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Beef Cattle Research Update

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Blood plasma concentrations of chlortetracycline achieved by administration of a mineral formulation to adult beef cows

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Due to concerns about extended administration of medically important antimicrobials, chlortetracycline (CTC) use in livestock has recently been scrutinized. Since January 2017 its legal use in the United States has shifted from an over-the-counter product to one requiring a veterinary feed directive (FDA, 2015). The CTC label for anaplasmosis control lacks a defined duration. Revision of label claims to define duration is objective 1.1 in the FDA's report on their 5-year plan for supporting antimicrobial stewardship in veterinary settings (FDA, 2018). From 2009 to 2016 drugs in the tetracycline class consistently constituted 70% by weight of all medically important antibiotics sold or distributed in the domestic United States for use in food-producing animals (FDA, 2016). This percentage is much greater than for any other single class of medically important antimicrobials. Although the potency of tetracyclines is relatively low compared with some other classes of drugs, this overwhelming percentage still indicates common and consistent use.

The plasma concentrations and other population pharmacokinetic parameters have been established for CTC administration as a top-dressed, bunk-fed supplement at doses of 4.4, 11, or 22 mg/kg of BW−1/d−1 (Reinbold et al., 2010). However, the product administered and mode of administration used by Reinbold et al. (2010) is not what is typically used to control anaplasmosis in adult cows on pasture.

- Our study objectives were to characterize steady-state plasma chlortetracycline (CTC) concentrations achieved by adult beef cows treated with a commercial, CTC-containing mineral supplement under 2 conditions, where intake was controlled and under conditions when intake was uncontrolled, as in a pasture setting typical of production practices for anaplasmosis control.
- Thirty cows were allocated to 3 individually administered treatment groups: nonmedicated control (NM-F), medicated mineral administered via gelatin capsule (M-C), or medicated mineral fed in a small amount of grain (M-F). After a washout period, 15 of the original cows received an intended CTC dose of 1.1 mg/kg of BW−1/d−1 administered via a mineral feeder in a pasture setting (M-P). Blood samples were collected at multiple time points, and plasma chlortetracycline concentrations were quantified.
- **Results:** Mean plasma chlortetracycline concentrations for M-C and M-F treatments were 20.2 and 19.3 ng/mL, respectively, with no differences in mean, minimum, or maximum plasma concentrations. Conversely, differences in both median and minimum plasma concentrations were detected when the dose was controlled (M-C or M-F) compared with when the dose was administered via mineral feeder in a pasture setting (M-P).
- **Implications**: Future CTC studies can be designed using individual intake in grain because administration by gelatin capsule offers no advantage in dosage consistency. The assumption that mean consumption from a mineral feeder will achieve the same plasma CTC concentrations as individual or bunk-fed experiments should be further analyzed. The pharmacodynamics parameters associated with efficacy were not evaluated in this study and remain unknown.

Influence of prenatal transportation stress-induced differential DNA methylation on the physiological control of behavior and stress response in suckling Brahman bull calves

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Alteration of behavior and stress responsiveness is among the most noted outcomes of prenatal stress (PNS) in mammals. The mechanisms controlling these alterations are still largely unclear; however, it is known that stress incurred by a gestating dam can result in suppression of the placental barrier enzyme 11β-hydroxysteroid dehydrogenase type 2 (11-βHSD2). This enzyme converts cortisol to an inactive form prior to entering fetal circulation; therefore, decreased 11-βHSD2 can result in increased fetal exposure to corticosteroids.

Because behavior and stress response phenotypes are of economic and biologic significance to beef cattle production, this study sought to understand the mechanisms by which a common stressor for beef cattle, transportation, incurred by a pregnant dam could affect behavior and the stress response of offspring. The objective of this study was to identify differentially methylated genes from a previously reported genome-wide assessment of DNA methylation in prenatally stressed bull calves that were related to behavior and stress responses.

Mature Brahman cows (n = 48) were transported for 2-hour periods at 60 ± 5, 80 ± 5, 100 ± 5, 120 ± 5, and 140 ± 5 days of gestation (Transported group) or maintained as nontransported Controls (n = 48). From the offspring born to Transported and Control cows, a subset of 28-day old intact bulls (n = 7 PNS; n = 7 Control) were evaluated for methylation of DNA of behavior and stress response–associated genes.

