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Effects of Management Strategies and Molecular Breeding Values on Cattle Performance and Carcass Traits

Benjamin Collins Williamson
University of Arkansas, Fayetteville

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**Effects of Management Strategies and Molecular Breeding Values on Cattle Performance
and Carcass Traits**

**Effects of Management Strategies and Molecular Breeding Values on Cattle Performance
and Carcass Traits**

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Animal Science

By

Benjamin C. Williamson

Morehead State University

Bachelor of Science in Agricultural Sciences, 2009

May 2012

University of Arkansas

Abstract

Forty-eight Gelbvieh x Angus steers (265 ± 40 kg) were utilized to determine the relationships among molecular breeding values (MBV), steer performance, and carcass traits. Body weight (BW), hip height (HH), hip width (HW), exit velocity (EV; rate at which steers exited the squeeze chute and traversed 1.8 m) and body ultrasound measurements of steers were recorded at d 0, 93 and 154 of grazing mixed stockpiled endophyte-infected and -free tall fescue. Tissue samples were collected for genomic profiling (Igenity, Merial Limited, Duluth, GA). Steers were transported to the Oklahoma State U fed for 159 d, harvested and carcass parameters recorded. At d 0 and 154 of grazing, BW was correlated ($P < 0.05$) with MBV for ADG ($r = 0.31$ and 0.32 for d 0 and 154, respectively). Hip width was correlated ($P < 0.05$) with MBV for ADG ($r = 0.33$ and 0.32 for d 0 and 154, respectively) at d 0 and 154. An inverse correlation between EV and MBV for LM area on d 0 ($P < 0.01$; $r = -0.48$) and d 154 ($P < 0.03$; $r = -0.03$) of grazing was observed; on d 93, EV and MBV for LM area tended to be inversely correlated. Ultrasound measurements for intramuscular fat on d 0 were correlated ($P < 0.05$) with MBV for docility ($r = 0.40$). Predictive potential of MBV from the stepwise procedure for steer performance and carcass composition was low ($r^2 \leq 0.22$). Molecular breeding values were correlated with several measurable traits that can be obtained on-farm. Incorporation of MBV may aid cattle producers in more accurate selection practices to increase profitability of beef production.

Environmental and managerial conditions are known to affect subsequent performance and carcass traits of beef cattle. The objective of the second study was to document the effect of stocking rate (SR), grazing method (GM) and breed of sire on carcass traits. Steers and heifers ($n = 460$) grazed 'Maton' rye (*Secale cereale L.*) and 'TAM90' annual ryegrass (*Lolium*

multiflorum L.) pastures from January to mid-May during 5 yr. Cattle were allotted to stocking rates (SR) of high (9 animals/ha), medium (6 animals/ha), or low (4 animals/ha), GM of continuous (CONT) or rotational (RT), and fed in commercial feedyards. Calves were sired by bulls from the following breeds; Angus (n = 171), Bonsmara (n = 108), Brahman (n = 109), Braunvieh (n = 31), Hereford (n = 12), and Simmental (n = 29). Body condition score (BCS); ultrasound measurements of intramuscular fat (UIMF), longissimus dorsi muscle area, and rump fat at end of grazing; ADG during grazing (119 d \pm 25) and feedyard (125 d \pm 28) phases; hot carcass weight (HCW); carcass ribfat (CRF); carcass LM area (CLMA); and yield grade (YG) were determined. Effects of year, gender, SR, GM, breed of sire, and interactions were determined by ANOVA. Simmental offspring had greater ($P < 0.01$) amounts of UIMF than Bonsmara and Brahman (0.11 ± 0.03 and 0.13 ± 0.03 , respectively). Stocking rate affected the HCW of cattle ($P < 0.05$) with high SR (314.1 ± 5.8 kg) cattle having lighter HCW than low SR (329.0 ± 4.9 kg). Stocking rates and breed of sire did affect carcass traits, and these variables can be managed to maximize carcass value.

This thesis is approved for recommendation
to the Graduate Council.

Thesis Director:

Dr. Charles F. Rosenkrans, Jr

Thesis Committee:

Dr. Michael L. Looper

Dr. Randy L. Raper

Dr. Rick W. Rorie

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Dedication

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I would like to make part of this dedication to the memory of fellow graduate student Mathew Rowe. Matt was an outstanding individual in both intellect and work ethic, and should be remembered for both. He was taken from this world and his new bride too soon, and will be missed by all. I considered Matt both a peer and friend, and may he rest in peace.

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Chapter I

Introduction

Beef cattle are a significant portion of the agricultural economy in the state of Arkansas. According to the last national survey, there were an estimated 1,720,000 (NASS, 2011) beef cows and calves inventoried in the state, ranking Arkansas 17th among other states in the nation. Annual receipts in 2010 for cows and calves sold totaled \$625,996,000, ranking the state 21st in the U.S. for total sales of cows and calves (NASS, 2011), making the beef industry the largest livestock industry in the state, behind the poultry industry. Cattle are an economically important commodity, and are important to the future growth and prosperity of agriculture in the state of Arkansas.

In a survey conducted with beef producers and support industry in the state of Arkansas, several concerns were identified (Troxel et al., 2006). Among them, there was a great concern of the input cost and profit margins that currently exist. It is important to capitalize on the premiums that are available with high quality and yielding carcasses. Management and environmental factors play a role in the carcass quality at harvest, but minimal research documents the long term effects of management during the stocker phase on carcass quality. Producers also identified the lack of cattle quality as a concern for the Arkansas beef industry. By identifying management decisions such as stocking rate, grazing method, and breed of sire that result in better quality carcasses, Arkansas producers may capture the highest premiums available.

There are genetic parameters that influence this potential performance and carcass quality of cattle. Traditionally, the best tool producers had to identify animals of superior genetic quality was expected progeny differences (EPD), but these can only be calculated with performance records that are collected with pedigreed animals. This is impractical for commercial producers who implement crossbreeding programs to capitalize on heterosis. In recent years, researchers have investigated differences in the sequences of the bovine genome and its association with performance variables. Commercial companies have developed molecular breeding values (MBV) from combining the performance differences that are associated with the differences in genome known as single nucleotide polymorphisms (SNP). These MBV may aid producers in selecting genetically superior cattle without ancestry, possibly helping to improve cattle quality that concerned Arkansas producers as reported by Troxel et al. (2006). The incorporation of these tools may aid in making Arkansas beef producers more profitable, hence streaming more money in the rural economy of Arkansas and making the state's beef industry more competitive on the national market.

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Chapter II:
Literature Review

Forage Systems for Beef Production: Forages utilized for grazing systems in the United States are divided into two primary classifications, warm and cool season forages. These forage species are classified by either the three- or four-carbon photosynthetic pathway the plant utilizes, and are therefore referred to as either a C₃ or C₄ plants (Furbank and Taylor, 1995). Cool season species are classified as C₃ plants and are better suited to cooler, moist climates. As a result, these forages tend to grow during the cooler times of the year such as the spring and fall. Plants classified as C₄ are warm season forages that conduct photosynthesis in inner chloroplast cells so not to lose energy in more extreme temperatures. That allows C₄ plants to grow during summer months and excel in the hotter, more humid southern region of the United States.

