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Entitled Investigating Methods for Using Ractopamine Hydrochloride in Domestic Beef Cattle and Factors Affecting Body Condition of Cattle on Il N'gwesi Ranch in Kenya, Africa

For the degree of Master of Science

Is approved by the final examining committee:

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INVESTIGATING METHODS FOR USING RACTOPAMINE HYDROCHLORIDE IN DOMESTIC BEEF CATTLE AND FACTORS AFFECTING BODY CONDITION OF CATTLE ON IL N'GWESI GROUP RANCH IN KENYA, AFRICA

A Thesis

Submitted to the Faculty

of

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by

Kyle Christian Culp

In Partial Fulfillment of the

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of

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To my mother, Coleen Culp

Your unconditional love and support has impacted my life more than I could ever attempt to explain with words.

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LIST OF ABBREVIATIONS

ß-AA	ß-adrenergic agonist
ß-AR	ß-adrenergic receptor
ß1-AA	ß1-adrenergic agonist
ß2-AA	ß2-adrenergic agonist
ß1-AR	ß1-adrenergic receptor
ß2-AR	ß2-adrenergic receptor
ß3-AR	ß3-adrenergic receptor
ADG	Average daily gain
BCS	Body condition score
BIF	Beef Improvement Federation
BW	Body weight
cAMP	Cyclic adenosine monophosphate
CL	Corpus luteum
CNT	Ractopamine hydrochloride continuous treatment
CON	Control treatment
CREB	Cyclic adenosine monophosphate response element binding protein
CV	Coefficient of variation

DM	Dry matter
DMI	Dry matter intake
DPP	Days postpartum
E_2	Estradiol-17ß
FS	Frame score
FT	Adjusted 12^{th}-rib fat thickness
G:F	Gain-to-feed ratio
GH	Growth hormone
HC	Hide color
HCW	Hot carcass weight
IGF-1	Insulin-like growth factor 1
KPH	Percent kidney, pelvic, and heart fat
LH	Luteinizing hormone
LM	Longissimus muscle
mRNA	Messenger ribonucleic acid
OPT	Ractopamine hydrochloride cow treatment
P4	Progesterone
$PGF_{2\alpha}$	Prostaglandin $F_{2\alpha}$
pH	Measure of acidity or alkalinity of a solution
PPI	Postpartum interval
RH	Ractopamine hydrochloride

SAS	Statistical Analysis System
SSF	Slice shear force
STEP	Ractopamine hydrochloride step-up treatment
SX	Sex class
TAI	Timed artificial insemination
TBA	Trenbolone acetate
$TBA+E_2$	Trenbolone acetate and estradiol-17ß
WBSF	Warner-Bratzler shear force
YG	Yield grade
ZH	Zilpaterol hydrochloride

ABSTRACT

Culp, Kyle C. M.S., Purdue University, May 2010. Investigating Methods for Using Ractopamine Hydrochloride in Domestic Beef Cattle and Factors Affecting Body Condition of Cattle on Il N'gwesi Group Ranch in Kenya, Africa. Major Professors: Clinton P. Rusk and Roger L. Tormoehlen.

Two experiments were conducted to evaluate the effects of ractopamine hydrochloride (RH) supplementation on 1) feeding performance and carcass characteristics of finishing steers, and 2) reproductive efficiency and maintenance of body condition of lactating primiparous cows. An additional experiment was conducted to determine physical factors of Kenyan cattle that contribute to differences in body condition. To determine the impact of RH on feedlot performance in cattle, 36 steers were blocked by initial body weight (BW), and randomly assigned to one of three treatments 1) control (0 mg RH fed: CON), 2) daily supplementation of 200 mg RH from d 0 to d 42 (CNT) and 3), daily supplementation of 100 mg RH from d 0 to d 21, no RH from d 21 to 28, and daily supplementation of 300 mg RH from d 28 to d 42 (STEP), all cattle were harvested prior to feeding on d 43. Steers in the CON treatment had greater marbling scores (P = 0.04) than CNT, with STEP being intermediate to both treatments. Quality grade tended to differ (P = 0.08) between treatments. The CON treatment of steers had greater quality grade scores compared to the CNT treatment with STEP being intermediate to both. Feeding performance was not altered due to RH supplementation

when fed continuously or in a step-up design over a period of 42 days. Carcass quality was not improved, and continuous RH administration may have a negative effect on marbling, and final quality grades of beef steers. To determine the impact of RH on reproductive function and weight changes in cows, 64 primiparous cows were stratified and blocked by days postpartum (DPP), resumption of estrus, BW, and body condition score (BCS), to receive either a control diet (CON) or a control diet including 300 mg/hd/d RH (OPT) fed 35 d prior to breeding. Cows in the CON treatment had greater ($P < 0.01$) daily losses in BW than the OPT treatment group (-1.08 ± 0.09 and -0.71 ± 0.09 kg/d, respectively). At the conclusion of the feeding period BCS of the CON treatment (5.55 ± 0.11) were decreased ($P < 0.01$) compared to the OPT treatment (6.02 ± 0.11). Timed AI (68.75%, 53.13%) and breeding season pregnancy rates 84.38% and 71.88%, CON and OPT, respectively) did not differ between treatments. Inclusion of RH in cow diets increased nutritional status, however, dietary RH failed to improve reproductive performance. The objective of the final study presented was to evaluate the factors affecting the body condition of cattle on Il N'gwesi group ranch in central Kenya, Africa. Weanling and yearling aged cattle had greater BCS ($P < 0.001$) than mature cattle (3.52, 3.66, and 3.08, respectively). Steers, bulls and heifers had greater BCS (P < 0.001) than cows (3.73, 3.60, 3.59, and 2.88, respectively). Additionally, there was a hide color × frame score (FS) interaction ($P < 0.01$), indicating the greatest BCS of light colored cattle is at FS-3, and the greatest BCS of dark colored cattle is at FS-4. Therefore, heifers, steers, and bulls, may be more apt to survive than mature cows, and hide color in relation to FS should be used as selection criteria.

CHAPTER 1

LITERATURE REVIEW

Domestic Beef Production

Production efficiency is a primary concern among animal science researchers as the constant need to improve the efficiency of animal protein production has a direct reflection on each sector of the food animal industry. The need for technological advances to improve agricultural efficiency must be balanced by legislative mandates regarding animal welfare practices, consumer demands, and the expectation that the global population will double in the next 30-40 years (NRC, 1994). The amount of food necessary to accommodate these changes within the beef cattle industry, specifically, is reflected by the status of our national cow herd and global market share.

United States beef production in 2008 totaled just over 26.5 billion pounds and is predicted to have a slight decline in 2009. In the first quarter of 2009, beef exportation rose 7% compared to the first quarter of 2008 to 384 million pounds mainly due to the increase in Japanese trade and re-opening of the Korean market. A simultaneous increase of 10% in the importation of beef during the first quarter of 2009 was noted, as well. However, with the poor global economy and an increasingly strong U.S. dollar, total exports throughout 2009 are expected to decline, though an increase of 10% in exportation in 2010 is on the horizon (Livestock, Dairy, and Poultry Outlook, 2009). The number of beef cows in the U.S. has decreased 2% in 2009. In Indiana, the cattle inventory has dropped 3% from 2008 to 860,000 head, while the number of beef cows has decreased 9% to around 213,000 head. Fewer beef cows nationally equates to an eventual reduction in slaughter cattle availability which may compromise total beef produced.

Variability in the United States' participation in world trade and the global economic crisis has undoubtedly impacted domestic agricultural production practices. Yet, the erratic behavior of commodity markets in recent years, such as corn and soybean prices plummeting to $2.60 per bushel and below $6.50 per bushel respectively, in January 2006, and then reaching never before seen highs of $7.75 per bushel and almost $16.00 per bushel, respectively, in June 2008 (Chicago Board of Trade, 2008), illustrates the difficulty producers face when calculating input costs. With the primary expense of beef production being feed costs (Ward, 1980), determining the most efficient feeding protocols to reduce the dependence on volatile commodities would benefit all phases of the beef industry.

Accordingly, compounds to enhance beef production such as anabolic steroid implants and β-adrenergic agonists (ß-AA) as feed ingredients have been developed and are commonly used by U.S. beef producers in an effort to increase the domestic beef supply with fewer land resources and tightened production restrictions. With the current challenges facing domestic beef production, the shrinking national cow herd and unpredictable commodity costs in particular, investigating supplementation strategies of existing feed ingredients that can be practically applied during the entire life cycle of cattle could result in reduced costs and improved production methods for U.S. beef producers.

Growth Enhancers

Anabolic Steroid Implants

Multiple studies of implant treatments containing trenbolone acetate and estradiol-17β (TBA+E_2) have demonstrated anabolic responses on skeletal muscle, adipose, and bone tissue resulting in increased feedlot performance. Johnson et al., (1996) reported a 13% increase in feed efficiency of steers implanted with TBA+E_2 during the first 40 d as well as an increase in average daily gain (ADG) and longissimus muscle area (LM) at 115 d and a decrease in percent kidney, pelvic, and heart fat (KPH) at 143 d versus non-implanted steers. Final slaughter weights and ADG across the entire feeding period of both steers and heifers have been shown to increase due to TBA+E_2 treatment (Smith et al., 2007). The effects of various dosage concentrations of trenbolone acetate (TBA), estradiol-17β **(**E_2), and TBA+E_2 on carcass characteristics in heifers were illustrated by Schneider, et al., (2007). Across multiple dosages HCW and LM area were generally increased while KPH was decreased. In this same study, beef quality grades and LM tenderness was not negatively impacted by relatively low doses of anabolic steroids. Increased LM area in response to TBA+E_2 is attributed to the steroid induced release of IGF-1 from the liver resulting in the up-regulation of steady-state IGF-I mRNA concentrations in LM cells (Pampusch, et al., 2008). In general, most reports indicate there is little or no effect on fat thickness due to TBA+E_2 implants (Eversole et al., 1989;

Perry et al., 1991; Bartle et al., 1992), however, there are mixed reports on the effect implants may have on intramuscular fat. Roeber et al. (2000), Platter et al. (2003), Duckett et al. (1999), and Boles et al (2008), all reported decreases in marbling scores attributed to implantation of anabolic steroids, Bruns et al. (2005) determined the physiological time period at which implants are most effective. They reported that a reduction in marbling due to steroidal implantation may be attributed to anabolic activity during early periods of growth. However, Smith et al. (2007), refuted these claims by reporting no differences in intramuscular fat of implanted cattle, and only slight alterations in fatty acid profiles, suggesting there is no linkage between anabolic steroid implants and adipocyte development, but rather an apparent decrease due to enlarged LM areas.

β-Adrenergic Agonists

β-adrenergic agonists bind to ß-adrenergic receptors (ß-AR) and are structural anolgues to naturally occurring hormones known as catecholamines (Strydom et al., 1998). Accordingly, when fed orally, ß-AA have similar actions as epinephrine and norephinephrine and stimulate ß-AR (Mersmann, 1998). A study by Moloney et al. (1991) indicated that ß-AA supplementation would have a positive impact on the feedlot industry by increasing growth rates and skeletal muscle development of most livestock species. The incorporation of ß-AA into the beef feedlot industry, however, has been much slower than implants as they have only recently been approved for use in the United States by the Food and Drug Administration. The first approved ß-AA was Optaflexx™ (β1-AA, ractopamine hydrochloride; RH) in March 2004, followed more recently by Zilmax™ (β2-AA, zilpaterol hydrochloride; ZH) in August 2006. Unlike anabolic steroid implants, RH a synthetic β1-AA, has been shown to not effect circulating IGF-1 or steady-state IGF-I mRNA concentrations in LM cells (Winterholler et al., 2008). Accordingly, the cellular response to RH must be primarily attributed to direct binding with ß-AR.

ß-Adrenergic Agonist Biomechanics

β-Adrenergic Receptors

Three known ß-AR subtypes exist; β1-AR, β2-AR, and β3-AR, which are present across almost all cell types of mammals. The varying quantity across species, across tissues, and even within tissues of subtypes of ß-AR causes the response elicited from exogenous administration of ß-AA to differ widely. Clinical trials with rats and guinea pigs have established that the β1- and β2-AR are most receptive to RH (Colbert et al., 1991). In cattle, however, Sillence and Matthews (1994) concluded that the β2-AR is the most abundant ß-AR in skeletal muscle and adipose tissue membranes.

The ß-AR is comprised of more than 400 amino acids forming a continuous polypeptide chain (Mersmann, 1998). Each polypeptide chain is structured by 7 transmembrane-spanning domains, an amino terminus that is extracellular, a carboxyl terminus that is intracellular, 3 interconnecting extracellular loops, and 3 intracellular loops which are embedded in the plasma membrane of the cell (Liggett, 2002). Mersmann (1998) indicated the ligand binding site is located in the center of the seven transmembrane domains, and amino acids from several of the domains are involved in binding. Once binding with a ß-AA has occurred, the ß-AR may be phosphorylated by a specific kinase located in intracellular loop 4, or by protein kinase A which can inactivate the receptor (Mersmann, 1998). Chronic stimulation of the ß-AR leads to removal from the plasma membrane, thereby reducing the response to ß-AA (Ostrowski et al., 1992; Schwinn et al., 1992; Strosberg, 1992; Kobilka and Hoffman, 1995).

Recently, chronic stimulation studies have been conducted to determine the effects of RH on ß-AR mRNA abundance and mixed results have been reported. In 2007, trials by Sissom et al. and Winterholler et al., on heifers and steers, respectively, demonstrated that feeding RH for 28 d had no effect on β1- and β3-AR mRNA, but tended to increase the presence of β2-AR mRNA ($P = 0.09$) in the semimebranosus muscle. Contrastingly, Winterholler et al. (2008), reported β1-AR mRNA was increased in the LM of beef steers, while there was no effect on β2- and β3-AR mRNA. In dairy steers, a decrease in β1- and β2-AR mRNA in LM tissue following RH administration was reported (Walker et al., 2007).

Signal Transduction Pathway

After the ß-AA attaches to the ligand binding site of the ß-AR it is then coupled with the G_s protein in portions of the intracellular loops 2, 3, and 4 (Mersmann, 1998). Coupling with the G_s protein indirectly initiates the production of one of the major intracellular signaling molecules, cyclic adenosine monophosphate (cAMP) by activating the enzyme responsible for cAMP production, adenylyl cyclase (Sillence and Matthews, 1994). Binding of cAMP to the protein kinase A results in enzymes being released that phosphorolate intracellular proteins such as hormone sensitive lipase, the rate-limiting enzyme for adipocyte triacylglycerol degradation. While phosphorylation is responsible for inhibiting other enzymes such as acetal-COA, effectively inactivating its ability to catalyze the biosynthesis of long-chain fatty acids, this action increases the transcriptional activity of the cAMP response element binding protein (CREB) (Mersmann, 1998). Protein kinase A phosporylates the CREB that binds to a cAMP response element stimulating transcription of that gene (Mersmann, 1998).

Effects of Ractopamine Hydrochloride on Finishing Cattle

Feedlot Performance

Marketed for beef cattle by Elanco Animal Health as Optaflexx™, RH is approved for feeding during the last 28 to 42 d prior to harvest at concentrations ranging from 70 to 430 mg/hd/d to increase ADG, and improve feed efficiency (G:F). Increasing ADG and G:F results in a direct increase in the profitability of the feedlot sector of the beef industry, particularly operations marketing on a live weight or carcass weight basis. The mixed efficacy reports in the literature are most likely a result of the broad feeding duration and dosage approval of Optaflexx™.

Numerous studies of varying feeding durations have reported increases in ADG and G:F (Anderson et al., 1989; Carroll et al., 1990; and Preston et al., 1990), however, few experiments have been conducted to define the optimal concentration level and feeding duration of RH to beef cattle to maximize production efficiency. Steers fed RH at a concentration of 300 mg/hd/d for 33 d reported a decrease in dry matter intake (DMI) per day, yet improvements in ADG(2%) and G:F (.063) were still noted (Avendaño-

Reyes, et al., 2006). An experiment conducted by Abney et al., (2007) focused more closely on rate and duration of administration than previous reports. Steers were fed RH for 28, 35, and 42 d at concentrations of 0, 100, and 200 mg/hd/d in a 3 x 3 factorial design. Maximal ADG occurred when RH was fed at 200 mg/h/d 35 d prior to slaughter. Data in swine by Williams et al. (2004) reported that the growth response to RH was greatest from d 6 to 22 and subsequently declined linearly.

