MANAGEMENT CONSIDERATIONS FOR SUCCESSFUL TECHNOLOGY IMPLEMENTATION IN BEEF PRODUCTION SYSTEMS

A Thesis
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Sciences

By

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In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Animal Sciences

April 2015

Fargo, North Dakota

North Dakota State University
Graduate School

Title

Management Considerations for Successful Technology Implementation in Beef Production Systems

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

Two experiments were conducted to evaluate management strategies that foster successful implementation of technology in beef production systems. In experiment 1, cow reproductive performance, BW, and serum concentrations of NEFA in cows and their calves were evaluated in response to moving cow-calf pairs from summer pastures into confinement feeding for a 10 d period of estrus synchronization and breeding. Reproductive performance was not impacted but calf BW were reduced in confined calves. In experiment 2, effects of moderate and aggressive implant strategies were evaluated in steers with varying genetic potential (GP) for gain and marbling. Steers with greater GP had greater intramuscular fat percentage before consuming high concentrate diets, and improved carcass marbling scores and quality grade compared with low genetic potential steers. Carcass marbling in steers of greater GP for marbling tended to be more sensitive to implant strategy than that of steers with lesser GP.

ACKNOWLEDGEMENTS

Dr. Dahlen, thank you for pushing me, for the laughs, and for the adventures. I am so appreciative of this entire experience you have provided and thankful for your guidance and mentorship. To my committee members, Drs. Joel Caton, Bryan Neville, and Kevin Sedivec thank you for your support and commitment to helping me succeed.

I owe a huge thank you to all of the help I received throughout my projects. The undergraduate students, Stephanie Gross, Kelli Chinn, Scott Alm, and Jordan Zenker, who toughed out the early mornings and blizzards to feed, the staff at ANPC, Terry Skunberg and Justin Gilbertson, the staff at the Central Grasslands, Rodney Schmidt and Cody Molle, and the hospitality of Dr. Bryan and Tammi Neville. These projects could not have gone smoothly without your hard work and dedication. Thank you all, so much.

Fellow graduate students, specifically Mellissa Crosswhite, Nichole Chapel, Casie Bass, Mattia Gunkleman, and Jordan Hieber, thank you for being my cheerleaders, supporters, and friends. You have helped to make this great experience, one of a kind.

Ty, thank you for your love and grace, and for supporting and believing in me. Mama, thank you for the constant supply of care packages, the surprise visits, and, most of all, your unconditional, loving support. Family and friends, thank you for the constant encouragement, love, and prayers, I am blessed to have you in my support system.

DEDICATION

Handsome Grandpa,

you instilled a passion, you believed in me,

you watched over me

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LIST OF ABBREVIATIONS

ADG	average daily gain
AGG	aggressive implant strategy
AI	artificial insemination
BCS	body condition score
BW	body weight
CAB	Certified Angus Beef
CIDR	controlled internal drug release
CON	control treatment group
CP	crude protein
CV	coefficient of variance
d	day
DF	dominant follicle
DL	dry lot treatment group
DM	dry matter
DMI	dry matter intake
DOF	days on feed
DPP	days post-partum
E_2	estradiol
ES	estrus synchronization
FTAI	fixed-time artificial insemination
g	gram
G:F	feed efficiency
GnRH	gonadotropin releasing hormone
GP	genetic potential
H	high genetic potential
ha	hectare

HCW	hot carcass weight
hr	hour
i.m.	intramuscular
IMF	intramuscular fat
IMFUS	percent intramuscular fat determined via ultrasound
kg	kilogram
km	kilometer
KPH	percent kidney, pelvic, and heart fat
L	low genetic potential
LH	luteinizing hormone
LM	longissimus muscle
LMA	longissimus muscle area
LMAUS	longissimus muscle area determined via ultrasound
m	meter
Mcal	mega calorie
mg	milligram
MOD	moderate implant strategy
NEFA	non-esterified fatty acid
NEg	net energy of gain
NE_m	net energy of maintenance
P_4	progesterone
RBFTUS	rib fat thickness determined via ultrasound
RF	rib fat
RMPFTUS	rump fat thickness determined via ultrasound
TBA	trenbolone acetate
YG	yield grade
µg	microgram

CHAPTER 1. INTRODUCTION AND REVIEW OF LITERATURE

Introduction

Over the past 35 years, total cattle inventory in the United States has declined, but pounds of beef production has continued to increase. Between 1980 and 2009 there was a 15% decrease in the total number of cattle and a 21% increase in pounds of beef production, with a net result of a 40% increase in pounds of beef produced per cow (NAHMS, 2009). This gain in efficiency can partially be attributed to the implementation of technologies such as antibiotics, growth-promoting implants, ionophores, parasiticides, beta-agonists, and vaccines in all sectors of the beef cattle industry.

A 2013 survey of North Dakota beef producers indicated that of those who plan to remain in the industry beyond 10 years, 22.6% are likely to use DNA profiling, 51% implement AI, 14% use embryo transfer, and 35.7% implant calves within the next five years (Schook et al., 2014). This is encouraging, as current adoption rate of some technologies in the United States are low. Between 1978 and 2007, the average herd size in the United States increased by 20% and, specifically, in North Dakota, increased 88% (USDA, 2009). As operations increase the number of females maintained on their operation, producers will continue to strive for further efficiency, looking for management strategies to optimize available resources, successfully implement technology, and maximize returns.

Within the cow-calf sector of the industry, considerable technology is focused on reproductive efficiency, most likely due to its vitality of a profitable cow-calf production system (Dzuik and Bellows, 1983). Artificial insemination (AI) and estrous synchronization (ES) are examples of reproductive technologies which, when used together, can benefit producers in a number of ways. Benefits of ES with fixed-time AI (FTAI) include increasing calf uniformity, heavier weaning weights, induce cyclicity in non-cycling females, increase rate of genetic improvement, and ability to incorporate superior genetics without owning a similar quality live bull (Nicholas, 1996; Lucy et al., 2001; Lamb et al., 2010; Rodgers et al., 2012; Steichen et al., 2013). Despite the potential benefits, less than 8% of all beef cattle operations used AI and ES in 2007 due largely to time and labor constraints (NAHMS, 2009). Current recommended protocols of FTAI require cattle to be handled a minimum of 3 times within a 10 to 14 d window. For producers with cattle that have access to hundreds of acres or more, gathering multiple times within a short time period can be a daunting task. There is a need to discover methods to incorporate AI while minimizing time and labor requirements without compromising pregnancy rates.

Another technology, genomics, has the potential to generate value in each sector of the beef industry by aiding in both management and selection decisions (Van Eenennaam and Drake, 2012). Genetic markers do not directly influence profit, but rather offer indications of how traits of economic importance such as growth and carcass traits, will be expressed in individuals, which in turn can influence profitability. Therefore, to understand the implications of genomic value, it needs to be determined whether phenotype of cattle with varying genetic potentials are differentially expressed in production scenarios. Previous work has shown positive correlation between gene markers and actual performance (DeVuyst et al., 2011); however additional examination of observed phenotype in animals with varying genotype is warranted. Early indications of future feedlot performance, obtained by genetic evaluation, may provide feedlot managers with an additional way to manage cattle with other available technologies, such as growth-promoting implants.

This literature review will discuss 2 specific management strategies for use with current technologies available to producers. First to be discussed is reproductive technologies, followed by performance of steers with differing genetic potentials in conjunction with different implant strategies.

Reproductive Technologies

Current Use

Estrus synchronization protocol research increased rapidly in the early 2000's with the formation of the Beef Reproduction Task Force, which was formed in order to coordinate efforts in breeding management protocols and deliver current research results to relevant audiences (Johnson et al., 2011). Research efforts were focused on reducing the number of handlings and cost without compromising fertility. With this research it became evident that there was variation across locations despite use of same protocol. Larson et al. (2006) reported that pregnancy rates to AI from 14 herds in 7 different states managed on a similar ES and AI protocol varied by as much as 30 percentage units. There is not a clear indication of specific variables responsible for variation in pregnancy results among locations, but likely a multitude of factors are responsible; a portion of which can be controlled by herd managers and others which cannot. Though factors such as weather cannot be controlled, things such as animal handling and managerial decisions are easier to control across locations and should be considered when designing experiments related to efficacy of ES and AI.

In an effort to educate producers about the use and benefits of AI, 11 workshops (Applied Reproductive Strategies in Beef Cattle) were hosted throughout the country by local university Animal Science Department faculty and National Cattlemen's Beef Association personnel. Following workshops in 2008 and 2010, attendees were given a survey to determine if any production changes were actually made based on information gained at the meetings. Thirty-one percent of respondents increased number of cows bred via AI, 40% increased use of single FTAI, 28% observed increased pregnancy rate to AI, and 71% had an increased overall confidence in AI programs. (Johnson et al., 2011). As research continues to identify ways to ease the labor constraints of AI protocols and increase pregnancy rates to AI, use of AI would be expected to increase.

Implications of Dry Lot Management around Breeding

As knowledge and confidence increases, producers may implement short term management practices to accomplish FTAI in order alleviate the inevitable time and labor. Practices may include moving cattle to confined lots or pastures during the synchronization period to save time gathering cows. Though little research has been done on management strategies around the time of breeding, there are certain aspects that should be taken into account. Managing cattle in confined settings most likely involves a change in diet and environment. In addition to reproductive performance of cows, the potential impacts on growth potential of suckling calves should also be considered when confining cow-calf pairs for FTAI. Confining cow-calf pairs to a dry lot for a short period of time may affect cow reproductive performance, milk production, and energy balance and calf performance, specifically, body weight (BW).

Animal performance could be variable depending on their experience in the respective environment. If animals are provided unfamiliar feed sources, they may have a reduced intake. Flores et al. (1989) reported that lambs which had experience grazing grass forage had a greater intake rate of grass than lambs which were only experienced with shrub forage, indicating lambs which are experience at foraging have better skills and are able to ingest more food compared to inexperienced lambs. This foraging concept may also be applied to cows and/or calves.

If an animal is not receiving adequate dietary energy, it is considered to be in negative energy balance, and, body reserves (adipose and protein) will be used for energy (Brennan et al, 2009). When adipose tissue is catabolized for energy, non-esterified fatty acids (NEFA) are released and circulating blood concentrations increase; therefore, evaluating blood NEFA concentration can give an indication of energy balance (Lucy et al., 1991; Brennan et al., 2009).