Forage species classified by their C₃ photosynthetic pathway are more digestible than C₄ plants when consumed by ruminants (Van Soest, 1982; Coblenz et al., 2004). Elevated temperatures during the growing season cause lignification in C₄ plants, elevated metabolic activity resulting in smaller pools of metabolite in the cellular contents, as well as a decrease in mesophyll (the photosynthetic tissue) concentration to leaf area ratio when compared to C₃ forages. Mesophyll is important to note because it is non-lignified and nearly 100% digestible (Nelson, 1994).

Cool season forages: Cool season annual forages are known to be of high quality and produce high forage yields (Royo et al., 1994; McCormick et al., 1998). Cool season annuals include plant species such as cereal rye (*Secale cereale* L.), oats (*Avena sativa*), and wheat (*Triticum aestivum* L). Cattle grazing these forage species can achieve average daily gain (ADG) of 1 kg or more (Uttey et al., 1975; Worrell et al., 1990; Coffey et al., 2002). Worrell et

al. (1990) found cereal rye was of good quality forage throughout the grazing season from December through March with percent of organic matter disappearance ranging from 74.5 to 83.6%.

Wheat is commonly grazed in the southern portions of the United States as a means for quick weight gains on growing cattle. Wheat pastures have been reported to contain crude protein (CP) above 20% and more than 70% digestible (Mader et al., 1986; Branine et al., 1990) allowing for moderate to high gains. Cereal rye (*Secale cereal L.*) is known to have similar nutrient value to winter wheat (Worrel et al., 1990) and withstand more extreme winter conditions than other winter annual forages. While cereal rye does produce large amounts of forage, it does not consistently produce the largest forage yield in every location when compared to other winter annual forages (West et al., 1988; Nelson et al., 1993). Research has indicated that cattle grazing cereal rye do not gain as much as cattle grazing wheat (Coffey et al., 2002; Beck et al., 2005).

Supplementation: It is a common practice to supplement cattle grazing winter annuals to either increase stocking rates or ADG. This is generally done with either grain or high fiber energy supplements (wheat middling, soybean hulls, cottonseed hulls, etc.) that are comprised of by-product feed additives. There was no difference in ADG of cattle that were supplemented with either grain or a high fiber energy supplements (Horn et al., 2005); however, cattle more readily consumed the high fiber by-product feeds compared to the grain feeds. This is an important consideration with bunk management. If cattle consume the high fiber feeds within 30 min compared to over a course of the day with the grain feeds, there is less potential of feed spoilage and loss. Another advantage of high fiber feed additives is the reduced risk of acidosis

due to the lack of starch in the diet (Horn et al., 2005), allowing cattle to continue to consume forage and gain weight from by-product feedstuffs.

Cattle that are thin when entering the feedyard are known to have greater compensatory gains when compared to cattle that carry more body condition (Sainz, 1995). Cattle that graze winter annual pastures are typically heavier and in better body condition than those grazing other forage types. As a result, they do not generally experience compensatory gains, but do have greater body weights at harvest. There are variation in reports as to if supplementing cattle while grazing winter annual pasture effects ADG in the feedyard, however, supplementation does not appear to affect feed intake or gain to feed (G:F) ratio (Horn et al., 2005).

Fescue: One of the most commonly grazed cool season perennial in the United States is tall fescue (*Lolium arundinacea*) which covers more than 14 million hectares. Tall fescue is of reasonably good quality to grazing animals with 12 to 16% CP with 61 to 66% TDN from the vegetative to boot stage, and 8 to 12% CP with 59 to 63% TDN in the boot to head stage (Ball et al., 2002). However, approximately 90% of fescue is infected with wild-type fungal endophyte *Neotyphodium coenophialum* (Ball et al., 2002) which has negative effects on animal performance. Often animals grazing endophyte-infected tall fescue (E+) suffer from fescue toxicosis (Stuedemann and Hoveland, 1988) which includes elevated body temperatures, retained rough hair coat in the summer, increased respiration rates, and reduced dry mater intake as well as growth (Schmidt and Osborn, 1993; Strickland et al., 1993; Thompson and Stuedemann, 1993). In severe instances, infected animals may slough off tips of ears and/or tails or may even lose their hooves (Read and Camp, 1986). In most non-severe cases, the symptoms will reduce

in 3 to 4 d once cattle are removed from E+ pastures and fed a non-toxic feedstuff (Aiken et al., 2001).

Due to its negative effect on acceptable body weight gains, E+ has been used primarily for cow/calf production (Hoveland, 1993). However, researchers are still trying to find ways to manage these adverse challenges of grazing E+ and utilize the existing stands for stocker production. One option is to graze cattle during the cooler times of the year. Cattle grazing E+ fescue in the fall and winter months show fewer symptoms of fescue toxicosis than those grazing during the spring and summer months (Hoveland et al, 1997; Hopkins et al, 2006). This is thought to be partially due to the decreased ambient temperatures, allowing the animals to better tolerate the effects of the ergot alkaloids. Another reason that this is a viable management strategy for minimizing toxicosis symptoms is the fluctuation in the concentration of alkaloids. Ergovaline is one alkaloid that is present in tall fescue that causes negative effects on animal health and performance (Rottinghaus et al., 1991); ergovaline concentrations increase through the growing season, peaking in midsummer when plants go to seed, as the seed head carries the greatest concentration of alkaloids. Concentrations decline until fall re-growth occurs, allowing for another peak in concentrations, and then declines again (Rottinghaus et al., 1991). However, this strategy comes with its challenges as well. In a review of stockpiled fescue, Poore et al. (2000) concluded that stockpiled fescue was more economical than traditional hay feeding. Nutrient values were deemed acceptable, however, growing cattle reached low to moderate gains, indicating that stockpiled forages may be better suited for mature brood cows. Gains in growing cattle can be increased with supplementation or with the use of implants. Other attempts to improve performance and decrease fescue toxicosis symptoms has been through the use of other forages to dilute the

stands of E+. Adding a legume mixture to fescue will aid in additional gains and reduced toxicosis symptoms (Thompson et al., 1993).

Tall fescue cultivars that lack fungal endophyte in the plant have been developed that creates a non-toxic cultivar (E-; Siegel et al., 1985). This was accomplished by storing tall fescue seed for at least a year, allowing the endophyte to die but allowing for acceptable germination of the seed. The results were a significant increase in performance by animals grazing these stands (Hoveland et al., 1993; Thompson et al., 1993). Several studies have compared responses of animals grazing either E+ or E- pastures. Hoveland et al. (1983) allowed yearling steers to graze stands of E+ or E- fescue in the fall and spring months. Steers grazing E+ stands had ADG of 0.50 kg per day, and steers grazing E- stands reached ADG of 0.83 kg. Steers grazing E+ also had a 0.8° C higher rectal temperature and rougher hair coats than steers grazing E- pastures (Thompson et al., 1993). Steers grazing highly infested (≥ 0.50) stand of E+ have an approximately 20% lower DMI when compared with cattle that are grazing a low infested (≤ 0.05) stand (Thompson et al., 1993; Waller et al., 1993)

Endophyte free varieties have improved performance of animals, but have not been able to withstand environmental stresses. The endophyte *Neotyphodium coenophialum* that is present in E+ has been found to aid the plant in stress tolerance and allowing it to thrive under extreme conditions (Clay et al., 1988; West et al., 1994). Gunter and Beck (2004) reported that stands of E- tall fescue could not withstand drought and intense grazing would eliminate the stand in less than 4 years. Fescue cultivars have been developed incorporating novel endophytes that aid the plant in its stress tolerance and stand persistence but does not have negative effects on animal performance and health. Bouton et al. (2002) found the novel variety of tall fescue MaxQ had

stand persistence ranging from 80 to 90% of that of E+ tall fescue as compared to 20% for E- when planted in closely grazed burmudagrass pastures, indicating that novel cultivars have acceptable stand persistence. Nihsen et al., 2004, reported cattle grazing novel endophyte fescue cultivars had similar ADG to that of E- and did not show symptoms of fescue toxicosis. Reports also have been published that show an increase of E+ persistence in pastures that have been sown with both E+ and E- cultivars or E- stands are in close proximity to E+ pastures (Shelby and Dalrymple, 1993). This is thought to be due to the added persistence of the E+ cultivars compared to the E- varieties.