Contrasting the DMI data reported by Avendaño-Reyes et al. (2006), Abney et al. (2007) reported a linear increase in DMI as the feeding period increased. However, the G:F increase may counteract the rise in cost associated with increased consumption. Similar to the ADG data reported by Abney et al. (2007) G:F was observed by the same scientists to be maximized at 35 d for steers fed 200 mg/hd/d, yet this maximal benefit was not realized until d 42 in steers fed 100 mg/hd/d. The theory of desensitization of ß-AR due to chronic stimulation described in the *β-Adrenergic Receptors* section of the present document appears to have contributed to the results found by Abney et al. (2007) with 35 d being the rate limiting feeding duration of RH at 200 mg/hd/d, and 42 d for steers fed 100 mg/hd/d for optimal ADG and G:F.

Some recent publications suggest feeding RH for a period of 28 d prior to harvest at a concentration of 200 mg/hd/d is sufficient to improve ADG and G:F without effecting dry matter intake (DMI). Winterholler et al. (2007) reported an increase in ADG of 4.6%, an improvement in G:F of 3.8%, and an 8 kg increase in hot carcass weight (HCW) of steers treated with RH versus untreated steers. Likewise, increases in ADG, G:F, of .23 and .25, respectively, were reported by Gruber et al. (2007). Though a decrease in DMI is preferred from an economic standpoint, feeding RH for 28 d at the

200/mg/hd/d concentration may reduce the volatility in DMI illustrated by other RH feeding approaches.

There is little data published on the performance effects of RH supplementation in feedlot heifers. Walker et al. (2006) documented that ADG and G:F is increased by 18% and 17 %, respectively, in heifers fed RH versus control heifers. Quinn et al. (2008), however, tested the effects of chronic stimulation in heifers with a study designed to determine the effects of RH administration based on duration and dosage concentration which included a step-up protocol where the concentration of RH was increased from 100 mg/hd/d to 300 mg/hd/d each 14 d over a period of 42 d. There were no differences in ADG; however, the RH fed cattle had an increase in carcass gain, which can be attributed to live performance. When compared to control heifers, there was a trend to improve G:F in RH supplemented heifers ($P \leq 0.10$). Dry matter intake was decreased in heifers fed 300 mg/hd/d compared to 200 mg/hd/d and heifers not fed RH. The step-up group was intermediate in all observed performance areas. Thus, in feedlot heifers, the theory of desensitization due to chronic stimulation is inconclusive and more research should be conducted to elucidate the phenomenon.

Carcass Characteristics

In addition to increasing ADG and improving G:F , the Optaflexx™ label claims to increase carcass leanness. Aside from this claim, research has indicated improvements in hot carcass weight (HCW), longissimus muscle area (LM), adjusted fat thickness (FT), and yield grade (YG), without detrimental effects on marbling and quality grade. Tenderness, however, is impacted as increases in Warner-Bratzler shear force (WBSF) and slice shear force (SSF; Schroeder, 2004) values in cattle fed RH have been documented (Avendaño-Reyes et al., 2006). For beef producers marketing on a carcass basis, the implications associated with the increased positive effects on carcass characteristics prevail over the detrimental effects of tenderness as the lone published sensory panel report concluded no changes in juiciness or flavor from RH treated meat compared to untreated meat (Schroeder, 2004).

Hot carcass weight has been repeatedly increased due to RH supplementation. Observations from Carroll et al. (1990), Schroeder et al., (2003a) Laudert et al. (2004), Avendaño-Reyes et al. (2006), Gruber et al. (2007), and Winterholler et al. (2007) all reported increased HCW in steers fed RH compared to control steers regardless of dosage concentration or duration of administration (6.4, 5.6, 4.9, 8.3, 4.9, and 8 kg, respectively). Though gains in HCW from feedlot heifers have not been reported as often as gains in their steer counterpart's, sufficient data exist to support this claim as well. Walker et al. (2006), reported gains of 6.9 kg from RH fed heifers. Quinn et al. (2008) documented a trend ($P \leq 0.10$) of HCW gains from pens of RH supplemented heifers compared to control heifers. When feeding RH, an increase in lean muscle deposition occurs (Mersmann, 1998) which is presumably the main contributing factor to the gains noted in HCW. Thus, increases in LM associated with feeding RH could be expected, as well.

Multiple factors impact yield grades of beef carcasses, however, the two most notable factors are LM and fat thickness (FT). Increases in LM following RH feeding have been documented by Carroll et al. (1990), Schroeder et al. (2003b), Gruber et al. (2007), and Abney (2007) in steers, while Laudert et al. (2004) corroborated this effect in beef heifers. Only one documented steer study has reported a decrease in FT. Holstein steers fed 300 mg/hd/d of RH had decreased FT of 0.08 cm (Vogel et al., 2005). However, 10th rib-fat depth has consistently decreased in swine administered RH (Uttaro et al., 1993; Williams et al., 1994; Crome et al., 1996; See et al., 2004). Not surprisingly, the lack of repeatability in RH effects on LM and FT has limited decreases in YG to two trials (Anderson et al., 1989; Abney et al., 2007). However, Avendaño-Reyes (2006) reported an increase in overall carcass yield (*P* = 0.018) of RH fed steers compared to non-supplemented steers. One of the major advantages of RH supplementation compared to other ß-AA is that no decreases in marbling scores have been reported in beef breeds of cattle, although calf-fed Holstein steers fed 200 mg/hd/d of RH reported average marbling score decreases of 17 points (Slight = 400, Small = 500, etc.; Vogel et al., 2005).

Another aspect of carcass quality is palatability of meat products. A toughening effect upon the LM area was reported by Avendaño-Reyes et al. (2006) for cattle supplemented with RH and ZH. The ß-AA meat compared to controls had increased WBSF and SSF values. However, according to tenderness classifications dictated by Miller et al. (2001) both of the ß-AA supplemented meat samples would have been classified as intermediate or acceptable in its shear force values. In this same study, reddening of the meat was increased by the ß-AA 5 days following display, but by d 14 the lean color was similar meat from the control group. Meat pH values for both ß-AA were unchanged relative to the control group. The reduction in meat tenderness associated with ß-AA supplementation has been attributed to two reasons. First, postmortem calpastatin activity which increases WBSF values are increased (Koomaraie et al., 1991; Wheeler and Koohmaraie, 1992; Geesink et al., 1993), and secondly, the increase in hypertrophy has been linked to increased muscle fiber diameters which causes a toughening effect on meat (Aalhus et al., 1992; Vestergaard et al., 1993). Both of these factors were noted in meat samples from cattle fed β2-AA, not β1-AA, of which RH is categorized. As a β1-AA, the increase in muscle mass attributed to RH feeding is primarily through an increase in protein synthesis with limited effects on protein degradation, unlike β2-AA which decrease protein degradation (Moloney et al., 1991; Moody et al., 2000).

Effects on Cull Cows

The economic impact of selling cull cows in a cow/calf operation has been estimated at 10-20% of annual revenue (Harboth, 2006). Therefore, the impact RH supplementation has on cow performance and carcass characteristics potentially has significant impacts on beef production. Unfortunately, minimal data has been published regarding this topic.

Dijkhuis and collaborators (2008) evaluated culled beef cows fed RH at concentrations of 0, 100, 200, and 300 mg/hd/d. No differences in feeding performance were reported, and only one carcass characteristic was altered due to RH feeding. There was an increase in percentage of fat free lean from cows supplemented with 300 mg/hd/d of RH versus control cows ($P < 0.05$). This report indicates that the slight benefit in carcass yield of feeding RH to cull cows would not counteract the cost of supplementation; however, packers may receive an indirect benefit in pounds of lean beef produced.

A study of culled Holstein cows was also conducted to determine potential advantages of feeding RH. Allen et al. (2009) assigned the cows to 3 treatments: 1) immediate slaughter, 2) feed for 90 d without RH supplementation, and 3) feed for 90 d with RH supplementation at 312 mg/hd/d for the final 32 d prior to harvest. The results of the study concluded that final body condition score (BCS) , BW, HCW, dressing percentage, external fat thickness and marbling score were all increased in treatments fed for 90 d ($P < 0.03$). Additionally, a sensory panel preferred beef from cows fed 90 d more than the product from immediately slaughtered ($P < 0.04$). No differences were attributed to feeding RH. In agreement with Dijkhuis et al. (2008), the producer's input cost for feeding RH was greater than no supplementation.

In a more in-depth examination, Harboth (2006), studied the effects of RH supplementation on cull cows with or without a steroid implant of TBA+E_2 and non-treated cows. Similar to the previous studies described in this section, there were few differences attributed to RH. Cows fed RH had greater kidney, pelvic, and heart fat (KPH) than non-RH-supplemented cows ($P = 0.05$). Fat thickness was less in cows treated with both RH and TBA+E_2 than cows treated with only one growth enhancer ($P = 0.02$). Expectedly, this same treatment group also had lower numerical YG than all other treatments ($P = 0.05$). Additionally, cows fed only RH had greater marbling scores than cows who only received an implant and control cows ($P = 0.04$). Again, slight carcass advantages were documented that would have a positive outcome for the packer, but did not justify the added cost of feeding RH. However, this study reveals implications that may have a greater impact for the cow/calf operation.

Supplementation of RH did not increase FT, however the increase in KPH suggests that BCS may have been improved. Since BCS at parturition is a primary determinant in the length of the postpartum interval (Short et al., 1990) in that cows at or approaching optimal BCS (5; Wagner et al., 1988) have shorter postpartum anestrous. Feeding RH may result in cows reaching an appropriate BCS for breeding, and thereby resuming cyclicity quicker following parturition. Shorter anestrous periods result in increased beef production throughout a cow's life cycle.

Potential Nutritional Effects of Ractopamine Hydrochloride on Reproduction

Reproductive Efficiency

The ability to maintain pregnancy also contributes greatly to reproductive success. Embryonic and early fetal losses decrease first service conception rates as indicated by Henricks et al. (1971), in which 89% fertilization was reported, however, only 60% of the embryos survived to d 42 post-insemination. In dairy cattle, Santos et al. (2004) reported a fertilization rate of 78%, with only 65% of fertilized eggs still being viable 5-6 d post-insemination, resulting in a 50% conception rate prior to maternal recognition of pregnancy and the production of interferon tau which is indirectly dependent on progesterone (P4). When a delay in P4 production post-ovulation occurs, blockage of luteolysis is reduced as conceptus development becomes limited and compromises its ability to produce the hormone responsible for maternal recognition of pregnancy, interferon tau (Darwash and Lamming, 1998; Mann and Lamming, 2001).

Role of Progesterone in Pregnancy

In addition to maintaining pregnancy, adequate P4 secretion by the CL is necessary for: healthy oocyte ovulation; uterine quiescence, which is critical in directing uterine secretions that allow for pregnancy to be maintained; and normal parturition. Progesterone plays a vital role in maintaining proper estrous cycles by regulating the establishment and timing of mechanisms for luteal regression (Garrett et al., 1988), and prepares the uterus for maternal recognition of pregnancy (Vincent and Inskeep, 1986). A corroborating report by Shaham-Albalancy et al. (2001) showed that lower concentrations of P4 prior to estrus may lead to decreased fertility due to altered endometrial morphology during the subsequent estrous cycle, as an increase in $PFG_{2\alpha}$ is elicited in response to oxytocin. A healthy oocyte may still be present; however, these effects may cause fertility to decrease. Furthermore, the pulse frequency of LH secretion stimulating follicular development is regulated via negative-feedback of P4 (Kinder et al., 1996). In support of this claim, a review of literature by Inskeep (2002) concluded that concentrations of P4 in peripheral circulation accounted for 37% of the frequency variation of LH pulses, and 38% of estradiol concentrations. The negative feedback action estradiol has on LH secretion directly effects the LH surge that induces ovulation (Legan et al., 1977), and initiates estrus expression.

Role of ß-adrenergic agonists on Progesterone Production

Like most mammalian tissues, beef cow ovaries are abundantly populated with ß-AR (Burden, 1978), and the stimulation of the receptors on the CL affects specific steroidal secretion, including P4 (Condon and Black, 1976). These scientists further examined the mechanisms associated with eliciting P4 production from the CL. Initially, the luteal tissue was treated with LH to determine the degree of responsiveness, and then the effect the catecholamines: epinephrine, norepinephrine, and isoproterenol, had on P4 were tested. Isoproterenol had the greatest effect (200% above controls) on eliciting P4; however, each agonist extracted a greater concentration of P4 than controls ($P < 0.025$). Each of the catecholamines used is not specific to either the α- or ß- adrenergic receptor. To determine which receptor type was responsible for promoting P4 production, the ß-AR block, propranolol was exposed to the luteal tissue prior to the adrenergic agonists. The reports of this portion of the experiment indicated that prior blockage of the ß-AR inhibited P4 production. To validate these results, a subsequent incubation period was performed using the α-adrenergic receptor block, phenoxybenzamine, prior to catecholamine exposure. The α-adrenergic receptor failed to prevent P4 production, and consequently, it was determined that ß-AR are abundant on the CL, and when stimulated increase P4 production. Additional studies in the bovine, in vitro and in vivo models (Godkins et al., 1977, and Skarynski et al., 1993; respectively) have corroborated the conclusion that ß-AR regulate the release of P4 from the CL.

Role of Nutritional Status on Pregnancy

Nutrient requirements of beef cattle differ between the various stages of production. These requirements are prioritized for body maintenance, fetal development, lactation, growth, and breeding (Rossi and Wilson, 2006). Therefore, poor or limited nutrients can negatively impact the production cycle. One of the most cost effective and easiest ways to determine if nutrient requirements are being met is by determining a numerical body condition score (BCS: 1-9 scale; 1 = emaciated, 9 = obese; Wagner et al., 1988) representing energy reserves in the form of lean muscle, adipose tissue or both that may be used to support physiological functions during times of increased nutrient demands. The outcomes of maintaining proper cow BCS impact cow-calf producers in various ways; not only do producers benefit from greater reproductive rates and shorter rebreeding intervals, but ultimately proper BCS can result in heavier calf weight at weaning. Lake et al., (2005) reported that pregnancy rates were increased in cows having a greater BCS at the initiation of the breeding season compared to cows having a lower BCS. Cow BCS of 5 to 6 at calving have been suggested to ensure adequate postpartum performance (Lamond, 1970; Dziuk and Bellows, 1983; Morrison et al., 1999). This can be attributed to the effect BCS has on the length of anestrous following parturition known as the postpartum interval. As BCS at parturition increases, the postpartum anestrous interval decreases (Houghton et al., 1990) allowing cows to be rebred sooner.

A more reliable method of determining nutritional status, often used by scientists, is to measure circulating IGF-1 concentrations in serum (Lalman et al., 2000; Zulu et al., 2002). During time periods when nutrient intake is adequate, GH regulates hepatic secretion of IGF-1 (Thissen et al., 1994; Roberts et al., 1997). When a negative energy balance is incurred, during the PPI for example, GH secretion is increased (Breier et al., 1988; Zulu et al., 2002) and a corresponding decrease in circulating IGF-1 is experienced (Thissen et al., 1994; Busato et al., 2002; Meikle et al., 2004). Although the mechanism for uncoupling GH-controlled regulation of IGF-1 has not been defined, Breier et al. (1988) suggests a reduction in hepatic binding of GH may explain the reduced secretion of IGF-1. Furthermore, decreased serum concentrations of IGF-1 may reduce negative feedback on the hypothalamus, compromising GH synthesis regulation, and upregulating secretion of GH (McGuire et al., 1992).