- **Results:** Many function terms, canonical pathways, and specific genes related to behavior, the stress response, and neural function were altered in PNS compared with Control bull calves. In general, opioid signaling, hypothalamic-pituitary-adrenal axis signaling, dopamine signaling, serotonin signaling, and γ-aminobutyric acid (GABA) signaling were among the most notable pathways related to behavior, the stress response, and neural function that were predicted to be altered in PNS compared with Control bulls.
- **Results:** Association of prenatal transportation stress with genes in behavior and stress response–related signaling pathways coincided with previously reported elevations in temperament scores and circulating concentrations of cortisol observed in the larger population of calves from the which bull calves in this study were derived (Littlejohn et al., 2016). Differential methylation of DNA in different brain regions has been associated with differences in temperament in cattle.
- **Implications:** Future studies will evaluate methylomic and transcriptomic differences in specific neural tissues of cattle exposed to prenatal stressors. Understanding how the prenatal environment shapes postnatal behavior and stress response phenotypes may provide novel opportunities for beef cattle improvement.

The impact of enhancement, degree of doneness, and USDA quality grade on beef flavor development

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Flavor has been well established as a main contributor to beef palatability. Recent studies revolving around beef quality factors have indicated an increased focus on flavor by consumers. These studies indicated that over 50% of the respondents selected flavor as the most important beef attribute when consuming beef. This has drastically increased from approximately 30% in older studies. Additionally, flavor has been strongly correlated to consumer overall liking. Beef flavor can be evaluated in several different ways, including consumer panel evaluation and volatile flavor compound production.

Enhancement is a processing strategy used by the beef industry to provide a more consistent eating experience of beef products. Typically, an enhancement solution consists of water, salt, and phosphates to improve flavor and juiciness. However, when evaluating the effects of enhancement on beef volatile flavor compounds, there has been minimal research previously conducted. Therefore, the objective of this study was to determine the impact of enhancement, degree of doneness, and USDA quality grade on beef volatile flavor compounds from cooked strip loin steaks. Second, this study aimed to evaluate relationships between volatile compounds and consumer sensory responses.

- Beef strip loins (n = 72; 24/grade) of 3 quality grades (USDA Prime, Low Choice, and Low Select) were enhanced (8% of green weight with brine containing 0.35% salt and 0.4% sodium phosphate) or not enhanced, and cooked to 3 degrees of doneness (DOD; Rare: 60°C; Medium: 71°C; Very Well Done: 83°C) before volatile analysis.
- **Results:** When comparing the volatile compound analysis to results produced from the consumer sensory analysis, it is interesting to note that the consumers resoundingly preferred

enhanced product, regardless of quality grade, for flavor liking. In addition to the additional moisture, the addition of salt with the sodium phosphate may be the contributing factor.

- **Results:** Consumer panelists may have preferred enhanced beef with addition of salt, as it is a contributing flavor enhancer, rather than non-enhanced steaks without the contribution of salt.
- **Implications:** Volatile compound production in beef is primarily driven by degree of doneness and quality grade. There is no strong link between enhancement and beef flavor development from a chemical standpoint, but it has a dramatic impact on consumer beef flavor liking scores.

Net return distributions when metaphylaxis is used to control bovine respiratory disease in high health-risk cattle

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Antimicrobials used to improve the well-being, health, and performance of cattle arriving at feedlots have received considerable public attention. Metaphylaxis, administration of an antimicrobial, generally via injection, is used by 39% of U.S. feedlots with 1000+ head capacity selectively on 17% of cattle to reduce adverse effects of bovine respiratory disease (BRD) in high health-risk cattle (USDA, 2019). Randomized control trials have generally confirmed metaphylaxis can reduce morbidity and mortality in feedlot cattle where health-risk susceptibility is high. Categorization as high health risk generally refers to cattle with one or more risk factors for BRD, which may include unknown health history, recent weaning, and various source and transport stressors.

When cohorts of cattle arrive at feedlots, feedlots assess animal health risks and decide whether to manage cattle with metaphylaxis. Perceived benefits of metaphylaxis for reducing cattle morbidity and mortality are weighed against costs to process, treat, and monitor cattle during their time on feed. If metaphylaxis is elected, feedlots must select the type of antimicrobial to administer. The selection of the specific antimicrobial to use is primarily based on veterinary consultation, past experience, and duration of action (USDA, 2013). While the effectiveness and cost of antimicrobials used for metaphylaxis vary, how these differences translate into expected net return distributions for heterogeneous cattle has not been described.

The objective of this study is to measure net return and return risk between "Upper Tier" and "Lower Tier" antimicrobials used for metaphylaxis and a "no metaphylaxis" option in high health-risk feedlot cattle. In particular, we test whether expected net return distributions vary across cattle placement weight, placement season, and antimicrobial tier administered.