Forage quality analysis: Chemical analyses are used to determine the quality of feedstuffs used in production so diets may be formulated appropriately for the stage of development of the animal. Three primary analyses used to determine quality are neutral detergent fiber (NDF), acid detergent fiber (ADF), and crude protein (CP).

Neutral detergent fiber is classified as the structural carbohydrates that include major cell wall components such as lignin, cellulose, and hemicellulose (Van Soest, 1991). These major fiber components are of variable digestibility in ruminant diets. A few minor cell wall components, including some protein, bound nitrogen, minerals, and cuticle also are found in NDF. These insoluble fiber components are extracted with a neutral (pH 7) sodium lauryl sulfate solution (Van Soest, 1991). Typically, as NDF concentration increases in a diet, dry matter intake (DMI) and animal performance decreases (Orskov, 1988).

Acid detergent fiber are the components of the cell wall that do not dissolve in a strong (1 N) acid solution. This process separates the residue into separate fractions of the feedstuff as soluble or insoluble in this solution. In the soluble portion of the solution, hemicelluloses and

cell wall proteins are primarily recovered. In the remaining residue, lignin, cellulose, and the least digestible noncarbohydrate fractions are recovered. This process aids in the estimation of lignin, cutin, cellulose, indigestible nitrogen, as well as silica. Acid detergent fiber is commonly used as a fast method of determining approximate fiber in feed and is sometimes used in place of crude fiber (Van Soest, 1994). Acid detergent fiber has a negative correlation with digestibility with digestibility decreasing as ADF concentrations increase.

Crude protein is composed of true protein (only amino acids) and any other nitrogenous product. The calculation for CP is the percent of N multiplied by 6.25, as protein is composed of approximately 16% N (Jurgens, 2007). Crude protein concentrations have been found to be associated with an increase in ADG, dry matter intake, and gain-to-feed ratios (Gleghorn et al., 2004).

Management effects on beef production

There are numerous factors that affect the performance and quality of beef production. Some of these factors can be addressed through selection and management decisions during the production cycle.

Cattle disposition affects subsequent performance and carcass composition. Excitable cattle generally gain less weight than more docile cattle (Tulloh, 1961; Fordyce and Goddard, 1984; Voisinet et al., 1997). Reinhardt et al. (2009) reported cattle that were less docile had lighter weights when entering the feedyard, as well as decreased fat thickness, longissimus muscle area (LMA), yield grade, marbling score, and percentage of cattle that grade choice at

harvest. Reduced mortality rates also have been observed with increased docility (Reinhardt et al., 2009).

It is common for beef production enterprises to vary in resources that are available at any given time (due to economics and/or environment). As a result, cattle enter commercial feedyards in a variety of conditions depending on the backgrounding management. As stocking rate increases, then cattle ADG decreases (Willms et al., 1986). One management strategy that can be implemented to retain ADG and increase stocking rates is rotational grazing (Pieper, 1980; Bertelsen et al., 1993). By allowing resting periods between grazing of separate pastures and forcing cattle to consume more of the available forage, forage output and quality can be improved allowing for increased gains per ha (Hafley, 1996). Aiken (1998) investigated the effects of continuous grazing, low intensive grazing (3 paddock rotation), and high intensive grazing (11 paddock rotation) while grazing winter annuals or warm season forages; this showed that there was an advantage to steer performance and forage quality while rotational grazing winter annuals, however not for warm season forages. Aiken (1998) also reported that there was no advantage to high intensive grazing verses low intensive grazing.

When forage availability is limited, cattle will typically enter the finishing phase at lower BW than cattle that were not restricted. Nutrient restriction during the development stage will result in increased compensatory gains in the feedyard (Sainz et al., 1995; Neel et al., 2007). However, Hersom et al. (2004) reported that despite restrictions in the stocker period, there were no compensatory gains when cattle were fed to a constant backfat endpoint. Restricted cattle during the development phase are fed finishing rations for a longer period of time and have a

greater DMI (Sainz et al., 1995; Herson et al., 2004) and will have a lower final BW when fed for the same length of time.

Although greater ADG is achieved by restricting cattle before receiving high concentrate finishing rations improving G:F conversions, concerns exist this impacts the quality of the carcass at harvest. Low-to-moderate gain cattle during backgrounding have lighter final BW and hot carcass weight (HCW) as cattle that have higher gains in the development stage (Neal et al., 2007), and high gain cattle had higher dressing percentages and reached higher quality grades than cattle managed for moderate to low gains during the stocker phase. Herson et al. (2004) showed similar results with cattle that had high gains during the stocking phase had higher HCW, kidney, heart, and pelvic fat (KPH), marbling scores and 12th rib backfat thickness.

Weights of calves entering feedyards have an impact on the subsequent performance while in the finishing phase. Heavier calves that enter the feedyard have reduced ADG, LMA per 45 kg of BW, and stay healthier with less incidence of mortality (Reinhardt et al., 2009). Reinhardt et al. (2009) also reported that initially heavier calves also yield heavier final BW and HCW, increased actual LMA, fat thickness, yield grade, and lower marbling score.

Effects of frame size and gender: Management considerations need to take into account the type of cattle that are being fed as well. Crouse et al. (1985) reported an interaction may occur between cattle frame size and energy content of finishing ration. Large framed steers receiving a lower energy diet may have a lighter harvest BW and less carcass fat than cattle fed higher energy diets. That indicates larger framed cattle may have more potential for growth and pay weight but must receive appropriate rations to reach that potential. Large framed cattle have larger BW, ADG, HCW, and LMA with less fat thickness and lower yield and quality grade.

However, smaller framed cattle, while containing a higher percentage of fat, have a higher fat to bone ratio (Crouse et al., 1985). Larger framed cattle, however, may not always yield more muscle as a higher percent of their carcass may be comprised of bone and connective tissue (Tatum et al., 1988; Reinhardt et al., 2009).

Gender has an effect on performance with heifers having less ADG, harvest BW, LMA, HCW, and are fatter when harvested with greater marbling scores and quality grades than steer contemporaries (Garrett and Hinman, 1971; Reinhardt et al., 2009). Reports also have indicated heifers seem to have reduced incidence of respiratory disease than male contemporaries (Cockett et al. 1992; Reinhardt et al., 2009), indicating that they may be better able to withstand health challenges.