Cows

Previous research indicates that abrupt diet changes can negatively impact reproductive performance (Hill et al., 1969; Perry et al., 2009; Bridges et al., 2012). For example, when heifers are developed in a feedlot and immediately turned out to pasture after AI, pregnancy success to AI is reduced compared to heifers developed on pasture (Perry et al., 2009; 2013). The reduction in pregnancy rates of feedlot developed heifers were positively related to post AI weight change. It is unclear of the exact mechanisms of how acute changes in nutrition can alter reproductive performance. Circulating hormones and metabolites such as growth hormone, NEFA, leptin, glucose and insulin may play a role in embryo development via alteration of the uterine histotroph (secretions of nutrients for early conceptus development); but further studies are warranted to consider this potential phenomenon (Leroy et al., 2008). Perry et al. (2009) reported no difference in circulating glucose on d 0 relative to breeding between heifers that became pregnant and heifers that did not become pregnant; however, on d 11, pregnant heifers had 5% more circulating glucose than non-pregnant heifers. Block et al. (2011) reviewed the importance of insulin-like growth factor-1 (IGF-1) on post-transfer embryo survival in stressed cows. Perhaps a change in these metabolites due to a diet alteration may explain an imbalance in the uterine histotroph. Kruse et al. (2013) reported reduced embryo quality, delayed embryo development, and decreased pregnancy rate to AI in heifers which were nutrient restricted (50%

energy requirements) immediately after AI up to embryo recovery on d 6, compared to heifers fed to gain. Kruse et al. (2013) speculated that reduction in reproductive performance in nutritionally stressed heifers may be due to the embryo's inability to properly elongate, resulting in failure of maternal recognition.

In a FTAI protocol, an unhealthy dominant follicle (DF) can lead to reduced pregnancy rates to AI (Vasconcelos et al., 2001). When comparing smaller DF to larger DF, small DF resulted in reduced subsequent corpus luteum volume, reduced progesterone concentrations, and reduced pregnancy rate to AI (Vasconcelos et al., 2001). If a negative energy balance is enough to suppress pulses of luteniezing hormone (LH), the ability of a DF to produce sufficient estradiol and the subsequent pre-ovulatory gonadotropin surge requisite for ovulation may be reduced (Roche et al., 2000). Hill et al. (1969) monitored heifers which were undernourished for 1 estrous cycle before AI and up to 18 d after AI. Undernourishment resulted in reduced follicle number after 10 d, greater variation in estrous cycle length, and more failures to conceive to AI than adequately fed heifers (Hill et al., 1969). Taken together, any type of undernourishment that may occur while managing cows in a dry lot, whether it be poor quality feed or reduced intake, could result in reduced fertility.

As mentioned previously, NEFA can be indicative of an animal's energy balance (Lucy et al., 1991 and Brennan et al., 2009). Villa-Godoy et al. (1989) reported cows in negative energy balance for approximately 60 d having greater circulating NEFA than cows in a positive energy balance ration; however, Schrick et al. (1990) did not observe differences in circulating NEFA between suckled cows fed high and low energy diets for 30 d. Non-esterified fatty acid are also found in the follicular fluid in positive correlation to blood plasma levels (Jorritsma et al., 2003) and increased follicular concentrations of NEFA may reduce fertility (Leroy et al., 2005). Even when not purposely restricting energy, circulating NEFA concentrations can give an indication of nutrient intake, animal activity, and may influence fertility.

Calves

At the time of breeding in mid-summer, suckling calves are consuming some forage organic matter for nutrients and energy while on pasture (Boggs, et al., 1980; Loy et al., 2002). Boggs et al. (1980) reported that during the month of July (time of breeding), for every kg of milk consumed per d, suckling calves consumed 0.4 kg of forage DM. As discussed previously, calves may have reduced intake if not familiar with feed sources other than summer grazing pastures (Flores et al., 1989). Hodgson et al. (1981) reported that inexperienced grazing calves took longer to adapt and increase intake in response to changing forage availability compared to experienced adult cattle. A review by Provenza and Balph (1988) reported livestock feeding on novel foods in unfamiliar environments ingest up to 40% less than animals who are familiar with the feed and environment. In all reviewed studies this difference lasted the entire length of trials, up to 10 mo (Provenza and Balph, 1988). Boggs et al. (1980) reported dam milk production had a greater influence on calf average daily gain and weaning weight than forage intake during the entire pre-weaning period. Taken together, the reports of Boggs et al. (1980) and Provenza and Balph (1988) elude to the concept that moving calves to dry lot management has the potential to affect their performance, whether it be through reduced forage intake or reduced milk consumption.

Management with Genetic Testing

Development of Genetic Testing

Mapping the cattle genome (Zimin et al., 2009) has led to a variety of genetic tests available to producers. While many studies evaluated how single nucleotide polymorphisms

(SNP) are related to observed physical traits (Van Eenennaam et al., 2007; Johnston and Graser, 2010; DeVuyst et al., 2011), few studies have looked at using genetic characteristics to guide selection, production, marketing, or management decisions. Previous economic studies have indicated that the value of using genetic information to manage cattle separately based on genetic potential groups is low, but using it to select and only feed preferable genotypes has a greater payback (Lusk, 2007; Lambert 2009). As technology improves, the cost of genetic testing decreases and the potential available genomic knowledge increases. The two previously mentioned studies, Lusk (2007) and Lambert (2009), only evaluated a single gene, but since then, testing has become available on a multitude on genes, thus much remains to be learned about the economic value of utilizing genetic information to improve feedlot performance.

Genomic tests offer producers the opportunity to more accurately predict genetic merit for their cattle. Commercial genetic testing can provide producers with a range of genetic information including parentage, presence of genetic defects, genetic markers, single nucleotide polymorphisms for qualitative traits such as hide color, and quantitative traits such as marbling score. Some traits, are controlled by one or only a few genes and their phenotype is simpler to predict with genotype, while others are controlled by many genes (polygenic) and phenotypes are more difficult to predict (Hartwell et al., 2011). Due to the polygenic nature of growth and carcass characteristics, which are important to beef producers, the variety of commercially available genetic evaluations may each be looking at different combinations of genes to predict one trait. Therefore, the accuracies of genetic evaluations may vary depending on which genes are taken into account. Garrick and Golden (2009) discussed the use of genetic testing in seed-stock to improve the value of breed sires. Fortes et al. (2012) evaluated genotype to phenotype association of first service conception and pregnancy in Brangus heifers, identifying candidate genes which could be used in future genomic selection strategies for replacement heifers. Other commercially available tests are marketed for selection of performance traits (average daily gain and feed efficiency) and carcass traits (tenderness or quality grade; Van Eenennaam et al., 2007; Weber et al., 2012).

Quantitative performance traits such as growth and carcass characteristics can be difficult to predict and measure before entering the feedlot stage and harvesting. Genetic markers associated with performance traits may provide valuable information to make decisions before investment of time and expense of cattle and feed. Intramuscular fat, which is correlated with marbling score and quality grade (Wall et al. 2004; MacNeil and Northcutt, 2008; MacNeil et al., 2010), is an economically important trait for feedlots that can be evaluated with genetic testing. DeVuyst et al. (2011) found a positive correlation between Igenity (Neogen, Lansing, MI) marbling markers and actual quality grade of feedlot steers. In contrast, Johnston and Graser (2010) did not find an association between GeneSTAR marbling markers and carcass marbling score. DeVuyst et al. (2011) was unable to correlate genotype and phenotype values for gain when using Igenity ADG panel score and actual ADG for Angus based steers fed for 135 to 257 d. Reports relating genotype to observed phenotype are varied and more genetic tests are being marketed to producers, resulting in a lack of data regarding the relationship among currently available genetic tests and observed phenotype. These data are critical for producers to make informed decisions about whether genetic tests are warranted in their situations, and how to best utilize the results of genetic tests. Furthermore, specific strategies (implant regimes, for example) to manage cattle of different genotypes have not been evaluated.

Implant Strategies

Hormone implants have been used since the 1950's (Preston, 1999) in beef production to improve performance and lower the cost of production (Duckett et al., 1997; Wileman et al., 2009). Implants are widely used in the feedlot sector. In 2011, for cattle < 700 lb, 80% of feedlots gave 2 or more implants and for cattle > 700 lb, 65% gave at least one implant (NAHMS 2013).

A variety of implants are available, with varying potencies depending on their active ingredient and dosage (Montgomery et al., 2001). Elevated circulating concentrations of hormones and subsequent growth promotion occur soon after implant placement and decline as the implant dissolves (Reinhardt, 2007). To offset the decline in growth promotion, cattle can be placed on an aggressive implant regime whereby an additional implant is applied to foster addition growth and feed efficiency (Samber et al., 1996; Parr et al., 2011). Benefits of implanting include increased LMA, greater ADG, and improved G:F (Bartle et al., 1992; Johnson et al., 1996; Bruns et al., 2005). Also attributed to implants is a reduction in marbling score in comparison to non-implanted cattle (Samber et al., 1996; Duckett et al., 1997; Reinhardt, 2007). An implant stimulates energy to be utilized for muscle protein synthesis in favor of fat deposition, explaining the reduction in intramuscular fat in implanted steers compared with non-implanted steers (Reinhardt, 2007). Previous research has reported a further reduction in marbling score when using a more aggressive implant strategy (re-implanting or one of greater potency) compared with more moderate implant regimens (Samber et al., 1996; Duckett et al., 1997; Platter et al., 2003). Duckett et al. (1997) reported a 2.5% reduction in marbling when implanting with a combination TBA/E_2 implant rather than a single estrogen, and a 4.3% reduction when utilizing two combination implants compared to a single combination implant.

Johnson et al (1996) found no difference in LMA between implanted and non-implanted steers that were slaughtered 40 d after implant, but implanted steers had larger LMA on d 115. Roeber et al. (2000) compared steers implanted with Revalor-S (Merck Animal Health, Summit, NJ) on d 0 with steers implanted on d 0 and re-implanted with the same implant on d 70 and fed for 140 d. The only carcass trait that differed between single and re-implanted steers was LMA in which re-implanted steers had greater LMA (Roeber et al., 2000). Duckett et al. (1997) reviewed comparisons between steers given a TBA/E_2 combination implant only on d 0 with steers implanted on d 0 and re-implanted later in the feeding period, each with combination implant and reported re-implanted steers had larger LMA than steers given one implant. Unlike others, Scaglia et al. (2004) did not report a difference in LMA after 161 to 176 DOF between steers implanted (Revalor-S) on d 0 to steers implanted on d 0 and 70.