Animals under superior nutritional status have increased IGF-1 concentrations and decreased GH concentrations when compared to animals with a subpar nutritional status (Lalman et al., 2000). In dairy cows, improved reproductive performance has been documented due to increased IGF-1 concentrations (Meikle et al., 2004). Similarly, the resumption of estrus following parturition in beef cows has been linked to circulating concentrations of IGF-1 (Roberts et al., 1997).

Role of ß-adrenergic agonists on Nutritional Status

Multiple stimulatory and inhibitory effects on growth regulating hormones can be attributed to ß-adrenergic agonist (ß-AA) supplementation. Insulin secretion is stimulated by the binding of ß-AA to islet cells of the pancreas (Moloney, 1991) and increased glucose uptake (Byrem et al., 1998). An additional indirect affect likely caused by administration of ß-AAs is mediated through control of GH and IGF-1 via the somatropic axis. Feeding efficiency, in most studies using β-agonists, is often improved as DMI remains unaltered, yet an increase in performance is documented (NRC, 1994. Theoretically, the following responses elicited in cattle fed ß-AA: increased protein synthesis, a decrease in circulating GH concentrations, increased circulating glucose concentrations and an enhanced LH response to GnRH challenge would benefit reproductive performance. The metabolic substrate, glucose, plays a vital role in beef cow reproductive performance by influencing the release of GnRH (Short and Adams, 1988; Keisler and Lucy, 1996; Wettemann et al., 2003). Elevating glucose concentrations promotes enhanced GnRH secretion and subsequent LH release, which is imperative for stimulating follicular growth and estradiol secretion. Together, these functions initiate ovulation during the postpartum anestrous period (Day, 2004) resulting in the resumption of normal estrous cycles. Very few studies have been conducted to determine the effects of feeding β-AA to cows. Early work by Hu et al. (1990) and Earnest et al. (1988), focused on the β2-agonist, clenbuterol, in which supplementation was initiated at 20 or 30 d postpartum for either a single day or for 21 d. Neither approach shortened the postpartum interval, most likely due to the timing of ß-AA administration. While increased protein synthesis associated with ß-AA supplementation would likely stimulate and hasten uterine involution, this process has almost certainly already occurred by 20-30 DPP. Recently, however, Allen et al. (2009) reported increases in BCS of Holstein cull cows fed RH for 90 d, and Harboth (2006), illustrated an increase in kidney, pelvic, and heart fat, which could have an effect on overall BCS, in beef cows supplemented with RH for 60 d.

Livestock Production on Il N'Gwesi Group Ranch, Kenya, Africa

Pastoralist Livestock Production

The traditional pastoralist herding system includes the gamut of beef cattle production from the cow-calf enterprise through the finishing phase, and from breeding stock development to culling or fatality. The pastoralist approach to raising livestock has a large impact on the ability to properly manage rangeland used for grazing cattle. Some, pastoralists settle into an area that allows their community to quickly realize the short-term benefits of over-grazing rangelands, which in turn, can cause severe long-term difficulties, such as erosion, due to lack of vegetation (Prior, 1994). This inability of the environment to sustain itself may lead to desertification which is generally an irreversible effect. On the other hand, few commercial ranches would be able to operate with financial success by limiting their herds to a stocking rate that maximizes individual animal performance because intensifying their land with a greater number of livestock would result in a greater total mass of livestock produced (Behnke and Abel, 1996). This is not only essential for financial success, but also to support the constant increase in human population, as well. While some reconnaissance efforts of the Maasai by De Leeuw et al. (1984) and Bell (1982), indicated, that their group ranches have numbers that are close to the recommended stocking rates during times of low rainfall. Pastoralist communities, however, tend to grow their herds as large as possible during positive growing seasons as a form of saving since cattle can typically be sold easily and at a profit when cash is needed (Siegmund-Schultze, et al., 2007). Introducing the concept of carrying capacity is one of the most popular methods to manage over-grazing. There are however, some obstacles that make this concept extremely difficult due to the fact that there are at least six stocking densities that may be viewed as overgrazing which could be defined as appropriate for their individual production criteria (Behnke and Abel, 1996). For instance, when the feed supply is overabundant in any production setting animal populations are typically increased. As the resources begin to decline and animals are not removed, they tend to not only utilize the forage outputs, but may indeed consume the entire plant, crippling future growth (Behnke and Abel, 1996). Without proper culling management, this investment strategy can leave long lasting negative effects on the rangeland.

Il N'gwesi Group Ranch Background

The Maasai owned community group ranch Il N'gwesi, is located in central Kenya, northwest of Mt. Kenya in the Kenyan Highlands. According to the BBC Weather Centre, the intertropical belt of cloud and rain travels quickly across Kenya during April and October. Due to the predominant seasonal winds, annual rainfall throughout the country varies considerably. This results in a double rainy season between March and May, and again between November and December with dry seasons during the interim periods. The Maasai of Il N'gwesi must rely upon these two annual rainy seasons, which only exceeds 1,250 mm per year in the highest parts, to replenish water sources and increase forage growth to supply the nutritional needs of their livestock. Although metabolic rates of indigenous cattle during periods of extreme drought are lowered (Western and Finch, 1986) to combat the lack of available forage and water, these unforeseen weather patterns always challenge livestock survivability.

Maasai Cattle Production and Impact of Body Condition

The Maasai living on Il N'gwesi raise their cattle according to the typical pastoralist model. This means the cattle are massed in large groups consisting of various ages and sexes, as opposed to small well defined herds, and the herds are grown as large as possible when resources are abundant. Understanding the herding structure of the Maasai may be difficult, as in many cases it is not the most productively efficient compared to western production practices. However, comparisons of Maasai beef production practices to western production practices are not only difficult, but are not relevant due to such dramatic differences in resources, climate, cattle type, and the socio-economic importance of cattle to the Maasai. Talbot (1986) concluded that within Maasai tribes, an individual's wealth and respect are greatly defined by the number of livestock they own. Recent research conducted on Il N'gwesi reinforces this conclusion, as household income increases there is also an increased priority to purchase additional livestock (DeVeau, 2008). Not surprisingly, added community prestige dictates increasing herd size rather than productive efficiency when purchasing livestock (Brown, 1971; Ruthenberg, 1971). During years consisting of typical weather patterns, this lack of selection pressure has little effect on cattle survivability, however, alternative production practices and a greater awareness of the factors that affect cattle survivability could dramatically reduce mortality rates during years of extreme drought.

Nutrient requirements of beef cattle differ between the various stages of production. These requirements are prioritized for body maintenance, fetal development, lactation, growth, and breeding (Rossi and Wilson, 2006). Therefore poor or limited nutrients can negatively impact the production cycle. One of the most cost effective and easiest ways to determine if nutrient requirements are being met is by evaluating BCS. The benefits of maintaining proper BCS are numerous and range from greater reproductive rates and increased market value to increased survivability. Lake et al., (2005) reported that pregnancy rates were increased in cows having a greater BCS at the initiation of the breeding season compared to cows having a lower BCS. This difference can be attributed to the effect BCS has on the length of anestrous following parturition, known as the postpartum interval. As BCS at parturition increases, the postpartum interval decreases (Houghton et al., 1990) allowing cows to rebreed sooner. Over the entire lifecycle of a cow, shortening the PPI results in more efficient beef production as more calves can be born in a shorter period of time. Economically, cattle marketed at a proper BCS generally receive higher premiums, and this trend has been confirmed in West Africa (Okike et al., 2004). Obviously, cattle being maintained at an appropriate BCS outperform their contemporaries and their ability to survive extended droughts is thought to be increased as adipose tissue reserves can be used for energy.

Conclusions

With increasing demands for U.S. beef production and a simultaneous drop in our national cow herd, the need to increase production efficiency is growing exponentially. The most efficient use of a growth stimulant that can increase performance characteristics without diminishing carcass quality and meat palatability is essential. Duration and level of feeding of RH is an issue that needs to be further researched to maximize its value. Most data indicates feeding RH has a positive impact on ADG, G:F, and HCW. However, chronic stimulation of the ß-AR has been noted in a few studies which have led to compromises in its efficacy of its use to improve feedlot performance. Additionally, some studies have indicated that meat quality could be negatively affected by excessive feeding of the synthetic compound. Recent research suggests that cow BCS could be improved via RH supplementation. The implications of increased cow BCS could result in shorter postpartum anestrous and ultimately, increased production efficiency for the cow/calf producer. With an understanding of the Maasai herding structure, and the socio-economic value associated with their cattle, it is clear that implementation of a culling strategy requires significant investigation. A system of culling cattle based on their ability to survive unpredicted drought periods would prove beneficial to Il N'gwesi residents to maximize the value of their assets, as well as the preservation of valuable land resources to help prevent desertification as a result of overgrazing. Accordingly, determining which factors have the greatest impact on the BCS of cattle in Il N'gwesi is imperative to guiding future production decisions. The severe drought of 2009 created an ideal situation to evaluate these factors.

Therefore, the studies presented in this thesis were designed to test the following hypotheses:

a) Intermittent/step-up feeding of RH will improve finishing performance and carcass characteristics compared to continuous 42 d delivery of RH.

b) Supplementation of RH to early lactation, primiparous cows will improve nutritional status, decrease the postpartum anestrous interval, and result in greater first service conception rates.

c) Specific physical characteristics of cattle living on Il N’gwesi can be used to predict survivability during periods of extended droughts, and identifying these characteristics will aid in developing culling strategies for resident cattle owners.

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CHAPTER 2

EFFECTS OF CONTINUOUS AND STEP-UP RACTOPAMINE HYDROCHLORIDE SUPPLEMENTATION PROTOCOLS ON FEEDING PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING STEERS

Abstract

The objectives of this study were to evaluate the effects of continuous (CNT) and step-up (STEP) ractopamine hydrochloride (RH) supplementation protocols during the last 42 d of the finishing period on feeding performance and carcass characteristics of finishing steers. Thirty-six Angus-Simmental cross steers (510 ± 4.99 kg initial BW) were used in this experiment. Initial steer BW was the average of two weights taken on consecutive days at the beginning of the trial. Steers were blocked by initial BW, and randomly assigned to one of three treatments 1) control (no dietary RH: CON), 2) daily supplementation of 200 mg RH from d 0 to d 42 (200 mg; CNT) and 3), daily supplementation of 100 mg RH from d 0 to d 21, no RH from d 21 to 28, and daily supplementation of 300 mg RH from d 28 to d 42 (STEP). Steers were fed ad libitum, weights were taken at 14 d intervals, and final BW were collected on d 41 and 42 prior to harvest to monitor feedlot performance. Hot carcass weights were taken post-

exsanguination, and following a 24-h chill, trained personnel collected dressing percent, 12th rib fat thickness, LM area, % KPH, preliminary yield grade, marbling score and quality grade. Initial BW were similar (*P* = 0.53) across all treatments (505.30, 513.26, 510.04 ± 4.99; CON, CNT, STEP, respectively). No differences were detected in overall dry matter intake (DMI) (P = 0.61) or in BW were apparent at d 14 (*P* = 0.48), d 28 (*P* = 0.26), or at the conclusion of the feeding period (*P* = 0.41). Likewise, ADG were also similar throughout the feeding period d 0-14 (*P* = 0.20), d 14-28 (*P* = 0.41), d 28-42 (*P* = 0.95), d 0-28 (*P* = 0.27); as were overall daily gains when compared across treatments (*P* = 0.52). Accordingly, there were no changes in total BW gain (*P* = 0.52), G:F (*P* = 0.36), or F:G (*P* = 0.40) due to dietary treatment. The lack of performance differences was reflected in several carcass measurements often impacted by live weight gain with no differences across treatments being detected for hot carcass weight (*P* = 0.31), dressing percent (*P* = 0.80), 12^{th} rib fat thickness (*P* = 0.35), LM area (*P* = 0.19), % KPH (*P* = 0.97), and yield grade (*P* = 0.38). However, the CON treatment had greater marbling scores (*P* = 0.04) than CNT fed steers, with STEP fed steers being intermediate to both treatments. This effect likely contributed to the trend in quality grade differences (*P* = 0.08) between CON and CNT treatments, with the STEP treatment again being intermediate. Feeding performance was not altered due to RH supplementation at either a constant level or a step-up protocol over a period of 42 days. Carcass quality was not improved, and chronic stimulation due to constant RH administration may have a negative effect on marbling, and potentially final quality grades of beef steers.

Introduction

Cost of production and feed efficiency are two factors often scrutinized by beef producers. With the current economic situation, the need for proven feeding strategies that benefit these two variables are inherently valuable to feedlot operations. Supplementing a ß-adrenergic agonist (ß-AA), such as ractopamine hydrochloride (RH), to livestock diets has been shown to benefit feed efficiency by partitioning feedstuffs toward protein synthesis rather than fat accretion (Baker et al., 1984; Ricks et al., 1984; Watkins et al., 1990). Marketed for beef cattle by Elanco Animal Health, Optaflexx™, is approved for feeding during the last 28 to 42 d prior to harvest at concentrations ranging from 70 to 430 mg/hd/d to increase average daily gains (ADG) and improve feed efficiency (G:F).

Increases in ADG and G:F as a result of adding RH to beef finishing diets have been duplicated in numerous experiments (Anderson et al., 1989; Carroll et al., 1990; and Preston et al., 1990). However, few trials have been conducted to define the optimal concentration and feeding duration of dietary RH in finishing cattle diets. Delivery of RH at a rate of 200 mg/hd/d for 35 d has been reported as the optimal method of continuous RH supplementation to improve ADG and G:F in finishing steers as a linear decline in growth response was evident from d 35-42 (Abney et al., 2007). In swine, the most effective duration of RH administration has been reported at d 22 (Williams et al., 2004). These duration of dietary RH thresholds may be due to desensitization of ß-adrenergic receptors (ß-AR) as a result of continuous RH feeding. Recently, chronic stimulation studies have been conducted to determine the effects of RH on ß-AR mRNA abundance, with the results being inconclusive regarding desensitization of ß-AR (Sissom et al., 2007; Walker et al., 2007; Winterholler et al., 2007; Winterholler et al., 2008).

When feeding RH, an increase in lean muscle deposition occurs (Mersmann, 1998). Increases in longissimus muscle area (LM) are well documented in finishing cattle fed RH (Carroll et al., 1990; Schroeder et al., 2003b; Laudert et al., 2004; Gruber et al., 2007; Abney et al., 2007 while). Only one documented steer (Holstein) study has reported a decrease in 12th rib fat thickness (FT) when RH was included in the diet (Vogel et al., 2005). One of the major advantages of RH supplementation compared to other ß-AA is that no decrease in marbling scores has been reported in beef cattle. However, Holstein steers fed 200 mg/hd/d of RH reported decreased marbling scores (Vogel et al., 2005), and a trend to decrease quality grade was reported due to duration of dietary RH inclusion (Abney et al., 2007).

The literature suggests continuous RH feeding for 42 d may decrease the responsiveness of ß-AR and impede growth performance and reduce carcass quality. Therefore, this study was designed to evaluate the effects of continuous and intermittent/step-up RH feeding protocols during the final 42 d of the finishing period on growth performance and carcass characteristics in beef steers.

Materials and Methods

Animals and Treatments

All procedures involving animals used in this study were approved by the Purdue Animal Care and Use Committee. Thirty-six Angus-Simmental cross steers (510 ± 4.99

kg initial BW) were used in this experiment. All steers were obtained from the Purdue University Southern Indiana Agricultural Center and were shipped to the Purdue University Animal Sciences Research and Education Center on d -140. Upon arrival, steers were fed a grower ration to transition to the finishing diet (Table 1) used in the trial. Steers were housed individually in a barn with concrete slatted floors in 1.4 m × 3.4 m pens with free access to an automated watering system. On d -100, the finishing diet was first administered, and then fed throughout the duration of the experiment. Initial steer BW was the average of weights taken on d -1 and d 0. Steers were blocked by initial BW, and randomly assigned to one of three treatments 1) control (no dietary RH: CON), 2) daily supplementation of 200 mg RH from d 0 to d 42 (200 mg; CNT) and 3), daily supplementation of 100 mg RH from d 0 to d 21, no RH from d 22 to 28, and daily supplementation of 300 mg RH from d 29 to d 42 (STEP). Bunks were evaluated daily at 0600 to determine the amount of feed to be offered, and steers were fed ad libitum at 0700 daily.