Breed Effects: Cattle of various breeds are used in production systems around the world, all with different strengths. Factors that deem which breed is beneficial for a given production scenario depends on environmental conditions, feed resources, and marketing strategies. In the United States, cattle of either *Bos indicus* or *Bos taurus* breeding are utilized in either purebred or crossbreeding programs. *Bos indicus* cattle are “humped” or “eared” cattle from Asia and are known for their ability to tolerate extreme heat and external parasites. *Bos taurus* breeds found in the United States can be split into two classifications based on their origin. British breeds originated from the British Isles, and are earlier maturing cattle with a maternal emphasis. Breeds that are known as Continental breeds originated in various parts of Europe and are typically described as more terminal breeds, producing calves that are larger, grow faster, and yield larger amounts of beef than British breeds (Williams et al., 2010).

Breed composition, and muscle and frame scores of feeder cattle that enter the feedyard are factors that significantly affect cattle performance (Marshall et al., 1990; Laborde et al.,

2001; Tatum et al., 1986a,b; Dolezal et al., 1993). Williams et al. (2010) performed a 20-yr meta-analysis for breed effects and concluded Hereford, Shorthorn, Limousin, Gelbvieh, Charolais, and Simmental all showed additional post-weaning growth when compared to Angus genetics, while Brahman cattle had less postweaning growth. Reinhardt et al. (2009) found Angus genetics had higher ADG while in the feedyard. This is evidence selection has resulted in a change in traditional breed stereotypes.

Significant variation exists in carcass traits of the various breeds. Hereford and Angus cattle have the most rib fat compared to other breeds, and Angus cattle also have higher quality grades compared with other breeds (Marshall, 1994; Reinhardt et al, 2009; Williams et al., 2010). Although Hereford cattle may be similar to Angus in rib fat, they yield less product than Angus(Williams et al., 2009). Braunvieh, Gelbvieh, and Simmental cattle yield leaner carcasses that are heavier muscled (Marshall, 1994; Williams et al., 2010). Cattle of Continental genetics (Simmental, Charolais, Gelbvieh, Limousine) are larger, have heavier HCW, larger LMA less fat thickness, and have a larger percentage that achieve yield grades 1 and 2. However, cattle of British (Angus, Hereford, and Shorthorn) decedents have higher marbling scores and a greater percentage of carcasses that grade Choice than cattle of Continental lineage (Crouse et al., 1975; Marshall, 1994; Reinhardt et al., 2009).

Bos indicus breeds have less intramuscular fat than British breeds, but are comparable to the Continental breeds (Williams et al., 2010). However, *Bos indicus* cattle have a greater shear force measurement and rank lower on sensory taste panels for tenderness than *Bos taurus* cattle (Marshall, 1994). This is still true when samples are compared at the same level of marbling (Koch, 1988). Crouse et al. (1989) found as the percentage of *Bos indicus* increased, shear force increased and sensory taste panel rating decreased. Shear force decreased for cattle with greater

percentage of *Bos taurus* genetics. Producers that utilize *Bos indicus* genetics for their heat tolerance may receive discounts because of the potential of reduced performance and carcass quality (Troxel and Barham, 2007). Williams et al. (2010) suggested that *Bos indicus* cattle do not perform to their full potential in more temperate climates as compared to hot, humid climates such as the southeastern United States where the cattle are better suited. In an effort to find alternative genetics adapted to subtropical climates, non-*Bos indicus* breeds acclimated to these conditions have been evaluated. Thrift et al. (2010) reviewed publications that compared alternative breeds to *Bos indicus* and *Bos taurus* breeds commonly found in the United States and concluded these subtropical adapted breeds have less growth and carcass potential than either other breed group.

Heterosis is when offspring from two separate breeds perform better than either of their purebred parents. Williams (2010) reported that British x British, Continental x British, Zebu (*Bos indicus*) x British, Continental x Zebu, and Continental x Continental biological crosses all had increased birth weight, weaning weight, post-weaning growth, carcass weight, and LM area than purebreds. Continental x British and continental x continental crosses resulted in a reduction in backfat while all other crosses showed a slight increase. Continental x continental crosses showed a decrease in marbling score while all other crosses resulted in an increased marbling score. The largest change in performance and carcass traits as a result of heterosis was found to be in the *Bos taurus* x *Bos indicus* cross cattle. This can be explained by the lack of relation between *Bos taurus* and *Bos indicus* cattle because they are of different species.

Cattle that have been selected to be genetically superior for more rapid growth are heavier, deposit fat at later times, and have heavier BW endpoints than cattle of genetics that are

slower growing (Crouse et al, 1975; Laborde et al., 2001). Reinhardt et al. (2009) reported cattle that were genetically comprised of more than 50% Angus lineage had greater performance in the feedyard as well as carcass fatness and quality grade than other breed groups. While there is a great deal of literature comparing differences in performance and carcass traits between breeds, it is important to reinvestigate these differences periodically in current populations. Breeders constantly apply selection pressures to improve various traits while possibly sacrificing others. Studies and reviews of breed comparisons of current populations always will be beneficial.

Ultrasound: Use of ultrasound to measure carcass characteristics of live animals is a tool that has become commonly used in the beef industry. Ultrasound technology as a means of estimating carcass measurements can be dated back to the middle of the 20th century (Hazel et al., 1959; Stouffer et al., 1959). This technology uses sound waves passed through the tissue to create an image based on reflectiveness. Images received by the machine are seen in a variety of shades of gray, with the more dense material being visible as white (bone) and less dense tissue being black in color (muscle). Gray images are intermediate in density and are generally fat deposits or connective tissues. Brethour (1990) reported a high correlation with the amount of speckle in the ultrasound image with marbling scores at harvest.

Real time ultrasound has been shown to be an accurate predictor of actual carcass measurements if the animal is harvested within 24 hours (Brethour, 1992; Perkins et al., 1992). As time progresses from when cattle are ultrasounded and to the time that they are harvested, larger discrepancies (difference between measurements) occur. Another concern is the repeatability of ultrasound measurements. Repeatability is defined as the ratio of variance within animals to total variance of ultrasounds of all animals (Lush, 1956). Several authors have

validated that carcass ultrasound measurements of backfat are repeatable with coefficients ranging from 0.81 to 0.98 (Edwards et al., 1989, Stouffer et al., 1989, Brethour, 1992).

McLaren et al. (1991) stated one of the largest errors associated with the accuracy of ultrasound is the variation in image quality and interpretation of this image by technicians. Perkins et al. (1992) conducted a study using two separate trained technicians to investigate errors associated with ultrasonography. These authors found no difference in terms of error when scanning large groups of cattle over time. However, it was noted that technicians skill did improve through the course of the study. We can conclude that as technician experience increases, then so will the reliability and accuracy of the ultrasound measurements (Perkins et al., 1992; Perkins et al., 1992b). It also is worth noting that as cattle increase in condition, so does the discrepancy and error size between measurements taken within a 24 hour period (Brethour, 1992).

