reviewed manuscripts
  - Filled some knowledge gaps and identified other gaps to be filled
Current Initiatives
Current Initiatives

- Current project in 2013-2018
  “Surveillance of *E. coli*, enterococci, antimicrobial resistance (AMR) and *Enterococcus* species distribution in beef operations and associated environments”

- Funded by Beef Cattle Research Council, Canadian Cattlemen’s Association
BCRC 2013-2018: Objectives

1) Sample Collection: Feedlot & downstream environment, processing plant and retail
2) Determine the AMR profiles and identify *E. coli* and *Enterococcus* spp.
3) Evaluate human clinical enterococcus isolates
4) Genetically characterize enterococci from human, livestock, environment and retail
5) Determine association between antimicrobial use information and resistance information from indicator bacteria
   - *E. coli* is common enteric indicator, but intrinsically resistant to macrolides. Emphasis will be on ESBL in *E. coli*
   - Enterococci selected as an indicator of macrolide resistance due to pervasiveness of macrolide use at feedlots and possible implications in human treatment
6) Determine nature of AMR genes and mobile genetic elements in metagenomic samples
**BCRC 2013-2018: Yearly sampling schedule**

- Four feedlots enrolled
- 25 composite fecal samples/feedlot from two feedlots bimonthly
- 25 composite fecal samples/feedlot from additional two feedlots on alternating months
  
  Yearly total = 600 composite pen samples
- 3 Catch basin samples from enrolled feedlots, *when available*, on same schedule as pen samples
  
  Yearly total = 72 (12 x 6) catch basin samples
- Metagenomic samples (feces & water) – sporadically taken from enrolled and additional feedlots
  
  Yearly total = contingent on budget and availability
- Surface water sampled seasonally
- Processing facility sampled once monthly

  Yearly total = 48 x 10 processing plant & meat samples
Summary

- Understanding the impact of feedlot AMU on AMR of animal or human consequence is extremely important for developing a sustainable plan for using antimicrobials in feedlot production.

- It is a complex issue that requires large-scale, structured research approaches with a multi-disciplinary team.

- Current baseline data suggests that the industry is on the right track for proactively developing a sustainable AMU plan for feedlots in Canada.
Summary

- Additional research, development, and innovation is required over time to continually improve our abilities to manage this complex issue in a proactive, data-driven manner.

- As a private veterinary practice, Feedlot Health has been actively involved in helping generate the samples, data, funding, industry support, etc. to improve our collective knowledge on AMU and AMR to develop and maintain a sustainable AMU plan for the feedlot industry.