Performance and Carcass Characteristics Data Collection

Weights were taken at 14 d intervals, and final BW were collected on d 41 and 42 prior to harvest to monitor feedlot performance. Steers were fed ad libitum and DMI and G:F were calculated. Hot carcass weights were collected post-exsanguination, and following a 24-h chill, trained personnel collected dressing percent, 12th rib fat thickness, LM area, KPH, preliminary yield grade, marbling score and quality grade. Final yield grades were determined according to the formula established by Aberle et al. (2001).

Statistical Analysis

Growth performance and carcass characteristics were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC) for a randomized complete block design, and individual steer was used as the experimental unit. Differences in LS means were considered significant when the p-value was ≤ 0.05, with a p-value ≤ 0.10 considered to be a tendency approaching significance.

Results

Performance

Initial BW were similar (*P* = 0.53) across all treatments (505.30, 513.26, 510.04 ± 4.99; CON, CNT, STEP, respectively; Table 2), and no BW differences were apparent at d 14 (*P* = 0.48), d 28 (*P* = 0.26), or at the conclusion of the feeding period (*P* = 0.41). Dry matter intake was unaffected, as well (*P* = 0.61). Daily gains were also similar throughout the feeding period d 0-14 (*P* = 0.20), d 15-28 (*P* = 0.41), d 29-42 (*P* = 0.95), d 0-28 (*P* = 0.27), and overall (*P* = 0.52), when compared across treatments. Accordingly, there were no changes in total BW gain (*P* = 0.52), G:F (*P* = 0.36), or F:G (*P* = 0.40) due to dietary treatment.

Final Carcass Characteristics

Carcass measurements often impacted by live weight gain were likewise unaffected. No differences across treatments were detected for hot carcass weight (*P* =

0.31; Table 3), dressing percent (*P* = 0.80), FT (*P* = 0.35), LM (*P* = 0.19), KPH (*P* = 0.97), and yield grade (*P* = 0.38). However, the CON treatment had greater marbling scores (*P* = 0.04) than CNT, with STEP being intermediate to both treatments. This effect likely contributed to the trend in quality grade differences (*P* = 0.08), in which the CON treatment had greater quality grade scores compared to CNT, with STEP being intermediate.

Discussion

Production variables such as ADG, DMI, and G:F have a significant impact on the financial viability of beef finishing operations. Each of these variables has repeatedly been improved through RH supplementation both in classical and contemporary feeding trials (Anderson et al., 1989; Carroll et al., 1990; Preston et al., 1990; Avendaño-Reyes et al., 2006; and Abney et al., 2007). In beef cattle, there is evidence of an optimal feeding threshold of 33-35 d (Avendaño-Reyes et al., 2006; and Abney et al., 2007, respectively) when RH is supplemented at a minimum level of 200/mg/hd/d prior to desensitization and subsequent down-regulation of the ß-AR resulting in decreased animal performance. The present study was designed to determine if an intermittent/step-up RH feeding method would prevent a reduction in finishing performance the final 7 d of a 42 d finishing period reported in continuous RH feeding (Abney et al., 2007). The data of this study corroborate that a 42 d feeding period of RH is not beneficial for feeding performance when levels exceed 100 mg/hd/d at any time during the feeding period as no increases in growth performance were detected due to RH supplementation.

The only published report of a step-up design tested the effects of continuous stimulation in heifers (Quinn et al., 2008). Dietary RH was increased from 100 mg/hd/d to 200 mg/hd/d on d 14, and subsequently increased to 300 mg/hd/d on d 28 with heifers being harvested on d 42. In the same report, the step-up treatment was intermediate in all observed performance traits; however, the RH fed cattle had an increase in carcass gain, which can be attributed to live performance. Similar to the present study, no differences in live performance were reported due to step-up RH feeding (Quinn et al., 2008). In the present study, the results of the STEP feeding protocol were difficult to evaluate. Although the maximum benefit of feeding RH at a level of 100 mg/hd/d has been previously thought to occur at d 42 (Abney et al., 2007), the ß-AR may have been desensitized by d 21 in this trial when RH was removed from the diet. Therefore, reintroducing RH to the diet 7 d later, at a rate of 300 mg/hd/d, may have resulted in a lower positive impact than predicted. As stated previously, increases in beef cattle performance have been reported up to 35 d following the inclusion of RH in the diet at a level of 200 mg/hd/d. However, in swine, d 22 has been noted as the point of inhibition for increased animal performance (Williams et al., 2004), and a corresponding desensitization. Accordingly, had the STEP protocol been configured for 21 d of 300 mg/hd/d of RH immediately following 14 d of 100 mg/hd/d and a 7 d ceasing of RH administration, instead of 21 d at 100 mg/hd/d followed by a 7 d removal of RH from the diet, and finishing with 14 d at the 300 mg/hd/d level, the secondary administration may have been more effective on feeding performance. The absence of negative effects on carcass characteristics due to the STEP regimen compared to the effects of the CNT feeding protocol suggests that chronic stimulation may in fact have a negative impact on carcass quality.

There are some numerical differences presented in the current data, which point out the inherent flaw of limited experimental units. These differences are presented in final BW, total BW gain, ADG, HCW, LM, and YG between the CNT and CON treatments, with final BW, total BW gain, and ADG, showing a broad numerical change between CNT and STEP. Therefore, it can be hypothesized that an increase in steers/experimental units may have resulted in statistical changes that would be more consistent with previous reports. However, in the present study, the numeric differences were inconclusive. Results from this study contradict previous reports regarding carcass differences due to RH supplementation. In fact, the decrease in marbling scores is the first report of its kind, although the trend toward decreased quality grades as a result of continuous RH administration has been reported before (Abney et al., 2007). The present data indicate an intermittent removal of RH during a 42 d finishing period may prevent a reduction in marbling score as a result of continuous RH feeding. Due to the genetic consistency of the steers in this study, and the extended transition period to the finishing diet prior to treatment initiation it is likely the decrease in intramuscular fat was associated with chronic RH stimulation. However, the decrease in marbling was not great enough to decrease potential carcass value, as the mean numerical marbling scores and quality grades for each treatment still resulted in carcasses grading USDA Choice.

Implications

Many of the results of this study conflict with those from early investigations of RH supplementation, yet the provide insight into pinpointing the most appropriate method of integrating RH into feeding protocols. Feeding performance was not altered due to RH supplementation at either a constant level or a step-up protocol over a 42 day period. Carcass quality was not improved, and chronic stimulation due to constant RH administration may have a negative effect on marbling, and potentially final quality grades of beef steers. From a producer standpoint, feeding cattle that lack the genetic propensity for elevated intramuscular fat may result in a failure to capture carcass premiums if carcasses grade high select rather than low choice. The phenomenon of chronic stimulation and its effect on desensitization in beef steers is still uncertain. Further research should be conducted to determine the most appropriate level of RH inclusion and the ideal feeding duration to maximize beef production efficiency.

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Table 2.1. Ingredients and chemical composition of diets fed to finishing steers.

	Treatments		
Ingredient, % of diet DM	CON	CNT	STEP
Corn silage	12.0	12.0	12.0
Cracked corn	80.0	80.0	80.0
Soybean meal	8.0	8.0	8.0
Supplement[1]	2.5	2.5	2.5
Urea	5.69	5.69	5.69
Ackey Mineral[2]	4.49	4.49	4.49
Calcium Carbonate	79.09	79.09	79.09
Salt	10.09	10.09	10.09
Rumensin, 80 mg/d[3]	0.52	0.52	0.52
Tylan 100[4]	0.126	0.126	0.126
Nutrients			
Dry matter[5]	68.1	68.1	68.1
Crude protein	15.9	15.9	15.9
NEg[6]	1.43	1.43	1.43
Fat	5.83	5.83	5.83
NDF[7]	25.8	25.8	25.8
eNDF[8]	9.2	9.2	9.2
Calcium	0.89	0.89	0.89
Phosphorus	0.44	0.44	0.44
Potassium	0.77	0.77	0.77
Magnesium	0.21	0.21	0.21
Zinc[9]	40.0	40.0	40.0
Copper[9]	20.0	20.0	20.0
Manganese	30.0	30.0	30.0
Cobalt[9]	1.0	1.0	1.0
Iodine[9]	1.0	1.0	1.0
Selenium[9]	0.65	0.65	0.65
Vitamin A[10]	2000.0	2000.0	2000.0
Vitamin E[10]	15.0	15.0	15.0
Rumensin[11]	30.0	30.0	30.0
Tylosin[11]	10.0	10.0	10.0
Ractopamine hydrochloride, mg/hd/d			
Trial d 0-21	---	200.0	100.0
Trial d 21-28	---	200.0	---
Trial d 28-42	---	200.0	300.0

[1]Supplement with no added zinc or copper. Expressed as a percentage of dry matter. Individual ingredients within the supplement are expressed as a percentage of DM of the supplement.
[2]Ackey Mineral, Dayton OH.
[3]80 g Monensin per lb.
[4]100 g Tylosin per lb.
[5]Percentage of as-fed.
[6]Expressed as Mcal/lb.
[7]Neutral detergent fiber.
[8]Effective Neutral detergent fiber in the diet.
[9]ppm
[10]IU per lb dry matter.
[11]g per ton dry matter.

Table 2.2. Effects of continuous and step-up ractopamine hydrochloride supplementation protocols on feeding performance in finishing steers

	Treatment[1]				
Item	CON	CNT	STEP	SEM[2]	*P*-value
Initial BW, kg	505.30	513.26	510.04	4.99	0.53
d 14 BW, kg	534.66	544.89	539.20	5.92	0.48
d 28 BW, kg	557.39	571.97	560.99	6.38	0.26
Final BW, kg	582.10	597.44	587.22	8.12	0.41
DMI, kg/d	8.66	8.26	8.48	0.29	0.61
Daily gain, kg (d 0-14)	2.10	2.26	2.09	0.80	0.20
Daily gain, kg (d 14-28)	1.62	1.94	1.56	0.21	0.41
Daily gain, kg (d 28-42)	1.77	1.82	1.87	0.24	0.95
Daily gain, kg (d 0-28)	1.86	2.10	1.82	0.13	0.27
Daily gain, kg (overall)	1.83	2.01	1.84	0.12	0.52
Total BW gain, kg	76.80	84.19	77.18	5.08	0.52
Gain/feed, kg/kg	0.16	0.18	0.17	0.01	0.36
Feed/Gain, kg/kg	6.79	5.68	6.16	0.57	0.40

[1]CON = no RH supplementation; CNT = 200 mg/hd/d RH supplementation from d 0-42; STEP = 100 mg/hd/d RH supplementation from d 0-21, no RH supplementation from d 21-28, 300 mg/hd/d RH supplementation from d 28-42

[2]The greatest SEM was presented (n = 12/treatment)

Table 2.3. Effects of continuous and step-up ractopamine hydrochloride supplementation protocols on carcass characteristics in finishing steers

	Treatment[1]				
Item	CON	CNT	STEP	SEM[2]	*P*-value
Hot carcass weight, kg	349.73	360.19	354.51	4.76	0.31
Dressing percent	60.17	60.33	60.50	0.003	0.80
12th rib fat thickness, cm	1.08	0.93	1.14	0.10	0.35
LM area, cm^2	94.95	102.31	99.45	2.79	0.19
KPH, %	2.17	2.13	2.17	0.15	0.97
Yield grade	2.21	1.85	2.09	0.18	0.38
Marbling score[3]	585.00[a]	530.83[b]	553.33[a,b]	14.32	0.04
Quality grade[4]	17.50[c]	17.00[d]	17.25[c,d]	0.15	0.08

[1]CON = no RH supplementation; CNT = 200 mg/hd/d RH supplementation from d 0-42; STEP = 100 mg/hd/d RH supplementation from d 0-21, no RH supplementation from d 21-28, 300 mg/hd/d RH supplementation from d 28-42

[2]The greatest SEM was presented (n = 12/treatment)

[3]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.

[4]Quality grade: 15 = $Select^-$, 16 = $Select^+$, 17 = $Choice^-$, 18 = $Choice^0$, 19 = $Choice^+$, etc.

[a,b]Means within a row lacking a common superscript differ ($P \leq 0.05$)

[c,d] Means within a row lacking a common superscript differ ($P \leq 0.10$)

CHAPTER 3

EFFECTS OF RACTOPAMINE HYDROCHLORIDE SUPPLEMENTATION ON REPRODUCTIVE EFFICICIENCY AND WEIGHT CHANGE IN YOUNG, GROWING, LACTATING BEEF COWS

Abstract

The objective of this experiment was to evaluate the effect of dietary ractopamine hydrochloride (RH) on reproductive efficiency and weight change in two-year old, lactating primiparous cows. Sixty-four Angus x Simmental cows were stratified and blocked by days postpartum (DPP), resumption of estrus, BW, and BCS, to receive either a control diet (CON) or a control diet including 300 mg/hd/d RH (OPT; first day of OPT feeding, experimental d -35). The 5 d Co-Synch protocol was used to synchronize estrus, and cows were bred via timed artificial insemination (TAI) on d 0. Trans-rectal untrasonography was conducted to diagnose pregnancy on d 30 and 90 determine TAI and overall breeding season pregnancy rates. A subset of cows (n = 12/treatment) were used to evaluate the effects of RH administration on follicular wave dynamics. Trans-rectal ultrasonography, used to evaluate follicular dynamics, commenced on d -28 and was conducted daily until an entire follicular wave had been observed for each cow (~18 d). Initial BW were similar (*P* = 0.79) between the CON and OPT treatments (591.44 ±

8.65 and 588.10 ± 8.65 kg, respectively) and no BW differences were detected throughout the experiment. However, the CON treatment had greater ($P < 0.01$) daily losses in BW than the OPT treatment (-1.08 ± 0.09 and -0.71 ± 0.09 kg/d, respectively). Body condition scores for the treatments were similar (6.51 ± 0.08, 6.50 ± 0.08 CON and OPT, respectively) at the initiation of the feeding period ($P = 0.92$). At the conclusion of the feeding period, BCS of the CON treatment (5.55 ± 0.11) were decreased ($P < 0.01$) compared to the OPT treatment (6.02 ± 0.11). Days postpartum at the initiation of estrous cycle activity were similar between treatments ($P = 0.75$; 56.37 and 57.89 ± 4.77, CON and OPT, respectively). No differences were observed between treatments for follicular dynamics measured via ultrasonography. Timed artificial insemination (68.75%, 53.13%) and breeding season pregnancy rates 84.38% and 71.88%, CON and OPT, respectively) did not differ between treatments. Including RH to the diet of two-year old lactating cows in good BCS (≥ 5) decreased the amount of BW and energy reserves lost during the initial stages of lactation. However, this did not impact days postpartum at resumption of estrous cycle activity, follicular dynamics, or pregnancy rates. Therefore, the feeding design of this study resulted in increased feed input costs without the benefit of improved pregnancy rates. The numeric decrease in pregnancy rates of RH supplemented cows suggests that feeding and removing RH at breeding does not improve conception rates, but instead may actually hinder conception rates. While it can be accepted that RH inclusion in cow diets will improve nutritional status, further research should be conducted to determine the most effective method of feeding RH to postpartum cows to positively impact reproductive performance.

Introduction

Reproductive success is the main determinant of profitability in cow-calf operations, and failure to conceive is one of the key detriments affecting domestic beef production (Diskin and Sreenan, 1980). Poor reproductive performance occurs when cows are anestrous at the beginning of the breeding season. Due to increased nutrient demands for growth in addition to lactation, primiparous cows may have a longer postpartum anestrous interval and subsequently, a lower proportion of these females may fail to initiate estrous cycles at the beginning of the breeding season, compared to multiparous cows.