Ultrasound also may be used to predict the time in which it would take to achieve a certain yield or quality grade. Brethour (2000b) found predicting the number of days on feed until cattle reach 10 mm of backfat for harvest is inefficient with receiver cattle with less than 2 mm backfat. Allowing animals time to deposit fat allows for more accurate projections of days on feed. Early in the feeding period, intramuscular fat is slow to deposit, at a rate of approximately 0.01 marbling points per day at low select, and steadily increases at a faster rate once the animal has reached low choice (Brethour, 2000b). If the animal starts with low traces of marbling, then it generally will not reach a choice quality grade within a conventional feeding period of less than 200 d (Brethour, 2000b). Brethour (2000b) also reported data that indicated a difference in rate of intramuscular fat deposition in breed type, documenting that Continental

breeds deposit both backfat and intramuscular fat at slower rates than earlier maturing British breeds. Ribfat seems to increase faster than intramuscular fat in all breed types. Once animals achieve 3 mm of ribfat, it seems possible to group cattle by the number of days they will obtain a common ribfat. Time until a common rib fat is reached is important because ribfat is the most important factor in yield grade and best indication of body composition (Powell, 1973); as rib fat thickness increases, intramuscular fat tends to increase as well (Brethour, 2000b).

An ultrasound measurement of body composition early in the production cycle can be used as a means of predicting endpoints that could be a beneficial tool to market and manage cattle to their most profitable potential. Crews et al. (2002) found body measurements recorded as yearlings had the best predictive value for final ribfat thickness and muscle area. However, these predictions were made while cattle were receiving concentrate finishing rations and not while cattle were grazing forage in the stocker phase. It would be beneficial for stocker producers to incorporate this same technology as a risk management Aiken et al. (2004) investigated the use of ultrasonography during the stocker phase as a means of predicting endpoints. Those authors incorporated the BW of cattle as they were removed from pasture, as well as body measurements of LMA and ribfat, and certain combinations of breed types into a regression model for predicting endpoints. It was concluded the proposed model was not economical, but could be improved with more observations, breed type comparisons, and incorporation of intramuscular fat measurements.

Predicting carcass composition has not been accomplished with the accuracy that was originally hoped. Brethour (2000) reported that predicting future quality grades has not been done with high enough accuracies to justify the time and monetary investment. These

conflicting reports in accuracies have been contributed to variance in technician skill, differences in algorithms for image analysis, conditions at time of ultrasound, as well as different ultrasound systems with differences being observed between systems and even the same model.

Molecular Markers: The genetic variance of animals play a significant role in their performance differences. One method of identifying these differences is with quantitative trait loci (QTL) that are related to economically important traits discovered with the use of genetic linkage mapping (Stone et al., 1999; Casas et al., 2000; Casas et al., 2003). These QTL identify an area of the genome to evaluate for single nucleotide polymorphisms (SNP; base pair changes in DNA sequence between chromosomes) and their association with variation of performance. Many SNPs have been identified and found to be related with various performance traits in beef cattle (Schenkel et al., 2006; Lusk, 2007; Sherman et al., 2010).

Dekkers (2004) reviewed ways to identify polymorphic regions in the loci, which can be accomplished in one of three ways. One is through direct markers which are loci that code for a functional mutation. These direct markers are expressed as a SNP and when identified, are difficult to associate with specific performance traits. As a result, the best example of this is seen with single-gene traits. Second are loci that have the functional mutation and are population wide disequilibrium (LD). Lastly are the loci with the functional mutation and are in population wide equilibrium (LE). The application of each of these markers, as with their detection, are also different. Direct markers, and to some extent LD markers, are relatively easy to use because the direct genotype and phenotype relationship. In contrast, LE must take into consideration different linkage phases and QTL of different families.

Recently, a commercially available molecular breeding value (MBV) estimate has become available. These MBV are comprised of a proprietary SNP panel that determines numerical differences in the potential performance of cattle based on their genotype. From this analysis, animals can be identified that have superior genetic potential for various performance and carcass traits with the intention of sorting these individuals into more consistent groups to manage and market appropriately. Use of genetic test comprised of only a few markers have not been largely effective (Dekkers et al., 2004), so large panels of SNP must be developed to have a relevant impact in the industry.

Opportunity also may exist for more rapid genetic improvements by more accurately identifying superior breeding stock earlier in their productive life. In a hypothetical analysis published by Van Eenennaam et al. (2011), a 29 to 158% increase in selection response and \$89 to \$565 added value per commercial bull were hypothesized. These types of reports have indicated both a monetary and genetic advantage to incorporating genetic technologies into production.

MacNeil et al. (2010) compiled data from the American Angus Association including intramuscular fat ultrasound data from yearling bulls and heifers, marbling scores from harvested cattle and MBV of marbling, in an attempt to more accurately predict breeding values. These authors found MBV may aid in approximately a 20% increase in genetic prediction for marbling when compared to intramuscular fat. Hays et al. (2009) reported an increase in reliabilities of GEBV (genomic estimated breeding value) compared with EBV (estimated breeding value) for dairy bulls with no progeny records ranging from 2 to 20%.

While there appears to be some significant advantages in the incorporation of these genetic technologies, few studies have been published that validate SNP panels that are

commercially available. Van Eenennaam et al. (2007) found GeneSTAR Tenderness and Igenity *Tender-GENE* test both were highly related to carcass tenderness and the GeneSTAR Quality Grade may be related with an increase in the number of cattle that grade Choice and Prime. Hall et al. (2009) reported a negative correlation between Igenity tenderness scores and Warner-Bratzler Shear Force. In an interesting observation, a positive correlation was found between Igenity docility scores and Warner-Bratzler Shear Force (Hall et al., 2009). This report indicates SNP panels may be linked together by use of certain markers in multiple traits MBV. Similarly, DeVuyst et al. (2011) found relationships between Igenity scores of traits that were not necessarily the same. For example, as Igenity score for yield grade increased, Igenity scores for marbling, percent choice, and average daily gain also increased. DeVuyst et al. (2011) reported correlations between Igenity scores for ADG, marbling, percent choice, LM area, tenderness fat thickness and yield grade with their respective traits in commercially fed cattle were low (mean $r = 0.13$) but were statistically significant. Genotypic correlations were slightly higher than the phenotypic correlations (DeVuyst et al., 2011). Angus type cattle tended to have higher correlations between performance traits and Igenity scores than those of Continental or other breed groups. With a limited amount of research available validating the use of MBV, more research is needed to determine their value in the beef industry.

Summary and Proposed Objectives: Many factors play a significant role in performance and yield of cattle in any phase of the industry. Nutrition, management, and genetics all must be taken into consideration to ensure the maximum performance potential and the highest quality product. Continued evaluation of new and old technologies must be considered so that we may validate their relevance and make better decisions from information generated. Objectives of this thesis are to:

- 1: validate the use of MBV and estimate their impact on production systems;
- 2: estimate the value of real time ultrasound during the stocker phase as a means of projecting endpoints of finished cattle;
- 3: determine breed effects on growing cattle with more recent representations of populations and less reviewed breeds.