Greater ADG and feed efficiency have been observed by Bartle et al., (1992), Johnson et al. (1996), and Bruns et al. (2005) at an interim period after implanting with a combination implant compared to non-implanted steers. Guiroy et al. (2002) did not observe a difference in feed efficiency, but did report an increase in ADG between implant treatments when steers were given either one, delayed implant (Revalor-S) on d 90 or an implant on d 0 and 90. Duckett et al. (1997) also reported re-implanted steers had less intra-muscular fat (IMF) than steers with one implant; however, Scaglia et al. (2004) did not observe differences in marbling with a similar implant regimen. If the reduction in marbling score is significant enough to reduce quality grades, the net result can be a reduction in overall carcass value. With the concept of genetic testing now available for traits which are economically important to the feedlot industry (ADG, G:F, and marbling), research of management strategies with genomic and implant technologies is warranted to identify additional improvement in animal performance..

The following chapters report studies that evaluate the use of technologies in beef cattle production. The first study evaluated the impact of managing cow-calf pairs in a dry lot for a 10 d ES and breeding period on reproductive performance of cows and weight change in cows and their calves. The second study evaluated the effects of moderate and aggressive implant strategies on Angus sired steers with varying GP for post weaning growth and marbling.

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CHAPTER 2. IMPACT OF MANAGING COW-CALF PAIRS ON PASTURE OR IN A DRY LOT DURING A 10 DAY SYNCHRONIZATION PERIOD ON REPRODUCTIVE PERFORMANCE AND WEIGHT CHANGE IN COWS AND THEIR CALVES

Abstract

The objective of this experiment was to determine the effects of moving cow-calf pairs from grazing summer pastures in early-July into dry lots for a 10 d ES and breeding period on reproductive performance and weight change in cows and their calves. Cow-calf pairs (n = 422) were stratified by calf sex and days post partum (DPP) and randomly assigned to one of two treatments: 1) pairs were removed from summer pastures and managed in dry lots during a 10 d synchronization and AI period (DL, n = 210), or 2) pairs remained on summer pasture for the synchronization and breeding period, and were gathered for each of 3 separate handling events to facilitate AI (CON, n = 212). The DL group was provided ad libitum grass hay, while the CON group had ad libitum access to native range pastures with both treatments having equal access to a vitamin/mineral supplement. All cows were exposed to 7-d CO-Synch + CIDR protocol with FTAI (d 10) at 60-66 hr after CIDR removal. Single day, unshrunk BW of cows and calves were recorded on d -10 and d 0 relative to breeding, with additional calf BW collected on d 35 and 88, and cow BW on d 95. Presence of a viable fetus was determined in cows on d 35 and 95 via transrectal ultrasonography. Cows and calves in the DL group had reduced ($P \leq 0.04$) weight gain during the 10 d synchronization period compared with cows and calves in the CON group. Calf concentrations of NEFA on d 0 were impacted by a treatment by group interaction ($P = 0.007$; 459.3, 502.8, 528.7, and 346.1 μmol/L serum for young DL, young CON, old DL, and old CON respectively). Concentrations of NEFA in DL cows were greater ($P = 0.001$) than CON cows on d 0. No differences ($P \geq 0.36$) were observed between treatments for pregnancy rate at d

35 (49.0% and 52.5% for CON and DL, respectively) or d 95 (91.0% and 89.6% for CON and DL, respectively), or cow BW on d 95. However, calves in the DL treatments were 6 kg lighter ($P \leq 0.003$) on d 35 and 9 kg lighter on d 88 (weaning) compared with calves in the CON group. Managing cow-calf pairs in the dry lot for a 10 d estrus synchronization and AI period did not affect reproductive performance of cows, but did have a negative impact on calf weaning weights.

Introduction

The use of AI offers many benefits to producers such as induced cyclicity in non-cycling females (Lucy et al., 2001), shifting of calving distribution to earlier in the year (Rodgers et al., 2012), resulting in older, heavier calves at weaning (Steichen et al., 2013) and the opportunity to incorporate superior genetics into their herd at a fraction of the cost required to own bulls of equivalent genetic value (Lamb et al., 2010). Despite the potential benefits, only 8% of producers in a 2007 survey indicated that they utilize AI (NAHMS, 2009). However, as operations increase the number of breeding females maintained and the need for efficiency grows, the use of reproductive technologies is likely to increase (NAHMS, 2009, Schook et al., 2014).

Current AI protocols require cattle to be handled at least 3 times within a 10 to 14 d period. There is variation in cattle management across herds as producers attempt to reduce the amount time and labor required of an AI protocol, which is the number one concern of producers (NAHMS, 2009). Differences in herd management may be causing differences in pregnancy rates to AI across locations, despite the use of similar protocols (Larson et al., 2006) An example of a management strategy is to confine cattle to dry lots or small pastures close to working facilities during the synchronization period to lessen the burden of gathering cattle multiple times.

Confining cow-calf pairs to a dry lot for a short period of time may affect energy balance, milk production and reproductive performance in cows. In addition, calf energy balance and growth may also be affected by short-term confinement. Abrupt diet changes have been reported to have negative impacts on reproductive performance (Hill et al., 1969; Perry et al., 2009; Bridges et al., 2012), energy balance (Zhang et al., 2013), milk production and calf performance (Chelikani et al., 2004). The consequences of moving cow-calf pairs from grazing pastures to dry lot feeding for a short period on cow reproductive performance and calf growth are currently unknown. Therefore, the objectives of this study were to evaluate the effects of moving cow-calf pairs from summer grazing to dry lot feeding for a 10 d period of ES on cow reproductive performance, BW, and concentration of NEFA, and calf BW and concentrations of NEFA.

Materials and Methods

This research was conducted in accordance with procedures approved by the North Dakota State University Institutional Animal Care and Use Committee.

Animal and Treatments

Angus crossbred cow-calf pairs (n = 422) at the Central Grasslands Research and Extension Center (CGREC) near Streeter, ND, were used in this study. Before the start of the experiment (June 30, 2014), cow-calf pairs had been grazing native range pastures for a period of 6 weeks. Cow-calf pairs were managed in two groups based on cow age: young (2 to 4 yr old, n = 209) and old (≥ 5 yr old, n = 213). Within management group, cows were stratified by DPP and calf sex, then randomly designated to one of two treatments (Figure 2.1): 1) pairs remained on summer pasture for the 10 d synchronization and breeding period, and were gathered each of the 3 times required to facilitate ES and AI (CON, n = 212), or 2) pairs were removed from summer pastures and managed in dry lots during a 10 d synchronization and breeding period, (DL, n = 210). At the onset of the trial, the mean BCS (scale of 1 to 9; 1 = emaciated, 9 = obese; Whitman, 1975) was 4.7, with a range of 3.5 to 6. Mean DPP was 67.7 d with a range of 30 to 102 d. Mean parity was 4.1 with a range of 1 to 11. The DL treatment group received ad libitum grass hay (all bales originated from same field; 10.7% CP) for the 10 d period; whereas, the CON group had unlimited access to native range pasture (11.6% CP, 9.5% CP, for young and old cows respectively; Table 2.1). Both groups had equal access to mineral supplement, which was supplied at a rate of 85 g $\cdot$ cow^{-1} $\cdot$ d^{-1}. Young and old cows of the DL treatments were managed in separate dry lots, of equal size, 32 m wide and 255 m long (approximately 0.8 ha). The young cows in the CON treatment were managed on a 32.4 ha pasture and the old cows on the CON treatment were managed on 64.7 ha pasture during the 10 d period. Prevalent grass species included blue grama (*Bouteloua gracilis*), needle and thread (*Stipa comate*), sun sedge (*Carex heliophilia*), western snowberry (*Symphoricarpos occidentalis*), and Kentucky bluegrass (*Poa pratensis*; Hirschfeld et al., 1996; Dong et al., 2014). Estrous cycles were synchronized in all cows by administering 100 μg of GnRH i.m. (2 mL of Factrel, Zoetis, Florham Park, NJ) and a CIDR (EAZI-Breed CIDR containing 1.38 g of progesterone, Zoetis), followed in 7 d by 25 mg of $PGF_{2\alpha}$ i.m. (5 mL Lutalyse, Zoetis) and CIDR removal, followed in 60 to 66 hr by FTAI and second injection of GnRH (7-day CO-Synch + CIDR, Larson et al., 2006). Estrus detection patches (Estrotect, Estrotect Inc., Spring Valley, WI) were placed on the tail head of each cow at CIDR removal (d -3) to serve as an estrus detection aid. Patches were scored at AI (d 0) using a 0 to 2 scale based on the amount of film on each patch that was removed (0 = untouched or a few scratches, 1 = approximately 50% removed, 2 = almost all or 100 % removed or missing patch). Patch scores of 0 and 1 were considered inactivated while scores of 2 were considered activated. For each working event, young and old groups were worked on consecutive days. On each working day, pairs were brought to handling facilities beginning at daybreak (around 0530 hr) and calves were sorted away from dams before processing began. On d -10, animals were sorted into respective treatment groups as they exited the chute, on d -3 DL and CON were worked as separate groups, and on d 0 treatment groups were mixed in the pens before processing to allow random order through the chute.