Total body energy reserves are often measured by a body condition score (BCS; 1 = emaciated; 9 = obese), and this score can be used as a representation of total body energy reserves available to support physiological functions during periods of increased nutrient demands (Whitman, 1975). Proper BCS has been reported to increase pregnancy rates (Lake et al., 2005), ensure adequate postpartum performance (Lamond, 1970; Dziuk and Bellows, 1983; Short et al., 1990; Morrison et al., 1999), and reduce the length of the postpartum anestrous period (Houghton, et al., 1990). In cull cows, the ß-adrenergic agonist (ß-AA), ractopamine hydrochloride (RH), has been reported to increase cow BCS (Allen et al., 2009) and percent kidney, pelvic, and heart fat (KPH) which may be an indicator of increased body energy reserves (Harboth, 2006).

In addition to potential increases in BCS, ß-AA alters steroidal secretions that could improve reproductive success. The ß-adrenergic receptors (ß-AR) present on beef cow ovaries (Burden, 1978) have been reported to regulate progesterone (P4) secretion from the CL, and continuous stimulation of ß-AR increased P4 production (Godkins et al., 1977, and Skarynski et al., 1993). When a delay in P4 production post-ovulation occurs, conceptus development is retarded and compromises its ability to produce interferon tau, the hormone responsible for maternal recognition of pregnancy (Mann et al., 2006).

With the peak of lactation coinciding with the breeding season, primiparous cows, are at a severe nutrient disadvantage due to their added growth requirements when attempting to conceive. Accordingly, inclusion of a ß-AA to the diets of lactating primiparous cows could reduce the negative impacts on reproductive performance associated with a negative energy balance. Therefore, RH was fed to determine its impact on BW, BCS, the duration of postpartum anestrous, follicular wave dynamics, timed artificial insemination (TAI) pregnancy rates, steroidal concentrations of P4 and breeding season pregnancy rates in two-year old lactating beef cows during the postpartum period.

Materials and Methods

Animals and Treatments

Sixty-four, two-year old lactating Angus x Simmental cows were used in accordance with procedures approved by the Purdue Animal Care and Use Committee. Cows were stratified and blocked by days postpartum (DPP; 40.47 ± 16.15; Table 1), resumption of estrus (20.31% ± 4.06), BW (589.77 ± 48.56), and BCS (6.51 ± 0.47), to either a control diet (CON) or a control diet including 300 mg/hd/d RH (OPT). The control diet was formulated to meet the maintenance requirements of the lactating cows. Cows were housed in six pens (3 pens/treatment). Day of first RH supplementation was considered experimental day -35, and treatment ceased on d 0 (day of TAI).

Synchronization and Timed Artificial Insemination Protocol

The 5 d Co-Synch protocol was used to synchronize estrus. On d -8, all cows received a controlled internal drug release device (CIDR; Pfizer Animal Health, New York, NY) and were administered 100 µg of GnRH (Cystorellin; Merial, Inselin, NJ) On d -3 CIDRs were removed and cows received two injections of $PGF_{2\alpha}$, (Lutalyse; Pfizer Animal Health, New York, NY) 12 hr apart. Cows were bred TAI concurrent with GnRH administration on d 0. Artificial insemination was performed by three technicians with semen from 11 sires. On d 7, 3 bulls were exposed for the remaining 53 d of a 60 d breeding season. Trans-rectal untrasonography was conducted to diagnose pregnancy on d 30 and d 90 to determine timed-AI and overall breeding season pregnancy rates.

Body Weight and Body Condition Score

Initial BW was determined by averaging individual weights obtained on d -36 and d -35. To monitor the effect of treatment on changes in BW, individual BW were obtained on d -21, and -7. Cows were weighed on consecutive dates at the conclusion of the study and the individual BW were averaged to determine final BW. Two independent evaluators were used to obtain BCS (1-9 scale; 1 = emaciated, 9 = obese) on d -36 and d -

35, and again on d -1 and d 0. The individual BCS measurements of each cow were then averaged to determine initial BCS and final BCS.

Ultrasonography and Blood Sampling

A subset of cows (n = 12/treatment) were used to evaluate the effects of OPT administration on follicular wave dynamics. The subset utilized for evaluating follicular dynamics were selected from cows that calved within a 7 d period and were 52.73 ± 2.19 and 52.73 ± 2.33 (CON and OPT, respectively) DPP at the initiation of ultrasonography. Trans-rectal ultrasonography using a variable mHz linear array transducer (Sonosite MicroMaxx, Sonosite, Bothell, WA) commenced on d -28 and was conducted daily. Location and diameter of all ovarian follicles ≥ 5 mm in diameter were monitored until a complete follicular wave was recorded (~21 d). Two cows initially selected for ultrasonography from the OPT treatment group were removed from the follicular wave portion of the study due to extensive tears in the rectal wall. Follicular wave parameters evaluated included the number of follicles at emergence (FAE; number of ovarian follicles present when the eventual dominant follicle emerged), interval from emergence to dominance (ETD; duration between emergence of dominant follicle and d diameter of dominant follicle was measured to be ≥ 2 mm larger than subordinate follicles, reported in d), duration of follicular dominance (DFD; duration between recognition of dominant follicle and subsequent ovulation or emergence of new follicular wave, reported in d), diameter of dominant follicle (DOF; greatest diameter of dominant follicle, reported in mm), follicular growth rate (FGR; difference in DOF and diameter in mm of dominant follicle at emergence divided by DFD, reported in mm/d) , and length of the follicular wave (LFW; duration between emergence of dominant follicle and either ovulation or emergence of new follicular wave, reported in d).

Blood samples were collected from all cows on d -35, -28, -21, -14, and -8 via jugular venipuncture to measure circulating P4 concentrations. Blood samples were immediately stored on ice until transferred to a laboratory where they were centrifuged at 1500 x g for 20 min. Directly following completion of centrifuge, plasma was decanted and stored at -20° until quantified for concentrations of P4. Cows were considered to have resumed normal estrous cycles 7 d prior to the first of two consecutive blood samples in which P_4 concentrations were > 1.0 ng/mL.

Hormone Quantification

Plasma concentrations of P_4 were determined using a commercially available RIA kit (Coat-a-Count®, Siemens Medical Solutions Diagnostics, Los Angeles, CA, USA) as instructed by the manufacturer. Average intra-assay coefficient of variation (CV) was 2.6 %, and inter-assay CV's (two assays) for pooled plasma samples containing 1.5 and 7.5 ng/mL were 2.4% and 2.8%, respectively. The average sensitivity (95%) of the assays was 0.04 ng/mL.

Statistical Analysis

Body weight, BCS, resumption of cyclicity prior to the breeding season and follicular dynamic data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) for a randomized complete block design. The fixed effects of treatment and block were included in the model, with individual cow serving as the experimental unit. Additionally, the 2-way interaction of treatment × block was initially included in the statistical model and subsequently removed if not significant (P > 0.05). The GLIMMIX procedure of SAS was used to analyze binary data including TAI and overall breeding season pregnancy rates. The fixed effects of treatment, replication, and resumption of estrus prior to initiation of trial as well as all interactions were assessed with DPP at initiation of the trial, artificial insemination technician, and sire serving as covariates. Effects of artificial insemination technician and sire were insignificant and removed from the model. Interactions that were not significant (P > 0.05) were removed from the model. Difference in means were considered significant when the p-value was ≤ 0.05, with a p-value ≤ 0.10 considered as a tendency approaching significance.

Results

Performance and BCS

Initial BW were similar (P = 0.79) between the CON and OPT treatments (591.44 ± 8.65 and 588.10 ± 8.65 kg, respectively; Table 2), and no BW differences were apparent at d -21 (Figure 3.1; P = 0.26), d -7 (P = 0.27), or at the conclusion of the feeding period (P = 0.41). However, the CON treatment had greater (P < 0.01) daily losses in BW than the OPT treatment (-1.08 ± 0.09 and -0.71 ± 0.09 kg/d, respectively). Body condition scores for the CON treatment (6.51 ± 0.08) and the OPT treatment (6.50 ± 0.08) were similar at the initiation of the feeding period (P = 0.92). However, at the conclusion of the feeding period BCS of the CON treatment (5.55 ± 0.11) was decreased ($P < 0.01$) compared to the OPT treatment (6.02 ± 0.11).

Follicular Dynamics and Pregnancy Rates

Days postpartum at the initiation of estrous cyclicity was similar ($P = 0.75$; Table 3) between the CON and OPT treatments (56.37 and 57.89 ± 4.77, respectively). No differences were observed between treatments for follicular dynamics measured via ultrasonography (Table 3). Timed artificial insemination (68.75%, 53.13%) and breeding season pregnancy rates 84.38% and 71.88%, CON and OPT, respectively) did not differ between treatments.

Discussion

The addition of RH to the diet of lactating, primiparous cows for 35 d prior to breeding reduced the amount of BW lost per day leading into the breeding season. Subsequently, changes in BCS indicated that loss of total body energy reserves throughout the study was decreased with RH administration. These findings emphasize that even when cows are at the greatest negative energy balance incurred throughout their lifetime, supplementation of RH may impede stored energy depletion. Differing from our hypothesis, differences in BW changes and BCS as a result of RH administration in the present study had no effect on either follicular wave dynamics, or reproductive performance including TAI and overall pregnancy rates, and the duration of the postpartum anestrous interval. These results suggest that mechanisms associated with stimulation of ß-AR, P4 secretion for instance (Skarzynski et al, 1993), is unaffected when the basal BCS at time of breeding is above the optimum score of five (Wagner et al., 1988). Three known ß-AR subtypes exist; the β1-adrenergic recptor, the β2-drenergic receptor, and the β3-adrenergic receptor, which are present across almost all cell types of mammals. The varying quantity across species, tissues, and even within tissues of subtypes of ß-AR causes the response elicited from exogenous administration of ß-AA to differ widely. Clinical trials with rats and guinea pigs have established that the β1- and β2-adrenergic receptors are most receptive to RH (Colbert et al., 1991). In cattle, however, Sillence and Matthews (1994) concluded that the β2-adrenergic receptor is the most abundant ß-AR in skeletal muscle and adipose tissue membranes in cattle. Despite the classification of RH as a ß1-adrenergic agonist (ß1-AA), positive responses in ADG and skeletal muscle tissue have been well documented in feedlot cattle. Additionally, in cull dairy and beef cows, BCS (Allen et al., 2009) and KPH (Harboth, 2006), respectively, have been increased in response to RH supplementation. It is clear that the abundance of ß2-adrenergic receptor subtypes present in skeletal muscle and adipose tissue of cattle elicit a positive response to RH, regardless of energy balance. There is evidence that ß-AA can impact reproductive processes such as P4 secretion (Condon and Black, 1976), however, which type of ß-AR facilitate these changes is still undefined.

While the non specific ß-AA, epinephrine has been documented to stimulate P4 concentrations of bovine luteal cells in vitro (Condon and Black, 1976), less in known about the specific ß-AR subtype responsible for these actions. Studies by Aguado et al.

(1982) and Jordan (1981) demonstrated that the ß-AR subtypes in rat ovaries vary immensely throughout the estrous cycle. Although, results from the present study did not directly address receptor populations, it could be derived that the lack of differences reported in the current data concerning follicular dynamics and pregnancy rates indicate that a ß1-AA is ineffective at stimulating the ß-AR present on bovine ovaries. However, experiments by Earnest et al., (1988) and Hu et al., (1990), studied the effects of the ß2-adrenergic agonist, clenbuterol, and neither reported changes in the duration of the postpartum anestrous interval similar to the results in the present study. Alternatively, the final BCS of cows in the present study signify that although a slight negative energy balance may have occurred, a period of inadequate net energy reserves and subsequent poor nutritional status was never experienced; advocating a reduction in circulating IGF-1 prior to insemination was also avoided. When adequate protein is available, plasma concentrations of IGF-1 are unaltered (Spicer et al., 1991; Lents et al., 2008) regardless of intake or protein supplementation (Lents et al., 2008). In support of this, resumption of normal estrous was unchanged in the present study, which has been linked to circulating IGF-1 concentrations (Roberts et al., 1997). Also, despite increased levels of IGF-1 having been demonstrated to increase conception rates (Meikle et al., 2004) in dairy cattle, no differences in TAI or overall pregnancy rates were reported, providing further evidence to support the absence of a period of poor nutritional status that could have resulted in decreased reproductive performance in the non RH supplemented treatment. Given the changes in BW and BCS reported in the present study, the addition of RH may have bolstered circulating IGF-1 concentrations which has the potential to increase circulating P4 levels post-insemination, and ultimately contribute to improved reproductive performance, specifically, improved TAI pregnancy rates. However, the removal of dietary RH at insemination in the current study could have induced a compensatory reduction in circulating IGF-1 due to the drastic alteration of nutritional status.

In summary, cows fed RH 35 d prior to TAI lost less weight per day, and maintained body energy reserves more efficiently than non-RH supplemented cows. However, neither treatment group in the present study had a final BCS low enough to indicate a nutrient deficiency. Additionally, resumption of estrous was similar across both treatments reinforcing that nutritional status throughout the feeding period was sufficient. Accordingly, no changes often associated with reduced circulating IGF-1 concentrations, an indicator of nutritional status, such as changes in follicular dynamics, duration of the postpartum anestrous interval, or pregnancy rates were documented.

Implications

Including RH to the diet of two-year old lactating cows in good BCS (≥ 5) decreased the amount of BW and energy reserves lost during the initial stages of lactation; however, there were no improvements from a reproductive standpoint. Therefore, the feeding design of the present study resulted in increased feed input costs without the benefit of improved pregnancy rates. In the current data, the numeric decrease in pregnancy rates of RH supplemented cows suggests that feeding and removing it at breeding does not improve conception rates, but rather may contribute to poorer reproductive performance. While it can be accepted that RH inclusion to cow diets improves nutritional status, further research should be elucidated to determine the most effective method of feeding RH to manipulate ovarian ß-AR, and subsequent P4 production for improving pregnancy rates.

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Table 3.1. Days postpartum and percent estrus at initiation of ractopamine hydrochloride supplementation of two-year old lactating primiparous cows.