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Chapter III:

Relationship between molecular breeding values, body measurements, performance, and carcass traits of Gelbvieh x Angus steers

Abstract

Forty-eight Gelbvieh x Angus steers (265 ± 40 kg) were utilized to determine the relationships among molecular breeding values (MBV), steer performance, and carcass traits. Body weight (BW), hip height (HH), hip width (HW), exit velocity (EV; rate at which steers exited the squeeze chute and traversed 1.8 m) and body ultrasound measurements of steers were recorded at d 0, 93 and 154 of grazing mixed stockpiled endophyte-infected and -free tall fescue. Tissue samples were collected for genomic profiling (Igenity, Merial Limited, Duluth, GA). Steers were transported to the Oklahoma State University, Williard Sparks Beef Research Center, Stillwater, OK and fed for 159 d, harvested and carcass parameters recorded. At d 0 and 154 of grazing, BW was correlated ($P < 0.05$) with MBV for ADG ($r = 0.31$ and 0.32 for d 0 and 154, respectively). Hip width was correlated ($P < 0.05$) with MBV for ADG ($r = 0.33$ and 0.32 for d 0 and 154, respectively) at d 0 and 154. An inverse correlation between EV and MBV for LM area on d 0 ($P < 0.01$; $r = -0.48$) and d 154 ($P < 0.03$; $r = -0.03$) of grazing was observed; on d 93, EV and MBV for LM area tended to be inversely correlated. Ultrasound measurements for intramuscular fat on d 0 were correlated ($P < 0.05$) with MBV for docility ($r = 0.40$). Predictive potential of MBV from the stepwise procedure for steer performance and carcass composition was low ($r^2 \leq 0.22$). Molecular breeding values were correlated with several measurable traits that can be obtained on-farm. Incorporation of MBV may aid cattle producers in more accurate selection practices to increase profitability of beef production.

Key Words: carcass prediction, growing cattle, molecular breeding value

Introduction

Single nucleotide polymorphisms (SNP) have been found to be associated with a variety of performance and carcass traits in beef cattle (Page et al., 2002; Sherman et al., 2010). The accumulation of various SNPs in the bovine genome has led to the development of molecular breeding values (MBV), which are calculations based on SNP that are found in the genome at specific locations (Sherman et al., 2009). Just as expected progeny differences (EPD) have allowed animal breeders to select outstanding individuals, MBV provide the opportunity for the same selection more rapidly and without pedigree information.

Genetic tests that are comprised of only a few markers have not been effective (Dekkers et al., 2004). Commercial companies such as Igenity (Merial Limited, Duluth, GA), MMI Genomics, Inc. (Davis, CA), and Pfizer, Inc. (NY, NY), have developed large SNP panels with proprietary algorithms and analyses. There have been few publications that verify the potential value and impact of these markers (Van Eenennaam et al., 2007; DeVuyst et al., 2011). DeVuyst (2011) found low correlations between phenotypic expression and Igenity scores for traits in fed cattle. More work is needed that estimates the value and impact of incorporating this technology in all segments of the beef industry. My objective was to determine the relationships and predictive value of MBV with stocker and feedlot growth rate, and carcass components of Gelbvieh x Angus steers.

Materials and Methods

Cattle

The committee for animal welfare at the USDA-ARS, Dale Bumpers Small Farms Research Center, Booneville, Arkansas, approved the animal procedures used in this experiment.

Gelbvieh x Angus steers ($n = 48$; initial BW = 265 ± 40 kg) originating from the University of Arkansas Livestock and Forestry Research Station near Batesville, AR, were used in this study. Steers grazed a stockpiled tall fescue pasture of endophyte infected and free for 154 d at a stocking rate of 1 steer /0.5 ha from Dec. 16th, 2009, until May 18th, 2010, and did not receive grain supplement. Clean water and a mineral supplement were available *ad libitum* throughout grazing. Formulated mineral concentrations were as follows: Fe 500 mg/kg, Mn 4000 mg/kg, Zn 6000 mg/kg, Cu 2000 mg/kg, Se mg/kg, I 100 mg/kg, and Co 25 mg/kg.

On d 0, 93, and 154 of the grazing period BW, hip height (HH), hip width (HW), and exit velocity (EV; rate at which steers exited the squeeze chute and traversed 1.8 m) were recorded. Cattle were removed from the pasture the day before data collection and held in a dry lot with access to hay and water overnight, with data collection the following morning. Longissimus muscle area (ULMA), intramuscular fat (UIMF) percentage, and rump fat (URF) thickness were determined by a trained technician using ultrasonography (Aloka SSD-500V with a 3.5-MHz linear array transducer) and Biosoft Toolbox software (Biotronics Inc., Ames, IA). Hip height was measured with the steer standing erect with feet squarely under the body. Hip width was measured by firmly closing a clamp over the edge of the hip bones and measuring the distance between clamp ends. Genomic DNA samples were collected via hair follicles using collection

tags purchased from Igenity (Merial Inc., Duluth, GA). Igenity MBV were determined for ADG, tenderness, marbling score, percent choice, yield grade, fat thickness, LMA, heifer pregnancy rate, stayability, maternal calving ease, and docility.

Following the grazing period, steers were transported to the Willard Sparks Beef Research Center feedyard, Oklahoma State University, Stillwater, and fed for 159 d from May 20th to October 28th, 2010. Cattle were deemed harvest ready when the pen was visually appraised to have 1 cm of ribfat. Steers were processed at the feedyard on the morning following arrival and received subcutaneous injections of Ivomec plus (6 mL; Merial), Vision 7 (2 mL; Intervet), Express 5 (2 mL; BI), and implanted with Revalor-S (Intervet). Steers were adapted to concentrate rations for 23 d using a two ration blend, starting with a 65% concentrate ration (Appendix 2) and gradually working to a 94% concentrate finishing ration (Appendix 3) which was fed for the duration of the finishing phase. Body weights were recorded at d 0 and 159 and feedyard ADG (FADG) calculated. Cattle were harvested at Tyson, Amarillo, TX and hot carcass weight (HCW) recorded. Following a 24 h chill, marbling (MARB), ribfat thickness (RF), longissimus dorsi muscle area (LMA), and internal fat (IF) were assessed and USDA yield grade (YG) calculated by trained personnel from West Texas A&M University. The first digit of the marbling numbers corresponds to the marbling score (1 = practically devoid, 2 = trace, 3 = slight, 4 = small, 5 = modest, 6 = moderate, 7 = slightly abundant, 8 = moderately abundant, and 9 = abundant) and the second number represents the percentage of marbling within that marbling score.

Forage

A pasture (24.3 ha) containing tall fescue [*Lolium arundinaceum*, (Shreb.), Darbysh.] cultivars AU Triumph (E-) and Kentucky 31 (E+) was stockpiled for grazing. The pasture was mowed approximately 150 d prior to grazing and no fertilizer was applied; however, at d 110 of grazing 50 kg/ha of N was applied. Grazing was initiated on Dec. 16 and terminated on May 18. Forage samples were collected at the beginning (Dec. 18), middle (Mar. 16), and termination (May 24) of grazing. Twelve to 15 grab samples of forage were collected at each sampling date for quality analysis. Quality samples were dried for 48 h at 105°C and nutrient analysis was completed by the Agricultural Diagnostic Service Laboratory, University of Arkansas. An additional 12 to 15 whole plant samples were taken to determine ergovaline concentrations. Plants were cut into 5.1 cm pieces and stored at -4°C. One hundred disk meter readings (Bransby et al., 1977) were recorded to determine forage availability on each forage sampling date.