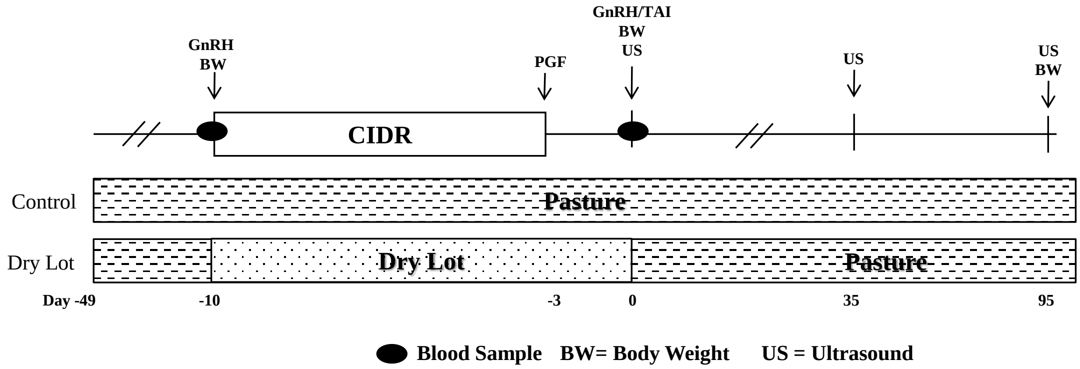

Figure 2.1. Schematic of the experimental treatments for cow-calf pairs managed in the pasture (control) or dry lot for a 10 d period to accomplish estrus synchronization and fixed-time AI (TAI). GnRH = 100 μg of i.m. injection of GnRH (Factrel, Zoetis, Florham Park, NJ); CIDR = treatment with a controlled internal drug release insert containing 1.38 g of progesterone (EAZI-Breed CIDR, Zoetis); PGF = 25 mg i.m. injection of $PGF_{2\alpha}$ (Lutalyse, Zoetis); US on d 0 performed for determination of dominant follicle diameter; US on d 35 and 95 performed for pregnancy determination

Distance from the center point of the pasture to the handling facility was 1.3 km for pairs in the young group (0.99 km at closest point and 1.68 km at furthest point) and 720 m for pairs in the old group (248 m at closest point and 1.27 km at furthest point). From the dry lot, both young and old pairs traveled approximately 175 m (40 m at closest point and 286 m at farthest point) to the sorting pens. Cows were processed first each working day, followed by calves. Immediately following TAI, all pairs were returned to summer pastures and reproductively sound cleanup bulls were placed in pastures from d 10 to 49 after AI. Treatment groups were managed together, within age group, throughout the remainder of the summer until determination of final pregnancy status.

Table 2.1. Diet composition fed to cows during a 10 d period of estrous synchronization and fixed time insemination[1]

Item	Young Pasture	Old Pasture	Dry Lot Hay
Dry Matter, %	78.9	67.9	90.0
Crude Protein, %	11.6	9.5	10.7
Crude Fat, %	2.3	1.0	1.61
ADF, %	37.1	36.0	38.9
Ash, %	9.1	8.2	8.36
NE_m, Mcal/kg	1.4	1.46	1.43
Phosphorus, %	0.23	0.21	0.21
Calcium, %	0.66	0.48	0.64

[1] All cows provided mineral supplement, supplied at a rate of 85 g · $cow^{-1} \cdot d^{-1}$ (6.16 g/kg of chlortetracylcin, 138.6 mg/kg of s-methoprene, 14.85% Ca, 7% P, 22.7% NaCl, 1% Mg, 0.1% K, 1,760 mg/kg Mn, 106 mg/kg Co, 1,100 mg/kg Cu, 60 mg/kg I, 27 mg/kg Se, 3,168 mg/kg Zn, 330 IU/g Vit. A, 33 IU/g Vit. D_3, 330 IU/kg Vit. E; Wind & Rain®Storm; Purina, Shoreview, MN).

Data Collection and Analysis

Body weights of cows were recorded on d -10, 0, and 95, whereas BW of calves were recorded on d -10, 0, 35, and 88 (weaning). No feed was provided to cows or calves in holding areas on working days before cattle were processed.

A subset of cow-calf pairs (n = 72), representing similar distributions of heifer and bull calves, DPP, and calf BW were selected for blood collection and ovarian evaluation. Whole blood samples were collected via jugular venipuncture from cows and calves on d -10 and 0 into 10-mL Vacutainer tubes (BD Worldwide, Franklin Lakes, NJ) without additives. After collection, blood was immediately placed on ice for up to 8 hr and centrifuged at 1,500 x *g* for 20 min at 3°C for serum harvest, then stored at -20°C until analyzed. Serum concentrations of NEFA were quantified in duplicate with an enzymatic colorimetric assay kit (NEFA-C Wako

Chemicals USA, Richmond, VA). The NEFA intra- and inter-assay CV were 4.5 and 14.7%, respectively.

The DF of each cow in the subset was evaluated via transrectal ultrasonography (7.5-MHz linear array transducer, Aloka 500V, Corimetrics Medical Systems Inc., Wallingford, CT) immediately before AI (d 0). The vertical and horizontal diameter of the largest follicle was measured and recorded. The diameter of the DF was defined as the average of the vertical and horizontal measurements of the largest follicle present in either ovary.

Pasture nutrient composition was determined by hand clipping forage to ground level inside a 0.25 m^2 quadrant (10 random locations in each pasture; young and old). Grasses, forbs, and shrubs were separated and analyzed independently. For determination of hay nutrient composition, a single core sample was collected from each of 20 round bales for analysis. Forage samples were dried in a forced-air oven (55°C, The Grieve Corporation, Round Lake, IL) for at least 48 hr then stored at room temperature. Dried feed samples were ground (Wiley Mill, Arthur H. Thomas Co., Philadelphia, PA) to pass a 2-mm screen and analyzed for DM; CP, crude fat, ash, S, P, K, Mg, Ca, Na, Fe, Mn, Cu, and Zn (methods 930.15, 990.03, 945.16, 985.01, respectively; AOAC, 2010).

Transrectal ultrasonography (5.0-MHz linear array transducer, Aloka 500V, Corimetrics Medical Systems Inc.) was used to determine presence and size of a viable fetus on d 35 and d 95. Examination on d 35 revealed the proportion of cows pregnant to AI, whereas examination on d 95 revealed the proportion of cows pregnant at the end of the breeding season (season ending pregnancy rate) and identified incidence of AI pregnancy loss.

Statistical Analysis

Binomial data were analyzed using the GENMOD procedure (SAS Inst. Inc., Cary, NC) and continuous data were analyzed with the GLM procedure (SAS Inst. Inc.). Models included treatment, management group, and their respective interactions. In addition, the model for concentrations of NEFA on d 0 included concentrations of NEFA on d -10 as a covariate. Data of the young group was analyzed separately in order to compare 2 year olds to 3 and 4 year old cows with cow age and treatment in the model. The experimental unit in all analyses was animal. Treatment and interaction means were separated with the least significant difference procedure and were considered significant at $P \leq 0.05$ and a tendency at $0.05 < P \leq 0.10$.

Results and Discussion

Reproductive Performance

There were no differences ($P \geq 0.16$) in reproductive performance between DL and CON treatments (Table 2.2). Pregnancy rate to AI (d 35) and season ending rates (d 95) were similar ($P \geq 0.50$) between the two treatments and no differences ($P = 0.16$) in pregnancy loss were observed (combined mean loss of 6.0 %). In addition, a similar proportion ($P = 0.19$) of cows in the DL and CON treatments had activated patches, indicating that there was similar estrus activity between the two treatments. Recall that nutrient contents were similar between hay fed to DL and pasture available to CON indicating that any effects of treatment may not be due to diet composition but to differences in intake. In the current study, DMI was not recorded but DMI in DL cows could have been reduced, resulting in a reduction in nutrient and energy supply (Osuji, 1974). When grazing livestock were introduced to a novel feed source, they spent significantly more time and energy foraging and less time ingesting feed (Osuji, 1974). Short et al. (1990) reported that nutrients are partitioned to basal metabolism and physical activity before estrous cycles and initiation of pregnancy. Taken together, if cows in the DL treatment experienced reduced intake of nutrients due to more time foraging, energy may have been partitioned away from estrus activity and pregnancy establishment. Cows in the current study were not naïve to dry lot management systems so they would not be expected to spend excessive time searching for feed sources. Previous research indicates that abrupt diet changes can negatively impact reproductive performance (Hill et al., 1969; Perry et al., 2009; Bridges et al., 2012). For example, when heifers were developed in a feedlot and immediately turned out to pasture after AI, pregnancy success to AI was reduced compared to heifers developed on pasture (Perry et al., 2009; Perry et al., 2013).

Table 2.2. Impact of moving cow-calf pairs into a dry lot for a 10 d estrus synchronization protocol on cow weight and reproductive performance

	Treatment	
Item	Pasture	Dry lot
No. of Cows	212	210
BCS	4.7 ± 0.03	4.7 ± 0.03
Body Weight, kg		
d -10	592.0 ± 5.8	590.5 ± 5.8
d 0	591.9^{x} ± 5.4	574.7^{y} ± 5.4
d 95	615.2 ± 5.7	607.5 ± 5.7
DF diameter, mm	14.4 ± 0.4	13.9 ± 0.4
	-----------% (no. of no.)	-------------
Estrus Expression[1]	65.6 (139/212)	59.6 (125/210)
Pregnancy Rate		
d 35	49.0 (104/212)	52.5 (110/210)
d 95	91.0 (193/212)	89.6(188/210)

^{xy}Means within row differ (*P* = 0.02)

[1]’Estrotect Patch, Estrotect Inc., Spring Valley, WI. Patch scores of 0 and 1 = inactivated, 2 = activated (0 = untouched or a few scratches, 1 = approximately of film 50% removed, 2 = almost all or 100 % removed or missing patch).

Heifers that were undernourished 17 d before AI had reduced number of follicles after 10 d of undernourishment, more variation in estrous cycle length, and had reduced conception rates compared with adequately fed heifers (Hill et al., 1969). Cows in the current study were not naïve to dry lot management systems, so the transitions between pasture and dry lot and back to pasture may not have as significant an impact as heifers in the previously mentioned studies. Progesterone is positively associated with fertility (Folman et al., 1973), so a reduction in P_4 could negatively impact conception rates. Research in cows and heifers reported that the effect of energy restriction were not observed in P_4 concentrations until at least the second estrous cycle following initiation of diets (Gombe and Hansel, 1973; Spitzer et al., 1978; Villa-Godoy et al., 1989). As cows in the DL treatment in the current study were only exposed to dry lot management for 10 d it is unlikely that they experienced a reduction in P_4. Luteinizing hormone is another important reproductive hormone which targets the ovary to stimulate ovulation, the formation of corpora lutea, and P_4 secretion (Senger, 2003). A review of nutritional effects on circulating hormones in beef cattle by Diskin et al. (2003) suggested that LH pulses are not acutely affected by energy restriction but concentrations decrease after chronic nutritional restriction when critical amounts of body fat are catabolized. In the current study, any nutritional restriction would be due to reduced intake, as previously discussed, and dry lot management was only for a short period of time, indicating that LH concentrations in the current study may not have been affected, thus no effect on pregnancy rates. Due to the fact that cows in the current study were familiar with dry lot management, it is unlikely that their intakes were reduced enough to impact P_4 or LH to the point where reproduction would have been impacted. Indeed, no treatment effects on reproductive performance were noted.