	Treatment		
Item	CON[1]	OPT[2]	SEM[3]
Initial days postpartum[4]	40.47	40.47	16.15
Resumption of estrus[5], %	21.88	18.75	4.06

[1]Cows were fed only a control diet formulated to meet the maintenance requirements of the lactating cows
[2]Cows were fed control diet supplemented with 300 mg/hd/d RH for 35 days prior to timed artificial insemination
[3]The greatest SEM was presented (n = 32/treatment)
[4]Mean days postpartum on d -35, initiation of RH delivery
[5]Percent cows determined to have resumed normal estrous cycles prior to d -35 (circulating progesterone > 1.0 ng/mL)

Table 3.2. Effects of ractopamine hydrochloride supplementation on performance and BCS[1] of two-year old lactating primiparous cows

	Treatment			
Item	CON[2]	OPT[3]	SEM[4]	*P*-value
Initial BW[5], kg	591.44	588.10	8.65	0.79
d -21 BW, kg	571.52	585.80	8.88	0.26
d -7 BW, kg	560.09	574.55	9.11	0.27
Final BW[6], kg	550.46	561.26	9.14	0.41
Daily BW change, kg	-1.08	-0.71	0.09	< 0.01
Initial BCS[7]	6.51	6.50	0.08	0.92
Final BCS[8]	5.55	6.02	0.11	< 0.01

[1]Body Condition Score (1-9 scale; 1 = emaciated, 9 = obese)
[2]Cows were fed only a control diet formulated to meet the maintenance requirements of the lactating cows
[3] Cows were fed control diet supplemented with 300 mg/hd/d RH for 35 days prior to timed artificial insemination
[4]The greatest SEM was presented (n = 32/treatment)
[5]Initial BW was determined by averaging individual weights obtained on d -36 and d -35
[6]Final BW was determined by averaging individual weights obtained on d -1 and d 0
[7]Initial BCS was determined by averaging individual BCS obtained on d -36 and d -35
[8]Final BCS was determined by averaging individual BCS obtained on d -1 and d 0

Table 3.3. Effects of ractopamine hydrochloride supplementation on duration of postpartum anestrous and follicular wave dynamics of two-year old lactating primiparous cows

	Treatment			
Item	CON[1]	OPT[2]	SEM[3]	*P*-value
Postpartum interval[4], d	56.37	57.89	3.38	0.75
Follicles at emergence[5]	18.73	17.44	2.66	0.73
Emergence to dominance[6], d	4.64	4.11	0.78	0.63
Duration of dominance[7], d	5.00	4.89	1.23	0.93
Diameter of follicle[8], mm	15.64	16.11	0.91	0.68
Follicular growth rate[9], mm/d	1.63	1.44	0.14	0.32
Length of follicular wave[10], d	9.73	9.00	0.75	0.48

[1]Cows were fed only a control diet formulated to meet the maintenance requirements of the lactating cows

[2] Cows were fed control diet supplemented with 300 mg/hd/d RH for 35 days prior to timed artificial insemination

[3]The greatest SEM was presented (postpartum interval n = 32/treatment; follicular wave dynamics n = 12 and 10, CON and OPT, respectively)

[4]Cows were considered to have resumed normal estrous cycles 7 d prior to the first of two consecutive blood samples to have progesterone concentrations > 1.0 ng/mL

[5]Number of ovarian follicles present when the eventual dominant follicle emerged

[6]Duration between emergence of dominant follicle and d diameter of dominant follicle was measured to be ≥ 2 mm larger than subordinate follicles

[7]Duration between recognition of dominant follicle and subsequent ovulation or emergence of new follicular wave

[8]Greatest diameter of dominant follicle

[9]Difference in greatest diameter of dominant follicle and diameter of dominant follicle at emergence divided by duration of follicular dominance

[10]Duration between emergence of dominant follicle and either ovulation or emergence of new follicular wave

Table 3.4. Effects of ractopamine hydrochloride supplementation on pregnancy rates of two-year old lactating primiparous cows

	Treatment			
Item	CON[1]	OPT[2]	SEM[3]	*P*-value
Timed-AI pregnancy rate[4], %	68.75	53.13	4.66	0.20
Overall breeding season[5], %	84.38	71.88	5.33	0.20

[1]Cows were fed only a control diet formulated to meet the maintenance requirements of the lactating cows

[2] Cows were fed control diet supplemented with 300 mg/hd/d RH for 35 days prior to timed artificial insemination

[3]The greatest SEM was presented (n = 32/treatment)

[4]The 5 d CO-Synch protocol was used to synchronize estrus, and all cows were bred timed-AI. Trans-rectal ultrasonography was conducted to diagnose pregnancy 30 d post-insemination.

[5]Three herd bulls were exposed 7 d post-insemination for 53 d to complete a 60 d breeding season. Trans-rectal ultrasonography was conducted to diagnose pregnancy 30 d and 90 d following timed artificial insemination.

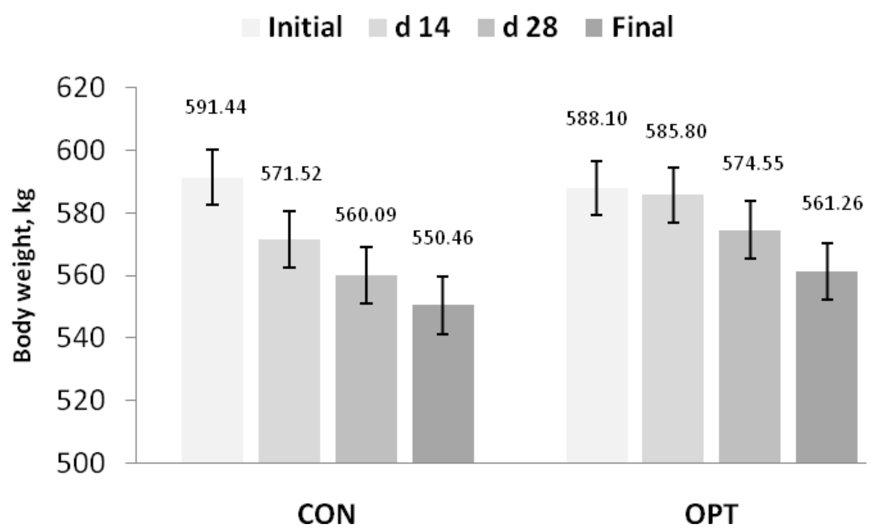

Figure 3.1. Body weight changes of two-year old lactating primiparous cows with or without dietary supplementation of ractopamine hydrochloride prior to timed artificial insemination. No differences were reported ($P \geq 0.26$) at any weigh period, however, there was an overall effect on daily weight change ($P < 0.01$) for the entire feeding period.

CHAPTER 4

FACTORS AFFECTING BODY CONDITION OF CATTLE ON IL N'GWESI GROUP RANCH

Abstract

The objective of this study was to evaluate the factors affecting the body condition of cattle on the Il N'gwesi group ranch in central Kenya, Africa. Seven hundred eleven cattle from Il N'gwesi and Isiolo, Kenya, were evaluated during a 20 d period in May 2009. Cattle age, breed, hide color (HC), frame score (FS) and sex class (SX) were documented to determine their influence on body condition score (BCS). Age determination was verified by Maasai herders or the cattle owners themselves and was subdivided into three classifications; weanlings (≤ 1 yr of age), yearlings (< 1 yr of age ≤ 3 yr of age), and mature (≥ 3 yr of age). Hide color was divided into three categories; light, spotted, and dark. Due to a lack of documentation to accurately assess breed composition cattle were evaluated for approximate *Bos indicus* and *Bos taurus* composition, with all 711 cattle being determined to be majority (> 90%) *Bos indicus*. Frame scores were estimated visually by a trained evaluator familiar with the United States Beef Improvement Federation's frame scoring guidelines. Body condition scores were determined by the same evaluator using a 1-9 scale with 1 being emaciated and 9

being obese (Whitman, 1975). A regression equation of BCS for all cattle was developed to determine the impact each factor had on BCS. A HC × FS interaction was detected to have a negative correlation on BCS (-0.079, $P < 0.0001$). As the age of cattle increased BCS decreased (-0.110, $P = 0.007$). Body condition scores increased as HC increased (light = 1, spotted = 2, dark = 3; 0.309, $P < 0.0001$). As SX classification increased (cow = 1, heifer = 2, bull = 3, steer = 4) BCS also increased (0.311, $P < 0.0001$). There were differences in BCS based on age ($P < 0.001$), SX ($P < 0.001$), and FS ($P < 0.001$), while no differences were attributed to HC ($P = 0.45$). Weanling and yearling aged cattle had greater BCS ($P < 0.001$) than mature cattle (3.52, 3.66, and 3.08, respectively). Steers, bulls and heifers had higher BCS (P < 0.001) than cows (3.73, 3.60, 3.59, and 2.88, respectively). Therefore immature cattle, steers, bulls, and heifers are apparently more apt to maintaining body condition. Additionally, HC in relation to FS could be used as selection criteria for predicting survivability.

Introduction

The Maasai owned community group ranch Il N'gwesi, is located in central Kenya, northwest of Mt. Kenya in the Kenyan Highlands. According to the BBC Weather Centre, the intertropical belt of cloud and rain travels quickly across Kenya during April and October, and due the predominant seasonal winds annual rainfall throughout the country varies considerably. This results in a double rainy season between March and May, and again between November and December with dry seasons during the interim periods. The Maasai of Il N’gwesi must rely upon these two annual rainy seasons, which only exceeds 1,250 mm per year in the highest parts, to replenish water sources and increase forage growth to supply the nutritional needs of their livestock. Although metabolic rates of indigenous cattle during periods of extreme drought are lowered (Western and Finch, 1986) to combat forage and water unavailability, these unforeseen circumstances always challenge livestock’s survivability.

The traditional pastoralist herding system includes the gamut of beef cattle production from the cow calf enterprise through the finishing phase, and from breeding stock development until culling or fatality. The Maasai living on Il N'gwesi raise their cattle according to this model. Meaning the cattle are herded in groups consisting of various ages and sexes, as opposed to small well defined herds. Understanding the herding structure of the Maasai may be difficult as in many cases it is not the most productively efficient compared to western production practices. However, comparisons of Maasai beef production practices to western production practices are not only difficult but are not relevant due to such dramatic differences in resources, climate, cattle type, and the socio-economic importance of cattle to the Maasai. Talbot (1986) concluded that within Maasai tribes an individual's wealth and respect are greatly defined by the number of livestock they own. Recent research conducted on Il N'gwesi reinforces this conclusion, as household income increases a concomitant increased priority is also placed upon purchasing additional livestock (DeVeau, 2008). Not surprisingly, added community prestige dictates increasing herd size rather than productive efficiency when purchasing livestock (Brown, 1971; Ruthenberg, 1971). During years consisting of typical weather patterns this lack of selection pressure has little effect on cattle survivability, however, alternative production practices and a greater awareness to the factors that affect cattle survivability could dramatically reduce mortality rates during years of extreme drought.

Nutrient requirements of beef cattle differ between the various stages of production. These requirements are prioritized for body maintenance, fetal development, lactation, growth, and breeding, therefore poor or limited nutrients can negatively impact the production cycle (Rossi and Wilson, 2006). One of the most cost effective and easiest ways to determine if nutrient requirements are being met is by body condition scoring (BCS; Rossi and Wilson, 2006). The benefits of maintaining proper BCS are numerous and range from greater reproductive rates and increased market value to increased survivability. Lake et al., (2005) reported that pregnancy rates were increased in cows having a greater BCS at the initiation of the breeding season compared to cows having a lower BCS. This can be attributed to the effect BCS has on the length of anestrous following parturition known as the postpartum interval (PPI). As BCS at parturition increases the PPI decreases (Houghton et al., 1990) allowing cows to be rebred sooner. Over the entire lifecycle of a cow, shortening the PPI results in more efficient beef production as cows can yield more calves over their productive lifespan. Economically, cattle marketed at a proper BCS generally receive higher premiums, and this trend has been confirmed in West Africa (Okike et al., 2004). Obviously, cattle being maintained at an appropriate BCS outperform their contemporaries and their ability to survive extended droughts is thought to be increased as adipose tissue reserves could be used to energy. Accordingly, determining which factors have the greatest impact on the BCS of cattle in Il N'gwesi is imperative to guiding future production decisions. The severe drought of 2009 created an ideal situation to evaluate these factors.

Materials and Methods

Animals and Factors Evaluated

Seven hundred eleven cattle from Il N’gwesi and Isiolo, Kenya, were evaluated during a 20 d period in May 2009. Six hundred sixty-eight of the cattle were owned by Maasai living in Il N’gwesi. The remaining 43 were evaluated at the Isiolo livestock market and were owned by unknown pastoralists. Of the 668 Il N’gwesi owned cattle that were observed, 427 originated from 1 of 3 identifiable neighborhoods (Leparua, Nadungoru, Ngare Ndare). One hundred forty-six of the cattle were evaluated at the time of sale to Ol Pejeta Conservancy, and due to mixing of several cattle during this process their exact location of origin could not be determined. The final 95 head were owned by a pastoralist that was unavailable for interview and accordingly were considered to be of unknown neighborhood origin. Age, breed, hide color (HC), frame score (FS) and sex class (SX) were documented to determine which factors have the greatest impact on cattle body condition score (BCS).

Age Determination

Written documentation of reproductive or production performance records are non-existent on Il N'gwesi. Therefore three methods of extracting cattle age information were employed: 1) English speaking herdsmen were interviewed directly by the cattle evaluator, 2) non-English speaking herdsmen were interviewed by a Maasai enumerator and the information was translated to the cattle evaluator, and 3) when ownership of cattle was unknown a Maasai tribesmen was consulted and the age was estimated. To minimize inaccuracies, age was categorized into 3 groups: weanlings ($\leq$ 1 yr of age), yearlings (< 1 yr of age $\leq$ 3 yr of age), and mature ($\geq$ 3 yr of age).

Breed Composition

The small East African shorthorn zebu has been the breed of choice for Maasai pastoralists, and in fact, is referred to as the 'Maasai Zebu' by Rege and Tawah (1999). Maasai Zebu belong to a much larger classification known as *Bos indicus*, and therefore it was necessary to determine if any other breeds of cattle were amongst the population. Although it is known the breed composition of cattle living in Il N'gwesi contains some proportion of the Boran and Sahiwal breeds, the lack of written documentation concerning cattle production made determining specific breed composition impossible. However, the cattle were evaluated to determine *Bos indicus* and *Bos taurus* composition, and all 711 cattle were determined to be high majority (> 90%) *Bos indicus*. Accordingly, breed composition data were not included in data analysis.

Hide Color

The variability in HC inherent in *Bos indicus* cattle forced color to be categorized into 3 groups; light, spotted and dark. The light category was for cattle with ≥ 90% of the same white to light gray HC. The spotted category was for cattle with < 90% of the same HC regardless of shade. Cattle in the dark category had ≥ 90% of the same HC ranging from red to black.

Frame Score Analysis

The Beef Improvement Federation (BIF; USA) has established guidelines to objectively estimate mature skeletal frame size in beef cattle. Frame scores are determined by measuring the height of the animal at the hip and relating the hip height to the age of the animal. Each numerical change in FS represents approximately a 5.0 cm difference in height between cattle of the same age (Hammack and Gill, 2009). Table 1 and Table 2 illustrate how FS is determined for male and female cattle based on BIF guidelines. The lack of hip height measuring tools and reliable records to verify cattle age made FS determination a subjective measurement on Il N'gwesi. An evaluator with sufficient training in estimating FS based on visual appraisal determined approximate hip height, and combined this information with the estimated age of the cattle provided via enumerator translation to determine FS.

Body Condition Analysis

Visual evaluation of adipose and muscle/adipose tissue over backbone (including spinous and transverse processes), loin edge, hipbone, sacrum, pinbone, and ribcage, were used to determine BCS. The scoring method is based on a 1 to 9 scale whereas 1 is emaciated and 9 is obese (Whitman, 1975). This method is commonly used in the United States to measure the apparent nutritional status of beef cattle and was selected as the most appropriate choice to determine the condition of the pastoralists' cattle as little handling is required and the evaluation can be concluded rapidly. Measuring BCS is subjective, and therefore one evaluator, who previously had been trained to determine BCS, evaluated all 711 head of cattle to maintain consistent scoring. After documenting age, breed, hide color, frame score and sex class the evaluator observed each of the cattle and determined BCS.

Statistical Analysis

Data were analyzed using the REG procedure of SAS (SAS Inst. Inc., Cary, NC). A regression equation was determined to explain the variables responsible for changes in BCS. The model included the fixed effects of age, hide color, and sex class. The interaction of HC × FS was significant ($P < 0.001$) and therefore was included in the model. Independently, FS was determined to not be significant ($P > 0.05$) and was removed from the model. All other possible interactions were tested for and removed from the model if not significant ($P > 0.05$). Least squares means of age, HC, FS and SX, as well as the interaction between HC × FS were analyzed by *t*-test using the PDIFF option in PROC MIXED.

Results

Regression equation

A regression analysis of BCS for all cattle is reported in Table 3. Figure 1 illustrates the HC × FS interaction that was detected to have a negative correlation on BCS (-0.079, $P < 0.0001$). Light HC cattle had the greatest change in BCS as FS increased from 3 to 5 (3.6 to 2.87; $P < 0.01$) whereas the changes in BCS for spotted and dark HC cattle as FS increased from 3 to 5 was approaching a trend (3.55 to 3.18, 3.45 to 3.11; $P > 0.06$, respectively). A decrease in BCS was correlated to an increase in the age of cattle (-0.110, $P = 0.007$). Body condition scores increased as HC increased (light = 1, spotted = 2, dark = 3; 0.309, $P < 0.0001$). There was also an increase in BCS as SX classification increased (cow = 1, heifer = 2, bull = 3, steer = 4; 0.311, $P < 0.0001$).