- Net returns and return risk were assessed using a net return simulation model adapted to allow for heterogeneity in high health-risk cattle placement characteristics and antimicrobial choice to control BRD.
  - The net return model incorporated how antimicrobials modify BRD health and performance outcomes. Health and performance outcomes were calibrated from published literature and proprietary feedlot data.
    - Proprietary data came from 10 Midwestern feedlots representing nearly 6 million animals and 50,000 cohorts.
    - Twelve placement-by-metaphylaxis decision combinations were assessed: high health-risk steer placement demographics were 600 or 800 lb steers placed in Winter (Oct–Mar) or Summer (Apr–Sept) managed with one of three different health programs: "no metaphylaxis," "Upper Tier" antimicrobial, or "Lower Tier" antimicrobial.
    - Net return distributions were compared between "no metaphylaxis" and a specific antimicrobial tier within specific cattle populations.
- **Results:** We found the expected incremental net return of administering an "Upper Tier" ("Lower Tier") antimicrobial for metaphylaxis compared to "no metaphylaxis" for high health-risk steers was $122.55 per head ($65.72) for 600 lb and $148.65 per head ($79.65) for 800 lb winter placements.
- **Results:** The incremental expected net return and risk mitigated by metaphylaxis varied by placement weight, season, and antimicrobial choice. The probability net returns would decline by at least $50 per head was significantly reduced (from approximately 4% to 40%) when any antimicrobial was used on high health-risk steers.
- **Implications:** Both antimicrobial tiers were valued more than not administering metaphylaxis, but this expected value varies by cattle placement season and placement weight. Further research is needed to determine how feedlots substitute between these tiers of antimicrobials in an attempt to match animal health risk with antimicrobial tier effectiveness and cost in an effort to maximize profit.

Characterization of water intake and water efficiency in beef cattle

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Freshwater is approximately 2.5% of all water resources, but water has often been viewed as unlimited. More recently, water crises have been viewed as one of the top five likely global risks reported by the World Economic Forum (2017). It is predicted that in 2025, 64% of the world population will live in a water-deprived basin, compared with 38% in 2009. Effects of climate change on water availability could force the livestock sector to establish a new priority in production of animal products that require less water.

Few studies have been conducted in beef cattle to examine how efficient cattle are at utilizing water. Currently, there are no heritability estimates in the scientific literature for water intake (WI) in beef cattle or other livestock animals.

Due to rising concerns about water availability in the future, it is important to understand the relationship between WI and other economically important traits like dry matter intake (DMI) and average daily gain (ADG). Thus, we must collect WI phenotypes, generate measures of water efficiency, and evaluate their relationships to other economically important production traits to determine if genetic antagonisms exist between these traits. The objective of this study was to calculate water efficiency and evaluate the relationships between WI, water efficiency, DMI, feed efficiency, and ADG.

- An Insentec system (Hokofarm Group, The Netherlands) at the Willard Sparks feedlot located at Oklahoma State University was utilized to collect daily WI and FI on 578 crossbreed steers over a 3-year period from May 2014 to March 2017.
    - Steers were fed in five feeding groups that consisted of three summer groups (group 1, n = 117, from May 2014 to August 2014; group 3, n = 118, from May 2015 to July 2015, and group 4, n = 105, from June 2016 to August 2016) and 2 winter groups (group 2, n = 115 from November 2014 to January 2015 and group 5, n = 123, from January 2017 to March 2017).
    - Intakes were collected over a 70-day period following a 21-day acclimation to be in accordance with test length guidelines for DMI and weight gain published by the Beef Improvement Federation. During the testing period, body weights were collected every 14 days. All groups were fed the same growing diet throughout the 70-day test period that consisted of 15% cracked corn, 51.36% wet corn sweet bran, 28.44% prairie hay, and 5.20% supplement.
- **Results:** Animals with low water intake ate less feed, had lower gains, and were more water efficient (as defined by water to gain ratio, W/G, and residual water intake, RWI). However, the amount of water consumed by animals had minimal phenotypic relationship with feed efficiency (residual feed intake [RFI], R2 = 0.1050 and feed to gain ratio (F/G) ratio R2 = 0.0726).
- **Results:** Cattle that had low DMI consumed less water, had lower gains, had lower RFI, and had higher F/G. The level of feed consumed had minimal relationship with water efficiency. WI, W/G, RWI, and ADG had moderate heritability estimates of 0.39, 0.39, 0.37, and 0.37, respectively. High heritability estimates were observed for DMI and RFI (0.67 and 0.65, respectively).
- **Results:** Feed to gain had a low heritability estimate of 0.16. WI had a strong positive genetic correlation with W/G (0.99) and RWI (0.88), thus selecting for decreased WI should also make cattle more water efficient. The genetic correlation between WI and ADG was 0.05; thus, selecting for low WI cattle should have little effect on growth. There is a low to moderate genetic correlation between WI and DMI (0.34).
- **Implications:** Water intake has no genetic correlation with ADG, moderate genetic correlations with DMI and RFI, and strong genetic correlations with RWI, W/G, and F/G. Water efficiency measures are highly genetically correlated and feed efficiency measures are also highly genetically correlated to each other. However, care should be taken to ensure that unintended changes do not occur in DMI or other production traits and incorporation of WI into a selection index would likely prove to be the most effective method for selection.

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