Dominant follicle diameter, on d 0, was not affected ($P = 0.40$) by treatment. As reported in earlier studies (Galvao et al., 2004), cow age impacted DF diameter with cows in the old group tending ($P = 0.06$) to have greater DF diameter than young cows (14.7 mm and 13.6 mm for old and young, respectively). Chronic energy restriction can impact DF growth rate, maximum diameter and persistence (Hill et al., 1969; Perry et al., 1991; Diskin et al., 2003). Acute nutrient restriction for 13 d reduced DF diameter in heifers restricted to 40% of NE_m requirements compared to non-restricted heifers (Lents et al., 2013). Mackey et al. (2000) also reported severe acute energy restriction (40% of maintenance) reduced growth rate, maximum diameter, and volume of the first DF after start of restriction in heifers. Hill et al. (1969) reported reduced number and size of follicles after 10 to 12 d of receiving 85% of NE_m requirements. Without knowing whether nutrient consumption was decreased in the current study it is difficult to compare to previous reports. Based on the reports of Hill et al. (1969), impacts on DF may not be expected in DL cows due to the short duration of diet change (10 d) and the fact that cows were allowed ad libitum access to hay (i.e. not comparable to severe restriction as reported by Mackey et al., 2000 and Lents et al., 2013). Taken together, results of the current study do not coincide with previous research regarding energy restriction on reproductive performance, indicating that if cows in the current study were restricted, it was not enough to elicit impacts on estrus activity, diameter of DF, pregnancy rate to AI, or season ending pregnancy rates.

Cow Weight Change and Concentrations of NEFA

During the 10 d breeding period, cows in the DL had reduced ($P = 0.02$) weight gain compared with CON, but similar ($P = 0.35$) BW at d 95 (Table 2.2). This weight difference may partially be due to a reduction in gut fill due to the increased DM content of hay fed to DL relative to pasture available to CON. Concentrations of NEFA on d 0 tended to be impacted by a treatment × management group interaction ($P = 0.06$; figure 2.2). Old cows in the DL treatment had greater ($P < 0.001$) concentrations of NEFA than old CON cows and both treatments in the young cows were intermediate. Non-esterified fatty acids are an indicator of energy balance and are released into blood after chemical breakdown of adipose tissues (Lucy et al., 1991; Radostits et al., 2007; Brennan et al., 2009). Richards et al. (1989) reported that weight loss due to a restricted energy diet is associated with an increase in concentration of NEFA and Radostits et al. (2007) explains the negative relationship of DMI with concentration of NEFA. Elevated ($P <$ 0.008) concentrations of NEFA for DL cows of the old group compared to CON cows observed in the current study are similar to reports of others following a type of feed restriction (Wertz-Lutz et al., 2006; Lents et al., 2013; Zhang et al., 2013). Lents et al. (2013) reported greater concentrations of NEFA in heifers restricted to 50% of NE_m requirements after only 2 d of restriction compared to non-restricted heifers. Zhang et al. (2013) restricted heifers to 50% of previously determined DMI and observed an increase in NEFA after 3 d of restriction compared to concentrations before restriction. Similarly, Wertz-Lutz et al. (2006) reported elevated NEFA in steers which were fasted for 48 hr compared to non-fasted steers. The greater concentrations of NEFA on d 0 in DL cows compared to CON indicates that cows were in a negative energy balance, not consuming adequate amounts of energy to prevent body fat mobilization during that time period. The increased negative energy balance of DL cows relative to CON cows may be due strictly to reduction in intake or increased energy expenditure with physical activity.

In the young cow group, there was no effect ($P = 0.3$) of treatment on d 0 serum NEFA. Perhaps the lack of difference observed in young cows was due, in part, to 2 year old cows having elevated concentration of NEFA (> 800 μmol/L) at the onset of treatments (d -10) compared to the 3 and 4 year olds which make up the young group (data not shown). In both CON and DL, 2 year old cows had declining NEFA during the 10 d period. Two year old cows have greater energy requirement than older cows due to an added component of growth, resulting in a differing physiological state in comparison to multiparous cows (Wathes et al., 2007). Low conception rates in 2 and 3 year old cows are improved with high energy after calving, indicating they may be in a negative energy balance because of the combined demands of maintenance, growth, lactation, and reproduction (Dunn et al., 1969; Odhiambo et al., 2009).

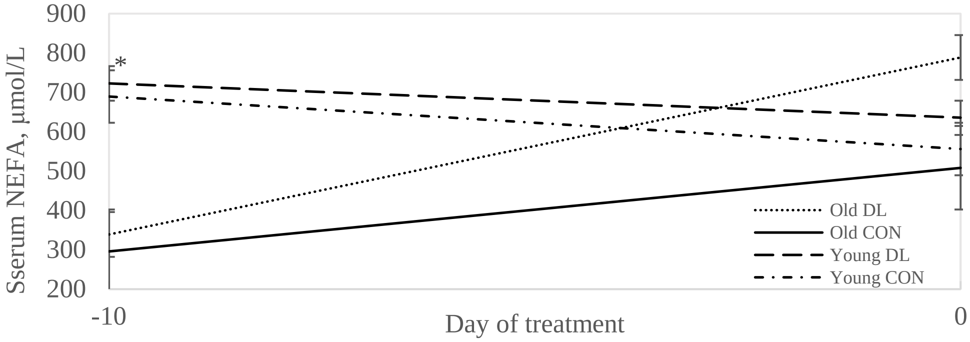

Figure 2.2. Least square means for concentrations of serum NEFA in cows during a 10 d estrus synchronization protocol in which cow-calf pairs were managed in a dry lot (DL) or on pasture (CON). Cows were managed in 2 groups, young and old. Treatment x group interaction (*P* =0.06)
*Group effect (*P* < 0.001)

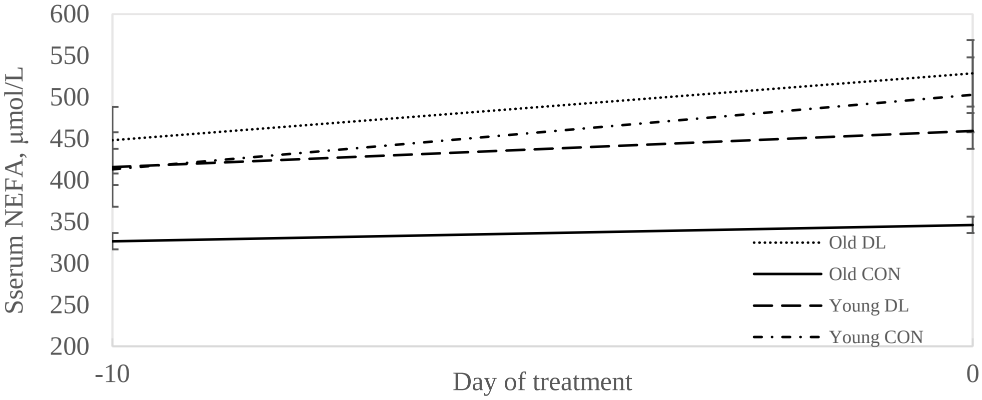

Figure 2.3. Least square means for concentrations of serum NEFA in calves during a 10 d estrus synchronization protocol in which cow-calf pairs were managed in a dry lot (DL) or on pasture (CON). Cows were managed in 2 groups, young and old.
Treatment x group interaction (*P* =0.002)

Milk production was not measured in the current study but based on results of previous work; a reduction in DL cows may be expected if their intakes were reduced (Perry et al., 1991 and Chelikani et al., 2004). Chelikani et al. (2004) reported over 55% reduction in milk yield after 48 hr of fasting compared to cows allowed access to a total mixed ration. Reduction in milk yield of fasted cows remained for up to 96 hr after refeeding following the 48 hr fast (Chelikani et al., 2004). Perry et al. (1991) reported reduced daily milk yield in beef cows receiving low energy (70% NE_m requirement) diets from calving to 60 d postpartum. Roche (2007) reported reduced milk yield in dairy cows fed a low DMI for 5 weeks post calving compared to high DMI (10 versus 15 kg $\cdot$ cow^{-1} $\cdot$ day^{-1} for low and high DMI, respectively), and the reduction lasted up to 15 weeks post calving. Milk production was not measured in the current study; however, the observed increase in NEFA concentrations indicate a negative energy balance was present, which may elicit a negative impact on milk production.

Calf Weight Change and Concentrations of NEFA

Calves in DL had reduced ($P \leq 0.04$) weight gain on d 10 and 35, and remained lighter ($P = 0.002$) at weaning compared with CON calves (Table 2.3). Similarly, calves removed from dams for 72 hr before AI were lighter 63 d later compared to calves that remained with dams (Marquezini et al., 2013). Quintans et al. (2010) reported reduced weaning weights when calves were removed from dams for 14 d before AI. Unlike the reports by Marquezini et al. (2013) and Qunitans et al. (2010), calves in the current study were not removed from dams for an extended period, other than to work through processing facilities; however, a potential decline in plane of nutrition can be compared. Reduced weight gain in DL calves, of the current study, may be a result of changes in environment and feed source. Calves in the current study were exposed to dry lot management for a brief time after calving and before being moved to summer pastures, so hay as a forage source may not be a complete novelty. However, they may have reduced intake due to the new environment. Boggs et al. (1980) reported that during the month of July (time of breeding), for every kg of milk consumed per day, suckling calves, similar in age to the current study, consumed 0.4 kg of forage dry matter. A review by Provenza and Balph (1988) reported livestock feeding on novel foods in unfamiliar environments ingested up to 40% less than animals who are familiar with the feed and environment. In all reviewed studies reduced intake lasted the entire length of trials, up to 10 mo (Provenza and Balph, 1988).

Boggs et al. (1980) reported that forage intake during the entire pre-weaning period was poorly related to calf average daily gain or weaning weight and dam milk production had the greatest influence on calf performance. Roche (2007) reported that an induced reduction of DMI of dairy cows for 5 weeks after calving resulted in reduced milk yield for up to 10 weeks after realimentation, however, after a short term DMI restriction (50% of previous ad libitum DMI) of 5 d, Velez and Donkin (2005) reported a reduction in milk yield that returned to yields similar of non-restricted cows by 4 d after DMI restriction. Though milk production was not measured in the current study, if reduced for a significant time after treatments, calf performance would be negatively affected and may explain the difference in BW present at weaning. The reduction in weaning weights of calves managed for 10 d in the DL would need to be weighed against the labor and time savings of the AI protocol in order for a producer to determine its worth.