Statistical Analysis

Statistics were calculated using Statistical Analysis Software (SAS) version 9.1. Pearson correlation coefficients were used to determine the relationship between the MBV and recorded phenotypic measurements, carcass measurements, and performance of steers. The stepwise procedure using forward selection was used to predict steer ADG, HCW, LMA, MARB, and YG. Variables that were used were body measurements at each collection date as well as MBV, and were incorporated into the equation at significance ($P < 0.05$) and tendencies ($P \geq 0.051$ and < 0.10).

Results

Descriptive statistics for each body measurement recorded during the grazing period by the sampling date are listed in Table 1. Steers did not gain weight during the first 93 d of grazing, however, steers did develop as indicated by an increase in skeletal growth of HH and HW. From d 93 to 154 of grazing, all body measurements increased. Exit velocity times increased at each recording date indicating that steers were more docile at the end of grazing. Ultrasound measurements increased for both ULMA and UIMF, but retained a constant amount of URF through the duration of grazing (Table 2). Average daily gain, final weight (FW) and carcass measurements descriptive statistics are reported in Table 3. Steers had minimal gains during the grazing phase and increased gains while in the feedyard.

Pearson coefficients showed few associations between MBV and body measurements. Molecular breeding values for ADG were correlated with BW on d 0 and 154 ($r = 0.31$ and 0.30 , respectively; $P < 0.05$) and tended ($P < 0.10$) to be correlated on d 93 ($r = 0.28$). Average daily gain MBV also was correlated ($P < 0.05$) with HW on d 0 and 154 ($r = 0.33$ and 0.32 , respectively). Exit velocity times were correlated ($P < 0.05$) with MBV for ADG on d 93 and 154 ($r = 0.32$ and 0.31 , respectively). Tenderness MBV was correlated ($P < 0.05$) with HH on d 154 ($r = 0.30$) and tended ($P < 0.10$) to be inversely correlated with EV on d 0 ($r = -0.26$). Molecular breeding values for LMA were negatively correlated ($P < 0.05$) with EV times on d 0 and 154 ($r = -0.48$ and -0.32 , respectively). Exit velocity times also tended ($P < 0.10$) to be inversely correlated with LMA MBV on d 93 ($r = -0.27$).

Molecular breeding values for ADG were associated ($P < 0.05$) with ULMA, UIMF, and URF (Table 4). Tenderness MBV tended ($P < 0.10$) to be correlated with ULMA and inversely correlated with URF. Marbling score and percent choice MBVs were correlated ($P < 0.05$) with

URF on d 154. Rump fat measurements were negatively correlated ($P < 0.05$) with the MBV for fat thickness. Ultrasound IMF percentages on d 0 were negatively correlated with the MBV for LMA, however, were positively correlated on d 93 ($p < 0.05$). On d 0, IMF percentages were correlated with the MBV for docility. Heifer pregnancy rates MBV tended to be correlated with ultrasound measurements for LMA on d 93 and IMF on d154 ($p < 0.10$). Maternal calving ease MBV was correlated with IMF on d 154 ($p < 0.05$).

Growth and carcass measurement correlated with MBV, listed in Table 5, shows that ADG MBV tended ($P < 0.10$) to be correlated with LMA. Feedlot ADG tended ($P < 0.10$) to be inversely correlated with MBV for tenderness as well as fat thickness. Average daily gain during the stocker phase (SADG) and LMA tended ($P < 0.10$) to be inversely correlated with MBV for YG and fat thickness. Molecular breeding values for maternal calving ease tended ($P < 0.10$) to be negatively correlated with SADG and KPH, positively correlated with IF, and were inversely correlated ($P < 0.05$) with MARB and SADG from d 93 to 154.

Stepwise coefficients that best fit a prediction model for HCW, MARB, LMA, and YG are listed in Table 6. Body weight at the end of grazing accounted for the most variation in HCW ($R^2=0.76$). All other variables, although some significant, accounted for little variation in the prediction model. The best single predictor variable for MARB and LMA was ULMA on d 154 of the grazing ($R^2=0.168$ and $R^2=0.460$, respectively). Intramuscular fat on d 93 of grazing served as the best single prediction variable for YG ($R^2 = 0.183$). Table 7 shows the stepwise regression analysis for ADG during both the grazing and feedyard phases. The best prediction variable for steer ADG was ULMA on d 0 ($R^2=0.115$) and the URF on d 93 for feedyard ADG ($R^2=0.179$)

Discussion

Molecular breeding value for ADG had the most correlations with body and ultrasound measurements; however, MBV for ADG was not associated with actual ADG either while steers were grazing or receiving concentrate rations. No correlations between ADG MBV and FADG or SADG were found; ADG MBV were associated with larger cattle in terms of weight, skeleton, and muscle. Hendrickson et al. (2005) reported BW at the end of grazing positively influenced carcass value and weight of retail product. This supports that selection for ADG with MBV may result in higher valued cattle.

Exit velocity on d 0 of grazing was negatively correlated with the MBV for tenderness, meaning if the animal exited the chute at a slower rate it had a lower MBV for tenderness which indicates that there less potential for a tender carcass. Hall et al. (2011) found that as the Igenity score for docility increased, and then Warner-Bratzler shear force (WBSF; pressure used to press through cooked meat) increased. This is consistent with our reports as a higher tenderness value indicates more tender meat, and the negative correlation shown reports that cattle deemed as more docile have lower tenderness scores. However, as we did not perform WBSF to determine actual tenderness in this study, further investigation needs to be done to determine actual WBSF with MBV for docility.

A variety of correlations were found between MBV and traits that were not related. For instance, the heifer pregnancy rate MBV was correlated with ultrasound measurements for ULMA and IMF and the maternal calving ease MBV was correlated with ultrasound IMF and internal fat and negatively correlated with SADG, MARB, and KPH. This supports interpretations of DeVuyst et al. (2011), who concluded that it was likely that SNP panels were

similar between specified traits. DeVuyst (2011) also found that the correlations that were found to be significant between Igenity scores and fed cattle traits were low, being similar to results found in the present study. Van Eenennaam et al. (2007) found that commercially available SNP panels for tenderness for GeneSTAR and Igenity had significant relationships with tenderness.

Use of ultrasound measurements during the grazing period as a means of predicting feedyard performance and carcass composition have not been successful (Aiken et al., 2004). Ultrasound LMA taken at the end of grazing showed significant regression estimates for MARB and LMA ($r^2 = 0.17$ and 0.46 , respectively). Longissimus muscle area measurements at the beginning of grazing had low associations with grazing and feedyard ADG ($r^2 = 0.12$ and 0.05 , respectively). The highest regression coefficient with feedyard ADG was URF at d 93 of grazing. From d 0 to 93 in the grazing period, steers had limited forage resources. Hence, this association is probably due to compensatory gains (Sainz et al., 1995; Neel et al., 2007). Intramuscular fat percentage on d 93 of grazing had the highest coefficient with YG ($r^2 = 0.18$). Hicks (1990) showed that cattle that were restricted and then fed *ad libitum* had greater YG than cattle fed *ad libitum* for the duration of feeding. Steers in the present study were most feed restricted at d 0 to 93 of grazing. Intramuscular fat is the last adipose tissue to deposit in cattle, so we may be able to imply that a IMF estimation during a time of restriction may have some predictive value for YG at harvest.