Least squares means data

Least squares means data (Table 4) indicates there were differences in BCS based on age ($P < 0.001$), SX ($P <0.001$), and FS ($P < 0.001$), while no differences were attributed to HC ($P = 0.45$). Weanling and yearling aged cattle had 0.44 and 0.58 increased BCS compared to mature cattle (3.52, 3.66, and 3.08, respectively; $P < 0.001$. Body condition scores were more favorable for steers, bulls and heifers than cows (3.73, 3.60, 3.59, and 2.88, respectively; $P < 0.001$). The data also indicates frame scores have an impact on BCS. The smallest framed cattle (FS-3) and the largest framed cattle (FS-5 and FS-6) had greater ($P < 0.001$) BCS (3.41, 3.24 and 3.38, respectively) than FS-4 cattle (3.09).

Discussion

The BCS of cattle on Il N'gwesi is dependent upon multiple variables such as the nutrient quality and availability of forages, which is directly affected by weather patterns and grazing systems, cattle productivity and performance, and an array of management decisions made by cattle owners or herders. Our intent was to identify physical traits of cattle during a drought that may be contributing to changes in BCS. The influence these physical traits have on BCS could provide insight for developing selection criteria to improve cattle survivability on Il N'gwesi.

Though specific breed composition was unavailable for the current study, it is commonly understood that the Il N'gwesi cattle are comprised of the Boran and Sahiwal breeds. The differences in BCS based on the HC × FS interaction may provide breed composition information that could be used in future selection decisions. The Oklahoma State University (1995) breed profile indicates that the color pattern of Sahiwal cattle ranges from reddish brown to red with varying amounts of white on the neck which is categorized as dark HC in the present study. According to the Boran Cattle Breeders Society (2009) the average mature size of Boran cattle at the withers is: bulls, 117-147 cm; cows, 114-128 cm. Therefore most Boran cattle would fall into one of the smaller FS categories at maturity. Understanding these two breed character differences allows for inferences to be made regarding adaptability in relation to the HC × FS interaction. Light HC small framed cattle are presumably high majority Boran, and dark HC larger framed cattle accordingly are high majority Sahiwal, while other combinations of HC and FS are probably a more even composition of the two breeds. Data from the present study thereby suggests that attempting to capture the benefits of hybrid vigor by crossing Boran and Sahiwal breeds may lead to decreased BCS and ultimately lowered survivability rates.

Differences in BCS based on Age, SX, and FS classification, though independent, may be somewhat related. The mature age classification included cattle in various production stages including pregnancy and early lactation which are the production stages associated with the highest maintenance requirements, and have been shown to decrease cows' ability to maintain good BCS as they age (Renquisht, et al., 2006). While all of the cattle on Il N'gwesi were combating the drought; steers, bulls, and heifers, regardless of their stage of development would have lower maintenance requirements than cows in production. The absence of high quality forage compounded with the added stress of lactation and/or gestation would result in cows having greater depletion of energy reserves than cattle from the other SXs. Prior research of *Bos indicus* cows corroborates smaller framed cattle having increased BCS compared to larger framed cattle (Vargas, et al., 1999). Nearly all of the females in the present study were either FS-3 or FS-4 (FS-3 and FS-4 n = 348; FS-5 n = 22) indicating that the increased maintenance demands of cows were not associated with the FS-5 and FS-6 cattle as they were all males.

Implications

Ability to maintain body condition is partially attributed to the relationship between hide color and frame size, which may be an indicator of breed purity. The adaptive nature of both breeds in production on Il N'gwesi appears to be specific to each breed type. Therefore, the results of crossbreeding may be increasing the biological demands of cattle that exceed nutrient resources and compromise survivability. Weanlings and yearlings are more capable of maintaining body condition than mature cattle. Steers, bulls, and heifers inherently are more apt to survive droughts than cows in production. Additionally, the impact of FS is more directly associated to cows in production than to steers, bulls, and heifers, whereby smaller framed cows are more adaptable than large framed cows. The authors suggest that to sustain cattle production on Il N'gwesi further research should be continued to monitor new challenges that may arise due to changing weather patterns.

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Table 4.1. Frame score formula and chart for male cattle. Values within the tables are reported in centimeters

Males

Frame Score = -11.548 + .04878(Height) – 0.0289 (Days of Age) + 0.00001947 (Days of Age)^2 + 0.0000334(Height)(Days of Age)

Age in Months	Frame Score								
	1	2	3	4	5	6	7	8	9
5	83.75	88.75	93.75	98.75	104.00	109.00	114.00	119.25	124.25
6	87.00	92.00	97.00	102.00	107.25	112.25	117.25	122.25	127.50
7	90.00	95.00	100.00	105.25	110.25	115.25	120.25	125.25	130.50
8	93.00	98.00	103.00	108.00	113.00	118.00	123.25	128.25	133.25
9	95.50	100.50	105.75	110.75	115.75	120.75	125.75	130.75	135.75
10	98.00	103.00	108.25	113.25	118.25	123.25	128.25	133.25	138.25
11	100.50	105.50	110.50	115.50	120.50	125.50	130.50	135.50	140.50
12	102.50	107.50	112.50	117.50	122.50	127.50	132.50	137.50	142.50
13	104.50	109.50	114.50	119.50	124.50	129.50	134.50	139.50	144.25
14	106.25	111.25	116.25	121.25	126.00	131.00	136.00	141.00	146.00
15	107.75	112.75	117.75	122.75	127.75	132.50	137.50	142.50	147.50
16	109.00	114.00	119.00	124.00	129.00	134.00	139.00	143.75	148.75
17	110.25	115.25	120.25	125.25	130.00	135.00	140.00	145.00	150.00
18	111.25	116.25	121.25	126.25	131.00	135.25	141.00	146.00	150.75
19	112.25	117.00	122.00	127.00	131.75	136.00	141.75	146.75	151.50
20	112.75	117.75	122.75	127.50	132.50	137.50	142.25	147.25	152.25
21	113.25	118.25	123.00	128.00	133.00	137.75	142.75	147.75	152.50

Adapted from Beef Improvement Federation, 2002

Table 4.2. Frame score formula and chart for female cattle. Values within the tables are reported in centimeters

Females

Frame Score = -11.7086 + .4723(Height) – 0.0239 (Days of Age) + 0.0000146 (Days of Age)^2 + 0.0000759(Height)(Days of Age)

Age in Months	Frame Score								
	1	2	3	4	5	6	7	8	9
5	82.75	87.75	93.00	98.25	103.25	108.50	113.75	118.75	124.00
6	85.25	90.50	95.50	100.75	105.75	111.00	116.25	121.25	126.50
7	87.75	92.75	98.00	103.00	108.25	113.25	118.50	123.50	128.75
8	90.00	95.00	100.25	105.25	110.25	115.50	120.50	125.50	130.75
9	92.00	97.25	102.25	107.25	112.25	117.50	122.50	127.50	132.50
10	94.00	99.00	104.00	109.25	114.25	119.25	124.25	129.25	134.50
11	95.75	100.75	105.75	110.75	116.00	121.00	126.00	131.00	136.00
12	97.50	102.50	107.50	112.50	117.50	122.50	127.50	132.50	137.50
13	99.00	104.00	109.00	113.75	118.75	123.75	128.75	133.75	138.75
14	100.25	105.25	110.25	115.25	120.00	125.00	130.00	135.00	140.00
15	101.50	106.50	111.25	116.25	121.25	126.25	131.00	136.00	141.00
16	102.50	107.50	112.25	117.25	122.25	127.00	132.00	137.00	141.75
17	103.50	108.25	113.25	118.00	123.00	127.75	132.75	137.75	142.50
18	104.25	109.00	114.00	118.75	123.75	128.50	133.50	138.25	143.25
19	104.75	109.75	114.50	119.25	124.25	129.00	134.00	138.75	143.50
20	105.25	110.25	115.00	119.75	124.50	129.50	134.25	139.00	144.00
21	105.75	110.50	115.25	120.00	125.00	129.75	134.50	139.25	144.25

Adapted from Beef Improvement Federation, 2002

Table 4.3 Regression equation of body condition scores of Il N'gwesi cattle.[1]

		Estimates of coefficients						
Item,	Intercept	Age[2]	HC[3]	SX[4]	HC×FS[5]	SE[6]	R^2 [7]	*P*-value[8]
BCS	2.87	-0.110	0.309	0.311	-0.079	0.14	0.22	<0.0001

[1]Regression equations based on change in BCS based on age, hide color, sex class and the interactions between color × frame score and sex class × frame score.

[2]Age of cattle; weanling = 1, yearling = 2, mature = 3

[3]Hide color; light = 1, spotted = 2, dark = 3

[4]Sex class; cow = 1, heifer = 2, bull = 3, steer = 4

[5]Interaction between hide color and frame score

[6]Standard error of the model

[7]Coefficient of determination of the model

[8]*P*-value of the model

Table 4.4. Least squares means of body condition scores of Il N'gwesi cattle by age, hide color, sex class and frame score.

Variable	Classification				SEM[1]	*P*-Value
Age	*Weanling*	*Yearling*	*Mature*			
n	101	152	458		-	-
Mean	3.52^a	3.66^a	3.08^b		0.08	< 0.001
Hide Color	*Light*	*Spotted*	*Dark*			
n	286	152	273		-	-
Mean	3.22	3.28	3.30		0.06	0.45
Sex Class	*Steer*	*Bull*	*Heifer*	*Cow*		
n	106	135	122	348	-	-
Mean	3.73^a	3.60^a	3.59^a	2.88^b	0.07	< 0.001
Frame Score	*3*	*4*	*5*	*6*		
n	335	275	80	21	-	-
Mean	3.41^a	3.09^b	3.24^a	3.38^a	0.17	< 0.001

[1]The greatest SEM was presented

[ab]Means within a row lacking a common superscript differ ($P \leq 0.05$)

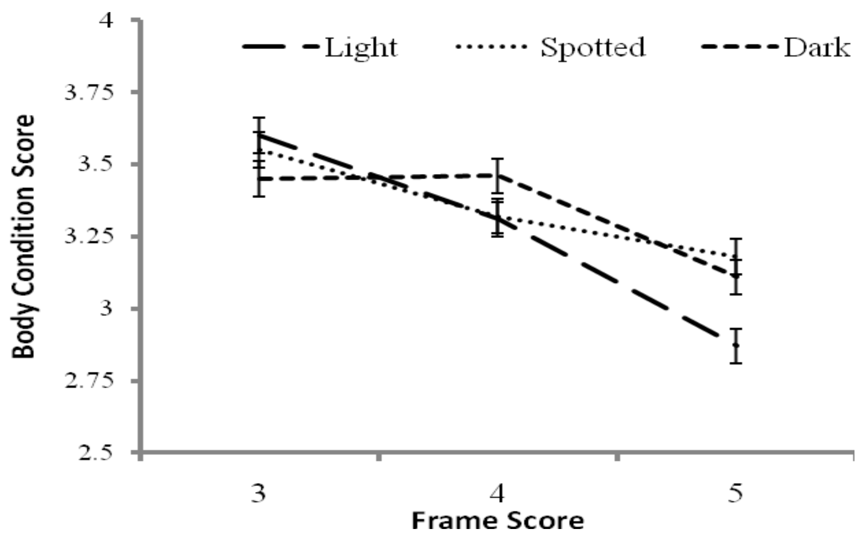

Figure 4.1. Hide color x frame score interaction ($P < 0.01$) for changes in body condition scores of cattle on Il N'gwesi Group Ranch. Cattle were categorized by hide color, light (≥ 90% same white or light gray hide color), spotted (< 90% same color hide regardless of shade), and dark (≥ 90% same dark red to black hide color).

CHAPTER 5

SUMMARY

Domestic beef production is focused on producing more pounds of beef with greater obstacles than ever before in history. Fewer land resources, a reduction in the national cow herd, greater production restrictions, and an increasing population are all contributing factors to the current situation. Fortunately, feed ingredients such as ractopamine hydrochloride (RH) have been developed and are able to promote growth efficiency without minimal detriment to carcass characteristics with low dosage rates. However, determining the most effective dosage rate and feeding protocol to maximize growth and carcass characteristics is still unknown. Sufficient research to conclude the effects of RH on reproductive efficiency in beef cattle are still undetermined as well. An understanding of the influence ß-adrenergic agonists, such as RH, could have on reproductive performance lends credence to hypotheses that supplementation of such feed ingredients may improve beef production through decreasing the postpartum anestrous interval and increasing pregnancy rates. In other parts of the world, specifically Kenya, Africa, beef cattle are raised for much different reasons than simply producing a consumable product as is the case in the United States. Cattle have an intrinsic value that allows them be viewed as a source of wealth, rather than as a commodity to produce wealth. Accordingly, culling strategies are rare or completely non-existent in many production settings. During times of extreme drought, however, cattle owners cull cattle out of necessity, but unfortunately have little guidance in making herd reduction decisions. By determining which easily identifiable factors can be selected for, or against, owners could make more informed culling decisions that will benefit cattle survivability rates during extreme weather conditions.

The results from the first study presented reveal that continuous supplementation of RH to steers during the final 42 days prior to harvest does not alter growth rates and can have a negative effect on final marbling scores which may potentially decrease quality grades. Feeding RH in a step-up protocol did not have any effect on finishing performance or carcass characteristics. Accordingly, the increased input cost of feeding RH to the steers in the present study did not provide an associated increase in production efficiency or final carcass value. The experiment presented in Chapter 3 of the current document reports that RH supplementation to lactating two-year old cows decreases the amount of BCS and BW lost following parturition, but did not have any effect on follicular dynamics or pregnancy rates. A numeric decrease in pregnancy rates was reported, however, in RH supplemented cows compared to the control treatment. This numeric decrease suggests that the time of removal of dietary RH may have an impact on reproductive function. The two trials focusing on dietary RH administration both produced results that fail to clarify the most appropriate method of supplementing RH to optimize beef production efficiency. Instead, the results of the experiments create new inquiries that reinforce the value of conducting additional research to determine optimal dosage rates and the most appropriate physiological time periods to elicit to most effective response to RH supplementation in both males and females.

The final study presented focused on the dilemma changing weather patterns are having on the survivability of cattle living on Il N'gwesi Group Ranch in Kenya, Africa. Due to a lack of scientific measuring tools available to cattle owners on the group ranch, it was determined that analyzing physical features of the cattle via visual evaluation was the most appropriate method for a developing a culling strategy to predict drought sustainability. It was reported that the relationship between hide color and frame size has an effect on body condition whereas those cattle that exhibit the hide color and frame size most associated with pure breeds of cattle that have been adapted to the local arid climate had greater nutrient stores. Additionally, mature cattle and cows, regardless of frame size, exhibited less body condition. While understanding which basic physical traits can be selected against to improve survivability rates provides the initial steps to implement a culling protocol, further research should be carried out to elucidate the most appropriate method of reducing herd size to maintain livestock production without compromising the pastoralist culture.