Table 2.3. Impact of moving cow-calf pairs into a dry lot for a 10 d estrus synchronization protocol on suckling calf weights

	Treatment		
Item	Pasture	Dry lot	SEM
No. of calves	212	210	
Body Weight, kg			
d -10	95.5	95.3	1.3
d 0	104.3^x	100.2^y	1.4
d 35	142.7^x	136.7^y	1.6
d 88	209.0^x	200.0^y	2.0

^{xy}Means within row differ ($P \leq 0.04$)

Calf Concentration of NEFAs on d 0 were impacted by a management group × treatment interaction (*P* = 0.002; Figure 2.3). Calves in the young group, from both treatments, and DL calves in the old group had greater ($P \leq 0.05$) concentrations of NEFA compared with CON calves in the old group. As mentioned previously, increased NEFA are most likely a result of catabolizing adipose tissue indicating a negative energy balance (Lucy et al., 1991; Radostits et al., 2007; Brennan et al., 2009). Results of the current study indicate that the DL treatment had more of an effect on calves in the old group than the young. Bernardini et al. (2012) also observed increased NEFA concentrations at the end of a 19 hr fasting period during transport in calves of similar age to the current study, but levels returned to pre-transport levels 3 d after transport. The association of weight loss with increased NEFA concentrations (Richards et al., 1989) may explain short term weight loss, but it is unclear if extended weight reduction in the current study is related to NEFA concentration.

Another potential explanation for the physiological changes occurring in the calves is a stress response. Acute stress can cause measurable changes in physiological status as observed by Lay et al. (1992) in response to hot-iron branding. The stress of being transported for 3 hr, held overnight with access to hay and water, and transported another 3 hr, resulted in newly weaned calves to lose a greater percentage of BW compared to non-transported newly weaned calves during the 24 hr transit period and weight differences were still present 21 d later (Arthington et al., 2003). Arthington et al. (2003) also reported that weaning resulted in increased cortisol and acute-phase proteins, indicative of a stress response. Additionally, ceruloplasmin and fibrinogen, 2 acute-phase proteins, were increase up to 17 d after transportation compared to non-transported calves (Arthington et al., 2003).

The impact on calf weights is indicative of a physiological change, but the concentration of NEFA evaluated in the current study do not fully explain the weight changes in the two management groups. Further evaluation is needed to determine the cause of the reduced weight gain of calves in the dry lot.

Implications

Moving cow-calf pairs from summer grazing into a dry lot setting for the 10 d period for estrus synchronization and artificial insemination did not impact dominant follicle diameter, activated estrus detection patches, pregnancy rate to artificial insemination, and season ending pregnancy rates. However, there was negative impact of the dry lot treatment on calf weights at the end of the breeding period that was still present at weaning. Producers must consider the reduction in weaning weights of calves alongside the reduced labor and time demands associated with implementation of estrus synchronization to determine whether managing cow-calf pairs in a dry lot during the breeding period warrants consideration on their operation.

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CHAPTER 3. EVALUATION OF IMPLANT STRATEGIES IN ANGUS-SIRED STEERS WITH HIGH AND LOW GENETIC POTENTIAL FOR MARBLING AND GAIN

Abstract

Sixty-nine Angus sired steer calves (initial BW = 332.3 kg) were used to determine the effects of a moderate or aggressive implant strategy on steers of high and low GP using the GeneMax (Zoetis, Florham Park, NJ) genetic profiling test. Steers were assigned to treatments in a 2 × 2 factorial design with factors of 1) composite GP score [high (H), mean score of 86.5, n = 35, or low (L), mean score of 25.3, n = 34); and 2) implant strategy [aggressive (AGG) or moderate (MOD)]. All steers were given the same implant (Revalor-S, Merck Animal Health, Summit, NJ), with the AGG group implanted on d 0 and d 70 and the MOD group only on d 70. A high concentrate (84.5%) diet was fed ad-libitum, once daily. Ultrasound was used to measure body composition characteristics on d 0 and 70. Steers were harvested after 140 DOF. At the d 0 and d 70 US, H steers had greater ($P < 0.001$) percent IMF than L steers, but no differences ($P \geq 0.2$) were observed in LMA, rib fat thickness (RBFTUS), or rump fat thickness (RMPFTUS). Steers in the AGG group had larger ($P = 0.02$) LMA and less ($P = 0.03$) IMF on d 70 than MOD steers and no differences ($P \geq 0.5$) in RBFTUS or RMPFTUS were observed. Over the entire 140 d feeding period, there were no differences ($P \geq 0.6$) in BW, ADG, DMI, or G:F between GP groups; however, AGG steers had greater ($P = 0.03$) ADG compared with MOD steers while still having similar ($P \geq 0.12$) DMI and G:F. At slaughter marbling score tended to be impacted by a GP × implant interaction (492.9, 538.3, 481.1, 463.7 for H-AGG, H-MOD, L-AGG, and L-MOD, respectively; $P = 0.06$). No differences ($P \geq 0.7$) were observed between GP groups for HCW, LMA, rib fat (RF), KPH, or yield grade (YG). Steers in the MOD group had less ($P =$

0.003) RF than AGG steers and had similar ($P \geq 0.14$) HCW, marbling, LMA, KPH, and YG. A greater proportion ($P = 0.03$) of steers in the H group had choice carcasses (100%) compared with L steers (88%). Results of this study indicate that the GeneMax test predicted differences in US IMF, carcass marbling, and quality grade. The overall quality grades observed indicates that it may be possible to manage cattle with poor GP to achieve acceptable performance.

Introduction

Hormone implants have been used since the 1950's (Preston, 1999) in beef production to improve performance and lower the cost of production (Duckett et al., 1997; Wileman et al., 2009). A variety of implants are available, with varying potencies depending on their active ingredient and dosage (Montgomery et al., 2001). Elevated circulating concentrations of hormones and subsequent growth promotion occur soon after implant placement, and as hormone in circulation falls below a threshold level, growth promotion stops (Reinhardt, 2007). To offset the decline in growth promotion, a more aggressive strategy can be used in which steers are re-implanted to foster additional growth and feed efficiency benefits (Samber et al., 1996; Parr et al., 2011). Unfortunately, aggressive implant strategies can result in reduced marbling score compared with more moderate implant strategies (Samber et al., 1996; Duckett et al., 1997; Platter et al., 2003).

As knowledge of the bovine genome expands, a variety of genetic tests are becoming available to predict an animal's genetic potential for economically important production traits. Though DeVuyst et al. (2011) observed positive correlation between Igenity (Neogen, Lansing, MI) marbling markers and actual quality grade of feedlot steers, additional examination of observed phenotype in cattle with varying genotype are warranted. In addition, a paucity of information is available regarding the feedlot performance and carcass characteristics of cattle with varying genetic potential when exposed to different implant strategies. Perhaps the early indication of genetic potential for growth and marbling available via genetic testing can be paired with an optimal implant strategy to maximize feedlot performance. This study was conducted to evaluate the effects of moderate and aggressive implant strategies in Angus based steers with varying genetic potentials for gain and marbling using the GeneMax (Zoetis, Florham Park, NJ).

Materials and Methods

All procedures were conducted within the guidelines and approval of the North Dakota State University Institutional Animal Care and Use Committee.

Animals and Treatments

At the time of weaning blood samples were collected via jugular venipuncture from 114 Angus-sired steers originating from North Dakota State University's Central Grasslands Research Extension Center (CGREC) in Streeter, ND. Samples were submitted to Angus Genetics Inc. (St. Joseph, MO) for determination of GeneMax score. GeneMax scores represented the GP for post weaning growth and marbling potential of Angus based calves. Results include 3 scores for each animal; individual scores for growth and marbling (each reported in quintiles; 1 to 5) are used to calculate a composite score ranging from 1 to 100, with 1 being the least and 100 being greatest GP.

Sixty nine steers (average 10 m of age, initial BW = 332.3 kg), representing the greatest (H, n = 35) and least (L, n = 34) composite GP scores were selected from the original population for this experiment. Steers were assigned to treatments in a 2 × 2 factorial arrangement with factors of GP score (H or L) and implant strategy (MOD or AGG). Within GP group, steers were paired according to overall GP score and BW, then steers from each pair were randomly assigned to each implant treatment. The four resultant treatment groups were as follows: 1) high

GP score with AGG implant (H-AGG, n = 17), 2) high GP score with MOD implant (H-MOD, n = 18), 3) low GP with an AGG implant (L-AGG**,** n = 18), and 4) low GP score with MOD implant (L-MOD, n = 16). Implants administered in all instances contained 120 mg of TBA and 24 mg of E_2 (Revalor-S, Merck Animal Health, Summit, NJ). Steers in the AGG treatment were implanted on d 0 and d 70. Steers in the MOD treatment were implanted only on d 70.

Steers were transported from the CGREC to the Animal Nutrition and Physiology Center at North Dakota State University on January 2. The Animal Nutrition Physiology Center is an indoor, temperature controlled facility (12°C), equipped with Calan gate feeding systems (American Calan, Northwood, NH). Each pen housed 6 steers (1 bunk/steer), measured 23.7 m^2 (3.95 m^2/animal) and had slatted, concrete floors. Steers from each treatment factor combination were present in each pen to avoid any location effects. The trial began after an initial 32 d acclimation period to the Calan system and a high concentrate ration. Steers had continual access to water and were fed once daily at 0630 hr considering the preceding 3-d feed delivery and bunk scores to achieve ad libitum feeding The finishing diet was comprised an 85% concentrate diet containing 1.25 Mcal/kg NEg and 17.2 % CP (Table 3.1). Orts were collected weekly and analyzed for DM for determination of DMI.

Table 3.1. Nutrient content of total mixed ration

Item	Total Mixed Ration[1]
Dry Matter, %	57.6
Crude Protein, %	17.2
Fat, Crude, %	4.48
Acid detergent fiber, %	12.7
Ash, %	4.82
Total digestible nutrients, %	79.1
49	1.25
Digestible energy, Mcal/kg	3.48
Metabolizable energy, Mcal/kg	3.21
Sulfur, %	0.44
Phosphorus, %	0.57
Potassium, %	0.97
Magnesium, %	0.29
Calcium, %	0.79
Sodium, %	0.28
Iron, mg/kg	276.0
Manganese, mg/kg	61.3
Copper, mg/kg	26.0
Zinc, mg/kg	122.0

[1] Consisted of dry rolled corn, wet distillers grain, grass hay, and supplement, fed at 55.5%, 29.0%, 12.1%, and 3.4% of diet DM, respectively. Supplement contained 29% Ca, 10.9% Salt, 1.0% Mg, 0.10% K, 3750 mg/kg of Zn, 1653.44 mg/kg of monensin (Elanco Animal Health, Indianapolis, IN), 750 mg/kg of Cu, 7.5 mg/kg of Se, 132,275 IU/kg of Vitamin A, 13,227 IU/kg of Vitamin D3, and 136 IU/kg of Vitamin E.