VITA

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EDUCATION:

Purdue University, College of Agriculture, West Lafayette, IN
Master of Science in Agricultural Education May 2010
***Specialization*:** Extension Education
***Thesis*:** Investigating methods for using ractopamine hydrochloride in domestic beef cattle and factors affecting body condition of cattle on Il N'gwesi group ranch in Kenya, Africa
Major Professors: Dr. Clinton P. Rusk and Dr. Roger L. Tormoehlen
Research Professors: Dr. G. Allen Bridges and Dr. Scott L. Lake
Cumulative GPA: 3.60/ 4.0

Texas A&M University, College of Agriculture and Life Sciences, College Station, TX
Bachelor of Science in Animal Science (Production Option) May 2007
Cumulative GPA: 3.74/ 4.0
Graduated Magna Cum Laude

Connors State College, Department of Agriculture, Warner, OK
Associate of Science in Agriculture May 2005
Cumulative GPA: 3.93/4.0
Graduated Magna Cum Laude

RESEARCH INTERESTS and LABORATORY PROCEDURES:

- Evaluating the effects of ß-adrenergic agonists on performance and carcass characteristics of finishing steers and reproductive efficiency of cows
- Assessment of group ranch livestock production methods in Kenya, Africa, and development of educational materials to improve production practices
- Utilization of extension programming to communicate animal science topics to youth
- Radioimmunoassay determination of circulating serum progesterone concentrations

- Collect, dry freeze, and store post-mortem adipose and protein tissue samples of beef cattle for mRNA and nutrient analysis
- Utilization of ultrasonography techniques to map follicular development on cow ovaries and track changes in 13th rib subcutaneous fat deposition in finishing cattle

CERTIFICATIONS:

- National Embryo Transfer School, Senatobia, MS; Beef Cattle Embryo Transfer Technician
- Texas A&M University Advanced Reproductive Management Course, College Station, TX; Beef Cattle Artificial Insemination Technician

WORK EXPERIENCES:

Graduate Student Assistant August 2009-Present

Purdue University; West Lafayette, IN –
Department of Youth Development and Agricultural Education

- Assist with preparation and execution of 4-H livestock shows at Indiana State Fair
- Coordinate state 4-H/FFA animal science focused career development events, including Livestock Skill-a-Thon, Meats Evaluation and Livestock Evaluation
- Co-manage statewide youth educational programs, such as Indiana Junior Pork Day and Purdue Animal Science Workshops for Youth
- Expand collaborative teaching efforts between faculty and staff from multiple departments, as well as between Animal Sciences Research and Education Center unit managers and prominent livestock producers in order to effectively deliver youth animal science programming
- Co-develop a comprehensive youth livestock judging initiative, including two one-day introductory camps, a four-day experiential learning camp and a youth workshop for coaches

Graduate Research Assistant August 2007-August 2009

Purdue University; West Lafayette, IN – Department of Animal Sciences

- Studied the nutritional impacts of ractopamine hydrochloride on beef steers and lactating primiparous cows
- Evaluated the production and marketing methods of pastoralists in Kenya, Africa, as well as physical attributes that may affect the body condition of their cattle
- Assisted advisor and peers in various activities, in addition to completing thesis research
- Conducted statistical analysis on data available from studies
- Developed a mutually beneficial working environment between myself and beef unit management and staff

- Handled livestock and collected respective data samples in a humane and ethical manner
- Instructed the principles of livestock evaluation to undergraduate students

Summer Extension Intern; Huntington, IN Summer 2007
Purdue University Cooperative Extension; *West Lafayette, IN*
- Obtained hands-on experience in the occupation of Extension education
- Organized and promoted multiple programs geared toward enhancing the education of local residents through group workshops, specific topics included: financial planning, impacts of poverty, farm safety, and livestock production
- Developed teaching materials based on entomology life cycles to be used for experiential learning with butterfly gardens at local elementary school
- Managed PQA youth certification filing and database update

Livestock Handler August 2005-May 2007
Navasota Livestock Auction; Navasota, TX
- Directed livestock consignments to systematic locations in order to maximize sale efficiency and livestock needs
- Monitored sale inventory to ensure transaction accuracy
- Calculated load weights for transportation that minimized animal welfare concerns without constraining pre-established timing deadlines

Junior Gilt Show Intern February 2007
San Antonio Livestock Exposition; San Antonio, TX
- Designed swine show ring and show ring entrance to promote a low-stress environment for livestock and exhibitors
- Managed show ring activities in an effort to provide an exceptional learning experience for youth, all while promoting safe animal handling practices
- Represented the College of Agriculture and Life Sciences at Texas A&M University by interacting with show officials and Texas livestock industry leaders

Sales and Marketing Intern; Starkville, MS Summer 2006
Elanco Animal Health; Greenfield, IN
- Executed strategic marketing and sales initiatives by meeting with existing clients and identifying new customers
- Developed a retention plan for newly recognized stocker cattle key accounts
- Established business relationships with veterinarians, stocker cattle producers, sale barn managers, and influential livestock producers in Alabama, Mississippi, and Louisiana
- Presented biweekly reviews to personal supervisor, culminating in an overall internship analysis presentation to leading Elanco professionals

Livestock Breeds Display Intern October 2005

State Fair of Texas; Dallas, TX

- Provided general care, including feeding, watering, and washing, approximately 40 head of livestock; 20 cattle, 10 swine, and 10 sheep and goats combined
- Maintained an educational display, geared toward non-agriculturally affiliated fair visitors, explaining the purpose and characteristics of various breeds of livestock
- Educated fair visitors on multiple topics, such as animal welfare, livestock production methods, and the life cycle of food animals through display tours

Student Worker August 2003-May 2005

Connors State College Ranch; Warner, OK

- Assisted in the daily operation of a working livestock ranch consisting of 350 cows, 30 ewes, and a 100 head capacity bull test, which functions twice a year
- Supervised in the breeding and management decisions of a 10-head swine unit, in addition to the preparation of introductory animal science labs

TEACHING EXPERIENCES:

Teaching Assistant Spring 2010

Purdue University; West Lafayette, IN

YDAE 591 – Animal Science Education for Youth

- Introduce opportunities to enhance current 4-H/Youth education efforts through multimedia and specific content instruction, including the 4-H SET initiative
- Oversee development of animal science directed educational materials to be used by Extension staff and volunteers involved with youth animal science projects
- Supervise creation of proper animal care verification forms for youth to be used in conjunction with Indiana Farm Bureau's "Champions of Animal Care" program

Assistant Livestock Judging Coach Fall 2007-Fall 2009

Purdue University; West Lafayette, IN

- Coordinated on-site visits to livestock industry leaders and producers for experiential learning opportunities
- Taught fundamentals of visual livestock appraisal and its application to livestock production
- Instructed students on various livestock production and marketing systems and the importance of establishing protocols to maintain safe animal welfare, while enhancing production efficiency
- Trained the interpretation of livestock production data and their implementation as a selection tool for beef cattle, swine, and sheep
- Educated students on the proper format and delivery of oral reasons for defending livestock placings, and the crossover value of communication skills in all careers

Teaching Assistant Fall 2009

Purdue University; West Lafayette, IN

ANSC 301 – Growth and Development of Livestock, Laboratory

- Taught live evaluation and pricing of swine
- Presented important characteristics in swine carcass evaluation
- Educated proper use of formulas to determine pork carcass value
- Assisted in planning and preparation of laboratory schedule

Teaching Assistant Fall 2006

Texas A&M University; College Station, TX

ANSC 315 – Livestock Evaluation

- Assisted in development of learning materials for class text
- Delivered course content to over 60 undergraduate animal science students
- Facilitated the application of information and evaluation techniques taught in the classroom through live animal evaluation labs

INVITED PRESENTATIONS:

- **Selecting 4-H Swine Projects**: Indiana Junior Pork Day; Purdue University, West Lafayette, IN (2009 & 2010)
- **Successfully Completing Livestock Enrollment Forms**: 4-H Youth Development Skills Café Training Breakout Session; Purdue University, West Lafayette, IN (2010)
- **Beef Cattle Grading**: Purdue Animal Science Workshops for Youth; West Lafayette, IN (2008 & 2009)
- **Understanding Livestock Carcass Grades**: ANSC 370 – Livestock Evaluation; Purdue University, West Lafayette, IN (2008, 2009)
- **Scenarios and Performance Data**: ANSC 370 – Livestock Evaluation; Purdue University, West Lafayette, IN (2008 & 2009)
- **Estrus Detection and Artificial Insemination in Swine**: Seminar Presentation; Casper College, Casper, WY (2009)
- **How to Check Pregnancy in Swine Using Ultrasonography**: ANSC 443 – Swine Management, Laboratory; Purdue University, West Lafayette, IN (2009)
- **Live Evaluation of Market Swine**: Purdue Animal Science Workshops for Youth; West Lafayette, IN (2009)
- **Introduction to Swine Evaluation**: "Tradition in Excellence" Livestock Judging Camp; Connors State College, Warner, OK (2009)
- **Selecting Breeding Heifers**: Indiana Junior Beef Cattle Association Leadership Day; Purdue University, West Lafayette, IN (2008)
- **Presenting Oral Reasons**: Clinton Central FFA Chapter Livestock Judging Practice; Michigantown, IN (2008)

ORGANIZATIONAL MEMBERSHIPS:

- American Society of Animal Science
- National Swine Registry
- Certified Pedigreed Swine
- Phi Theta Kappa International Honor Society

ACTIVITIES:

- Children International Child Sponsor (2008 – Present)
- 4-H/FFA Youth Livestock Exhibition Judge in the following states by the completion of 2010:
    - Arizona, Arkansas, Florida, Illinois, Indiana, Michigan, Missouri, Nebraska, Ohio, Oklahoma, Tennessee, Texas, Utah, and Wisconsin.
- 4-H/FFA Youth Livestock Judging Event Official at the following state and national contests by the completion of 2010 in addition to numerous local and regional events:
    - *National 4-H*, Louisville, KY; *National FFA*, Indianapolis, IN; *Ak-Sar-Ben*, Omaha, NE; *Arizona National*, Phoenix, AZ; *Indiana State Contest*, West Lafayette, IN; *Texas State Contest*, College Station, TX; *San Antonio Livestock Exposition*, San Antonio, TX; and *Stockman Judging Contest*, Frankfort/Michigantown, IN.
- Department of Youth Development and Agricultural Education Strategic Planning Workshop Contributor, Purdue University (2009)
- Department of Youth Development and Agricultural Education Faculty Candidate Interviews Graduate Student Interviewer, Purdue University (2009)
- “Tradition in Excellence” Livestock Judging Camp Counselor, Connors State College (2009)
- Official Judge: National FFA Job Interview CDE; Indianapolis, IN (2008)
- Saddle and Sirloin member, Texas A&M University (2005-2007)
- Saddle and Sirloin Yearbook Contributing Writer, Texas A&M University (2006 & 2007)
- Saddle and Sirloin Ham Trimming Contest Co-Chair (2007)
- International Livestock Congress Delegate; Calgary, AB, Canada (2007)
- Student Senate Vice President, Connors State College (2004-2005)
- Chairman of “Student Activities” Committee, Connors State College (2004-2005)
- Aggie Club Treasurer, Connors State College (2004-2005)
- Chairman of “Make a Difference Day” Committee, Connors State College (2005)
- Youth Livestock Judging Camp Counselor, Texas A&M University (2005)
- Tulsa State Fair Swine Show Volunteer (2003 & 2004)
- State President, Indiana FFA Association, Trafalgar, IN (2002-2003)
- American FFA Degree Recipient (2003)
- Ten year 4-H member in Adams County, IN (1993-2002)

AWARDS AND HONORS:

- Animal Science Department Academic Scholarship, Texas A&M University (2005-2007)
- L. D. Wythe Memorial Judging Contest; High Individual Meats Evaluation, Texas A&M University (2005)
- Dean's Honor List, Texas A &M University (2005-2007)
- Named "Mr. Connors" (Outstanding Graduating Male Student of the Year), Connors State College (2005)
- President's Honor List Fall 2004 and Spring 2005, Connors State College
- Vice President's Honor List Fall 2003 and Spring 2004, Connors State College

Livestock Judging Team Texas A&M University (Undefeated National Champions – 2006)

- Collegiate Livestock Coaches' Association All-American
- Arizona National – Champion Team; High individual
- National Western Stock Show – Champion Team; Reserve high individual
- Dixie National – Champion Team; Twelfth high individual
- San Antonio Livestock Exposition – Champion Team; Reserve high individual
- Houston Livestock Show and Rodeo – Champion Team; Sixteenth high individual
- National Barrow Show – Champion Team; High individual overall
- State Fair of Texas – Champion Team; Third high individual
- Mid-South Fair – Champion Team; Third high individual
- American Royal – Champion Team; Thirteenth high individual
- NAILE – Champion Team; Reserve high individual

Livestock Judging Team Connors State College (2003 -2005)

- Junior College Coaches' Association All-American
- Arkansas-Oklahoma State Fair Champion Team; High individual *Both Freshman and Sophomore Years*
- Tulsa State Fair – Freshman– Fourth high team; High individual – Sophomore – Reserve High Team; Fourth high individual
- Louisiana State Fair – Champion Team; Third high individual
- American Royal – Eighth high team; Fifteenth high individual
- Cow Palace – Fourth high team; Fourth high individual
- NAILE – Third high team; Twelfth high individual
- Express Ranches Invitational – Champion Team; Seventh high individual
- Arizona National – Fifth high team; Eleventh high individual
- National Western – Fifth high team; Fourteenth high individual
- Southwest Livestock Exposition – Fifth high team
- San Antonio Livestock Exposition – Fifth high team
- Houston Livestock Show and Rodeo – Seventh high team; Twelfth high individual *Freshman year*

ABSTRACTS AND SCIENTIFIC PRESENTATIONS:

Culp, K. C., R. P. Lemenager, M. C. Claeys, P. J. Gunn, M. Van Emon, R. P. Arias, S. L. Lake, and G. A. Bridges. 2009. Efficacy of the 5 day CO-Synch estrous synchronization protocol with or without the inclusion of a CIDR in beef cows. J. Anim. Sci. 87(E-Suppl. 1):372. (Abstr.)

Culp, K. C., C. Fleenor, M. Claeys, R. Lemenager, and S. Lake. 2009. Effects of differing levels of glycerol supplementation on performance and carcass characteristics in feedlot steers. J. Anim. Sci. 87(E-Suppl. 3):128. (Abstr.) Poster Presentation.

Gunn, P. J., **K. C. Culp**, R. P. Arias, R. P. Lemenager, K. Heaton, S. L. Lake, and G. A. Bridges. 2009. Comparison of the CIDR Select and 5 day Co-Synch + CIDR protocols for synchronizing estrus in beef heifers. J. Anim. Sci. 87(E-Suppl. 1):265. (Abstr.)

Gunn, P., S. Lake, M. Claeys, and R. Lemenager. 2008. Effects of dietary fat and crude protein on feedlot performance and carcass characteristics in steers fed differing levels of distiller's dried grains with solubles. J. Anim. Sci. 86(E-Suppl. 3):115. (Abstr.) **Oral Presentation**.

EXTENSION PUBLICATIONS AND RESEARCH REPORTS:

Bridges, A., S. Lake, R. Lemenager, M. Claeys, P. Gunn, and **K. Culp**. 2009. Choosing an estrous synchronization program for replacement beef heifers. Available online at http://www.extension.purdue.edu/extmedia/AS/AS_592_W.pdf.

Bridges, A., S. Lake, R. Lemenager, M. Claeys, and **K. Culp**. 2009. Cost-Effective timed-AI options for beef cows. Available online at http://www.extension.purdue.edu/extmedia/AS/AS_592_W.pdf.

Culp, K., R. Lemenager, M. Claeys, I. Brooke, and K. Kuykendall. ß-adrenergic agonists in the show ring: A look at feeding ractopamine hydrochloride and zilpaterol hydrochloride to youth livestock projects. *In preparation*

Culp, K. C, and S. L. Lake. Il N'gwesi guide to body condition scoring. *In preparation*

MANUSCRIPTS IN PREPARATION:

Culp, K. C., M. C. Claeys, R. P. Lemenager, L. S. Lopes, C. K. Larson, and S. L. Lake. Effects of supplemental copper source on feedlot performance and carcass characteristics in finishing steers fed diets with elevated sulfur.

Culp, K. C., C. P. Rusk, G. A. Bridges, and S. L. Lake. Factors affecting body condition of cattle on Il N'gwesi group ranch.

Culp, K. C., and S. L. Lake. Effects of wealth class on beef cattle production and marketing strategies on Il N'gwesi group ranch.

Culp, K.C., M. C. Claeys, R. P. Lemenager, C. P. Rusk, G. A. Bridges, and S. L. Lake. Effects of continuous and step-up ractopamine hydrochloride supplementation protocols on feeding performance and carcass characteristics of finishing steers.

Culp, K.C., M. C. Claeys, R. P. Lemenager, C. P. Rusk, S. L. Lake, and G. A. Bridges. Effects of ractopamine hydrochloride supplementation on reproductive efficiency and weight change in young, growing, lactating beef cows.