Sample Collection and Analysis

Start weight for the experiment was determined by the average of weights collected on two consecutive days (d -1 and 0) of the feeding period. Interim weight was similarly determined by the average of weights collected on d 69 and 70, and the average of weights collected on d 139 and 140 were used to determine final BW. Overall average dressing percentage (63.4%) was used to calculate carcass adjusted final BW by dividing HCW by average dressing percent. Adjusted final BW was used to calculate carcass-adjusted ADG and G:F for the period of days

70 to 140 and 0 to 140. All final ADG and G:F calculations were made using the carcass-adjusted final weight.

Ort and feed samples were dried in a forced-air oven (55°C, The Grieve Corporation, Round Lake, IL) for at least 48 hr then stored at room temperature. Dried feed samples were ground (Wiley Mill, Arthur H. Thomas Co., Philadelphia, PA) to pass a 2-mm screen and analyzed for DM; CP, crude fat, ash, S, P, K, Mg, Ca, Na, Fe, Mn, Cu, and Zn (methods 930.15, 990.03, 945.16, 985.01, respectively; AOAC, 2010).

Ultrasound measurements were taken on d 0 and 70 by a single experienced technician with an Aloka 500V unit (Wallingford, CT) equipped with a 3.5-MHz, 17 cm linear array transducer. Values for percentage IMF, LMAUS, RMFTUS, and RBFTUS were estimated (Wall et al., 2004).

After 140 d on feed all steers were transported to and processed in a commercial abattoir. After routine processing procedures HCW was collected and carcasses chilled for 24 hr (2 °C) before determining LMA, RF, YG, quality grade, marbling number, and KPH. Data were determined for each carcass by a trained individual.

Statistical Analysis

Statistical analysis was performed using the general linear model (GLM) procedure of SAS (SAS Inst., Inc., Cary, NC) for continuous data and GENMOD procedure for binomial data. The models contained GP group (H or L), implant strategy (MOD or AGG), and the respective interaction, with steer as the experimental unit. Treatment and interaction means were separated with the least significant difference procedure and were considered significant at $P \leq 0.05$ and a tendency at $P \leq 0.10$.

Results and Discussion

Genetic Potential Scores

By design, mean composite GP values for H steers (86.5 ± 1.7, range 74 to 99) were greater (*P* < 0.001) than L steers (25.3 ± 1.7, range 5 to 45). Mean marbling scores were greater (*P* < 0.001) for H steers (3.7± 0.1, range 2 to 5) than L steers (1.4 ± 0.1, range 1 to 3). Likewise, mean gain scores were greater (*P* < 0.001) for H steers (3.83 ± 0.2, range 1 to 5) than L steers (2.88± 0.2, range 1 to 5).

Ultrasound Body Composition

No interactions were present among GP and implant factors for carcass ultrasound measurements at d 0 or d 70 (Table 3.2). Interestingly, at the start of the experiment H steers had greater intramuscular fat (IMF) deposition (*P* = 0.001) than L steers. To our knowledge there are no other reports of diverging IMF among steers of different genetic potential before being on a high-concentrate ration. Intramuscular fat is correlated to marbling score (Wall et al. 2004; MacNeil and Northcutt, 2008; MacNeil et al., 2010) which is the basis for quality grade. At the start of the experiment, overall, 25% of all the steers had IMF ≥ 4%, (the anticipated value needed to be considered for a choice carcass). Interestingly, a greater proportion (*P* = 0.01) of H steers (36.8%) had IMF ≥ 4% on d 0 compared with L steers (11.8%). The overall average IMF observed in the current study was 3.6%, similar to that observed by Maxwell et al. (2014) and Segers et al. (2013) in groups of similar age steers before being put on a high grain diet. Our observations support the concept that IMF deposition is a lifetime event, similar to reports by others (Bruns et al., 2004; Wall et al., 2004; Rhoades et al., 2009). On d 70, H steers still had greater IMF (*P* = 0.001) than L steers. Observation of differing IMF between GP groups before being placed on feed may foreshadow potential differences in marbling at the conclusion of the finishing period. No differences ($P \geq 0.16$) were observed among GP groups in LMAUS, RMPFTUS or RBFTUS on d 0 or 70. The GP test does not consider genes related to LM area or fat thickness so differences were not expected.

Table 3.2. Effect of genetic potential and implant strategy on ultrasound body composition characteristics of Angus-sired steers

	Genetic Potential[1]		Implant Group[2]		
Item	Low	High	Moderate	Aggressive	SEM
Intramuscular Fat, %					
d 0	3.26^x	3.83^y	3.58	3.52	0.09
d 70	3.81^x	4.39^y	4.27^x	3.92^y	0.12
LM Area, cm^2					
d 0	57.2	56.2	56.4	57.0	1.35
d 70	75.1	73.1	72.1^x	76.1^y	1.15
Rib Fat Thickness, cm					
d 0	0.79	0.74	0.74	0.76	0.03
d 70	1.17	1.14	1.17	1.14	0.03
Rump Fat Thickness, cm					
d 0	0.38	0.43	0.38	0.43	0.03
d 70	0.69	0.76	0.69	0.76	0.03

[1] Low = mean GP score, 86.5; High = mean GP score, 25.3. Determined using GeneMax, Zoetis, Florham Park, NJ

[2] Moderate = steers implanted on d 70; Aggressive = steers implanted d 0 and d 70, all implants contained 120 mg of TBA and 24 mg of E_2 (Revalor-S, Merck Animal Health, Summit, NJ)

^{xy}Means within factor and row differ ($P < 0.05$)

There was no differences ($P \geq 0.29$) in IMF, LMA, RBFTUS, and RMPFTUS between implant groups on d 0, as steers had not yet been implanted. After 70 d on feed, steers in the AGG implant group had larger LMAUS ($P = 0.02$) than steers in the MOD group. No differences were observed in LMA between implanted and non-implanted steers after 56 (Bruns et al., 2005) or 73 (Smith et al., 2007) DOF. When comparing implanted (Revalor-S on d 0) versus non-implanted steers, Johnson et al. (1996) observed no differences in carcass LMA when steers were slaughtered 40 d after implant, but implanted steers had greater carcass LMA than non-implanted steers on d 115. Johnson et al. (1996) observations seem to agree with our findings as d 70, when differences were observed in the current study falls between their slaughter dates.

Steers in the MOD implant group had greater ($P = 0.03$) IMF on d 70 compared with steers in the AGG group. In contrast, no differences in carcass marbling scores were observed between implanted and non-implanted steers slaughtered on d 40 or 115 (Johnson et al., 1996) or d 56 (Bruns et al.,2005). However, the mode of action of implants is to partition energy towards muscle protein synthesis in favor of fat deposition (Reinhardt, 2007) so the reduced IMF observed in MOD steers compared to AGG in the current study could be expected.

Feedlot Performance

No differences ($P \geq 0.60$) were observed between GP groups in BW, ADG, DMI, or G:F during any period evaluated (i.e. d 0 to 70, d 70 to 140, or d 0 to 140; Table 3.3) in spite of the H steers having greater genetic potential for gain than L steers (3.8 and 2.9 for H and L, respectively). DeVuyst et al. (2011) also failed to observe a phenotype effect in steer gain with different Igenity (Merial Ltd.) panel scores and fed for 135 to 257 d. Taken together, three possibilities exist; 1) genetic evaluations do not accurately separate steers into distinct gain groups, 2) greater divergence in GP scores for gain are required to observe a phenotypic gain response, or 3) greater experimental power is required to observe a phenotypic gain response.

Table 3.3. Effect of genetic potential and implant strategy on feedlot performance of Angus-sired steers

	Genetic Potential[1]		Implant Group[2]		
Item	Low	High	Moderate	Aggressive	SE
BW, kg					
d 0	331.2	327.0	329.5	328.8	4.46
d 70	474.2	470.3	462.96[x]	481.5[y]	5.04
d 140	610.6	606.8	601.47	615.9	7.2
Final Adjusted[3]	581.2	577.7	572.1	586.8	6.84
ADG, kg/d					
d 0-70	2.04	2.05	1.91[x]	2.18[y]	0.04
d 70-140[6]	1.53	1.53	1.56	1.50	0.05
d 0-140[6]	1.78	1.79	1.73[x]	1.84[y]	0.004
DMI, kg/d					
d 0-70	8.37	8.32	8.32	8.37	0.08
d 70-140	10.87	10.81	10.62[a]	11.07[b]	0.18
d 0-140	9.63	9.58	9.50	9.72	0.11
G:F					
d 0-70	0.24	0.25	0.23[x]	0.26[y]	0.005
d 70-140[4]	0.14	0.14	0.15	0.14	0.004
d 0-140[4]	0.19	0.19	0.18	0.19	0.003

[1] Low = mean GP score, 86.5; High = mean GP score, 25.3. Determined using GeneMax, Zoetis, Florham Park, NJ

[2] Moderate = steers implanted on d 70; Aggressive = steers implanted d 0 and d 70, all implants contained 120 mg of TBA and 24 mg of E_2 (Revalor-S, Merck Animal Health, Summit, NJ)

[3] Calculated as HCW divided by 0.634 (average dressing percentage)

[4] Calculated with carcass adjusted final BW

[xy] Means within factor and row differ ($P < 0.05$)

[ab] Means within factor and row tend to differ ($P < 0.10$).

During the first 70 d steers in the AGG implant group became 18.6 kg heavier (*P* = 0.01), had 0. 27 kg/d greater ADG (*P* < 0.001), and were 12% more efficient (*P* < 0.001) compared with steers in the MOD group. These findings were similar to others (Bartle et al., 1992; Johnson et al., 1996; Bruns et al., 2005) reporting greater ADG and feed efficiency at an interim period after implanting with a combination implant (TBA/E_2) compared with non-implanted steers. For the second period (d 70 to 140) there was a tendency (*P* = 0.08) for AGG steers to have greater DMI compared to MOD steers. Recall that AGG steers had greater ADG between d 0 and 70 resulting in an 18.6 kg heavier BW on d 70. The subsequent tendency for AGG steers to have greater DMI than MOD steers was likely a direct result of BW differences, as both groups were eating 2.0% of their BW between d 70 and 140. There was no differences ($P = 0.13$) in BW or ADG. Similarly, Scaglia et al. (2004) observed no differences ADG from d 63 to 116 in steers receiving their second implant on d 63 [Revalor-S, preceded by by Synovex-S (Zoetis) on d 1] compared with steers receiving their first implant on d 63 (Revalor-S). Lack of difference in ADG from d 70 to 140 in the current study was expected as the MOD and AGG groups both received the same implant on d 70.

In the current study, no differences ($P \geq 0.12$) were observed in carcass-adjusted BW, DMI, or G:F between the implant treatments over the entire feeding period (d 0 to 140). Similarly, no differences were observed in final BW, DMI, or G:F after 131 DOF between steers receiving a single Revalor-S on d 0 and steers receiving a RevalorIS (80 mg of TBA and 16 mg of E_2) on d 0 and Revalor-S between d 44 and 47 (Parr et al., 2011). Guiroy et al. (2002) also did not observe a difference in feed efficiency between implant treatments when steers were given either one, delayed implant (Revalor-S) on d 90 or an implant on d 0 and 90. In the current study, steers in the AGG group had greater ($P = 0.03$) ADG over the entire period compared to MOD steers; however, this seems to be strictly a result of increased ADG during the first 70 d when MOD steers did not have the growth promoting benefits of an implant. The observed difference in ADG is similar to findings of Guiroy et al. (2002) who reported steers given 2 implants gained more per day than those given one delayed implant during 210 DOF.

Carcass Characteristics

At slaughter, there were no differences ($P \geq 0.28$) between GP groups in HCW, LMA, RF, KPH%, or YG (Table 3.4). A greater proportion ($P = 0.03$) of steers in the H group had choice carcasses (100%) compared with L steers (87.8%). Interestingly, a tendency for an interaction ($P \leq 0.09$) between GP and implant factors was present for marbling number and proportion of carcasses qualifying for the Certified Angus Beef (CAB) program (Table 3.5). Marbling score and % CAB were reduced by the AGG implant strategy in H steers but that effect was not observed in L steers. Previous research has reported a further reduction in marbling score when re-implanting or using a more aggressive implant compared to more moderate regimens (Samber et al., 1996; Duckett et al., 1997; Platter et al., 2003). Duckett et al. (1997) reported a 2.5% reduction in marbling when implanting with a combination TBA/E_2 implant rather than a single estrogen, and a 4.3% reduction when utilizing two combination implants compared to a single combination implant. DeVuyst et al. (2011) reported that greater Igenity (Merial Ltd.) marbling panel scores correlated with improved quality grades. Contrary to our results, Johnston and Graser (2010) did not find association between GeneSTAR (Zoetis) marbling markers and carcass marbling score. Results from the current study would indicate that steers of differing GP scores may be managed differently to attain desirable quality grades. Steers with greater GP, based on GeneMax score, achieve greater marbling scores when implanted once compared to receiving two implants. Steers of lesser GP scores can be given two implants to reap full benefits of an implants potential, without negatively impacting marbling scores.

Table 3.4. Effect of genetic potential and implant strategy on carcass composition of Angus-sired steers after 140 d on feed

	Genetic Potential[1]		Implant Group[2]		
Item	Low	High	Moderate	Aggressive	SE
HCW, kg	371.4	369.2	362.7	372.02	4.35
LM Area, cm^2	88.37	87.72	88.37	87.72	1.10
RF[3], cm	1.37	0.53	1.19^x	1.52^y	0.08
KPH, %	2.35	2.34	2.33	2.37	0.05
Yield Grade	3.35	3.33	3.19^x	3.50^y	0.07
Quality Grade, %					
Choice	87.8^x	100^y	90.6	97.2	0. 04

[1] Low = mean genetic potential score, 86.5; High = mean genetic potential score, 25.3. determined using GeneMax, Zoetis, Florham Park, NJ

[2] Moderate = steers implanted on d 70; Aggressive = steers implanted d 0 and d 70, all implants contained 120 mg of TBA and 24 mg of E_2 (Revalor-S, Merck Animal Health, Summit, NJ)

[3] Carcass rib fat thickness

^{xy}Means within factor and row differ ($P < 0.05$)

Table 3.5. Effect of genetic potential[1] ×implant[2] strategy on marbling score and carcasses qualifying for Certified Angus Beef of Angus-sired steers after 140 d on feed[3]

	Treatment group[3]				
Item	HIAGG	HIMOD	LOAGG	LOMOD	SE
Marbling Score[4]	492.9^x	538.3^y	481.1^x	463.8^x	16.7
Certified Angus Beef, %	35.3^x	66.7^y	33.3^x	25.0^x	0.11

[1] Genetic potential (GP) determined using GeneMax, Zoetis, Florham Park, NJ

[2] Implant contained 120 mg of TBA and 24 mg of E_2 (Revalor-S, Merck Animal Health, Summit, NJ)

[3] Marbling score GP × Implant strategy $P = 0.08$; % Certified Angus Beef GP × Implant strategy $P = 0.06$

[4] HIAGG: Average GP score of 86.4, received implant on d 0 and d 70; HIMOD: Average GP score of 86.5, received implant on d 70; LOAGG: Average GP score of 25.8, received implant on d 0 and d 70; LOMOD: Average GP score of 24.8, received implant on d 70

[4] Marbling score based on $Small^{00} = 400$

^{xy}Means in the same row lacking a common superscript differ ($P \leq 0.05$)

Steers in the AGG group had thicker (*P* = 0.003) RF and greater (*P* = 0.003) yield grades than MOD steers but no differences ($P \geq 0.14$) were observed in HCW, marbling, LMA, or KPH. Scaglia et al. (2004) also reported no differences in HCW, marbling, or LMA between implant treatments, while others have noted differences in these carcass characteristics (Duckett et al., 1997; Roeber et al., 2000; Parr et al., 2011). Roeber et al. (2000) reported greater LMA in steers implanted on d 0 and 70 (Revelor-S) compared with steers only implanted on d 0 and fed for 140 d, but did not report differences in HCW, marbling, or quality grade. Duckett et al. (1997) reviewed comparisons of steers with a TBA/E_2 combination implant on d 0 with re-implanted steers and reported re-implanted steers had heavier HCW, larger LMA, and less IMF than steers with a single implant (Duckett et al., 1997). The greater RF observed in the AGG treatment is something not expected, as previous work reported that more aggressive implants result in reduced RF (Parr et al., 2011). In the current study, AGG steers would have been market ready before the MOD steers resulting in fewer overall DOF. Perry et al. (1991) compared steers implanted with Revalor-S to non-implanted controls and found that when slaughtering on an individual basis (when ultrasound predicted a small degree of marbling), implanted steers had fewer DOF than non-implanted steers. After cattle have reached physiological maturity, caloric intake above maintenance requirements will be partitioned in the form of adipose tissue rather than protein (Andrews, 1958), at least partly explaining the greater amount of RF observed in the AGG implant group compared to the MOD implant group.

While steers were being trained to the Calan gates they were also being adapted to high concentrate diets. Consequently at the start of the project all steers were receiving a full finishing diet. Due to steers being on finishing diets at the start of the project, our initial d 0 implant could also be considered a delayed implant strategy (as opposed to implanting on arrival before adaptation to finishing diets). Overall, quality grades were 94% choice in the current study. Delayed implanting could explain the overall good quality grades observed. Bruns et al., (2005) compared implant strategies using steers which were either not implanted, implanted (Revalor-S) upon arrival to the feedyard, or delayed implanted on d 56 and reported that steers implanted at arrival had a lower marbling score than non-implanted steers and delayed implanted steers were intermediate to the other two treatments.. Even steers in the L GP group, which had an average GP marbling score of 1.4 (28th percentile), still produced carcasses of exceptional quality (88% choice). As phenotype is a function of the additive effects of genotype and environment (Moyes and Schulte, 2008), the quality grades observed in L GP steers give an indication that poor genetic potential may be overcome with proper management to elicit a desired phenotype.

Implications

Results of this study indicate that commercially available predictions of genetic potential can be indicative of marbling potential and quality grades. Steers with greater genetic potential had greater percent intramuscular fat before consuming high concentrate diets, and improved marbling scores and quality grade at slaughter compared with low genetic potential steers. The difference in intramuscular fat on d 0 between genetic potential groups indicates that a portion of marbling accretion occurs before steers are being fed high concentrate diets. The overall quality of carcasses in the current study indicates that producers may be able to adopt management strategies that result in acceptable performance of steers with poor genetic potential. More aggressive implant strategies can affect feedlot performance and carcass characteristics at different points throughout the feeding period, but carcass marbling in steers of greater genetic potential seems to be more sensitive to implant strategy than that of steers with lesser genetic potential for marbling.

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CHAPTER 4. OVERALL CONCLUSIONS

In an effort to continue improved efficiency in the beef cattle industry, the innovation of strategies to implement technology is pertinent. The incorporation of artificial insemination and genomic profiling into beef cattle operations give producers the opportunity to improve their calf crop, improve carcass characteristics, and improve overall efficiency of beef production systems.

Reproductive performance of cows is not altered when managing in a dry lot for a 10 day period of estrus synchronization, indicating producers can eliminate some time that is required to gather cattle for synchronization protocols. However, BW of suckling calves which were maintained in the dry lot with their cows for 10 d were negatively impacted and the reduction was still present at the time of weaning. The reduction in weaning weights of calves needs to be weighed against the time and labor savings in order for a producer to determine its worth.

Genetic testing results can be indicative of marbling potential and quality grades. Steers with greater genetic potential have greater percent intramuscular fat before consuming high concentrate diets, which, to our knowledge, is a concept not reported before. Carcass marbling in steers of greater genetic potential appears to be more sensitive to implant strategy than that of steers with lesser genetic potential for marbling. Genetic testing gives feedlot managers the opportunity to select for high genetic potential animals to potentially realize premiums associated with improved quality grades. The overall quality of carcasses in the current study indicates that producers may be able to adopt management strategies that result in acceptable performance even in cattle with lesser genetic potential.