When regression analysis was used to determine predictive values of MBV for profitable traits including ADG, MARB, HCW, LMA, and YG, few significant variables were found. Molecular breeding values that tended to serve as predictors for SADG were stayability and marbling. Stayability, marbling, docility, and tenderness MBV had low regression coefficients for FADG ($r^2 \leq 0.11$). This suggests that SNP panels used for ADG hold little to no predictive

value for fed cattle that will have superior growth. Similar findings were also witnessed for carcass traits. For HCW and YG, stayability and heifer pregnancy rate MBV tended to account for some of the variation ($r^2 \leq 0.02$ and 0.19 , respectively). Percent choice MBV tended for some variation with marbling number but had a low regression value ($R^2 = 0.06$). There were no MBV that had a significant regression value for LMA. These data suggest that MBV hold very little predictive value for traits that are relevant to profitability in our growing cattle production system. Single nucleotide polymorphism panels may also need to be reevaluated as to determine as which SNPs are correctly associated as a predictor with which trait, as the percent choice MBV was the only predictor that was relevant for its specific trait and MBVs for reproductive traits fit into regression models for growth and carcass traits before said MBVs did. Our data supports that of DeVuyst (2011) in that the same genomic markers accounting for multiple traits. Further investigation needs to be made to associate genetic markers with specific traits so that MBV have a greater impact as a management tool in growing cattle.

Implications

Molecular breeding values were moderately related with body measurements of cattle. As predictors of performance and carcass parameters, MBV held little value when interpreted with regression analysis. Reproductive MBV were consistently correlated with various growth measurements through the production cycle of growing steers. This indicated that SNP may need to be re-evaluated as to which trait they have the most impact. Average daily gain MBV were not related with steer performance, but were consistently correlated with larger cattle. Predicting steer performance and carcass parameters with MBV or ultrasound was not effective. The best predictive tool was to weigh cattle at the beginning of each stage. In conclusion, current MBV for Gelbvieh Angus genetics serve as minor aids as a management tool for growing crossbred steers and more work needs to be completed in better determining the relationship between SNP and subsequent cattle performance in various production settings.

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Table 1. Means of the phenotypic measurements collected on d 0, 93, and 154 of Gelbvieh x Angus Steers during the grazing period

Phase	Variable ^a	N	Mean	Std Dev	Minimum	Maximum
d 0	BW, kg	48	265	40	185	361
	HH, cm	48	114.5	5.4	106.1	127.0
	HW, cm	48	32.7	2.6	27.3	38.1
	EV, s	47	0.62	0.15	0.33	0.91
d 93	BW, kg	48	263	40	186	366
	HH, cm	48	118.8	5.0	108.6	128.3
	HW, cm	48	33.9	2.3	30.5	39.4
	EV, s	48	0.68	0.26	0.13	1.57
d 154	BW, kg	47	302	39	218	388
	HH, cm	47	122.3	5.6	109.2	133.4
	HW, cm	47	35.9	2.4	29.2	40.6
	EV, s	47	1.04	0.78	0.36	3.87

^aBody weight (BW), hip height (HH), hip width (HW), exit velocity (EV: rate in seconds at which steers exited the squeeze chute and traversed 1.8 m)

Table 2. Means of the ultrasound measurements collected on d 0, 93, and 154 of Gelbvieh x Angus Steers during the grazing period

Phase	Variable ^a	N	Mean	Std Dev	Minimum	Maximum
d 0	ULMA, cm ²	48	13.61	2.39	8.48	18.64
	UIMF, %	45	2.44	0.51	1.36	3.51
	URF, cm	44	0.23	0.08	0.08	0.43
d 93	ULMA, cm ²	48	14.76	2.01	10.57	19.20
	UIMF, %	48	2.63	0.44	1.51	3.54
	URF, cm	48	0.18	0.03	0.13	0.25
d 154	ULMA, cm ²	47	17.20	1.91	13.41	21.46
	UIMF, %	45	2.50	0.58	1.16	3.92
	URF, cm	43	0.20	0.05	0.13	0.30

a: Longissimus dorsi muscle area (ULMA), percent intramuscular fat (UIMF), rump fat (URF).

Table 3. Means of ADG estimates during grazing and the feedlot phase and carcass traits of Gelbvieh x Angus Steers

Phase	Variable ^a	N	Mean	Std Dev	Minimum	Maximum
Stocker	SADG1, kg	48	-0.02	0.12	-0.25	0.32
	SADG2, kg	47	0.64	0.15	0.36	1.00
	SADG, kg	47	0.24	0.10	0.04	0.43
Feedlot	FW, kg	45	599	51	501	721
	FADG, kg	45	2.00	0.19	1.60	2.41
Carcass	HCW, kg	45	358	33	289	42
	MARB	45	46	9	31	65
	FT, cm	45	1.27	0.41	0.51	2.24
	LMA, cm ²	45	36.02	3.12	30.38	43.84
	KPH	45	3	1	2	4
	IF, cm	45	2.3	0.3	1.5	2.5
	USDA YG	45	2.65	0.72	0.72	4.00

a: Stocker ADG from d 0 to 93 (SADG1), stocker ADG from d 93 to 154 (SADG2), overall stocker ADG (SADG), feedlot ADG (FADG), final weight (FW), hot carcass weight (HCW), marbling number (MARB), ribfat thickness (RF), Longissimus dorsi muscle area (LMA), kidney, heart, and pelvic fat (KPH), internal fat (IF), and USDA yield grade (YG).

Table 4. Pearson coefficients between carcass ultrasound measurements collected on d 0, 93, and 154 and Molecular Breeding Values of Gelbvieh x Angus Steers during the stocker phase

	Molecular Breeding Values								
	Average Daily Gain	Tenderness	Marbling Score	Percent Choice	Fat Thickness	LMA	Heifer Pregnancy Rate	Maternal Calving Ease	Docility
LMA ¹	0.49*	0.25**							
LMA ²	0.30*						0.25**		
LMA ³	0.39*								
IMF ¹						-0.30*			0.40*
IMF ²	0.31*					0.30*			
IMF ³							0.27**	0.34*	
RF ¹	0.37*	-0.26**							
RF ²					-0.31*				
RF ³	0.32*		0.36*	0.38*					

1 = d0 of stocker

2 = d93 of stocker

3 = d154 of stocker

*p<0.05

**P<0.10

a: Carcass ultrasound measurements included Longissimus dorsi muscle area (LMA; cm²), percent intramuscular fat (IMF; %), rump fat (RF; cm).

Table 5. Pearson coefficients between carcass^a and performance^b traits and molecular breeding values of Gelbvieh x Angus Steers

	Molecular Breeding Values				
	Average Daily Gain	Tenderness	Yield Grade	Fat Thickness	Maternal Calving Ease
SADG, kg			-0.26**	-0.26**	-0.28**
SADG ¹ , kg					
SADG ² , kg					-0.32*
FADG, kg		-0.27**		-0.25**	
HCW, kg					
LMA, cm ²	0.26**		-0.28**	-0.27**	
MARB					-0.33*
RF, cm					
KPH					-0.28**
Intfat					0.28**
YG					

1 = ADG from d0 to 93 of the stocker phase

2 = ADG from d93 to 154 of the stocker phase

*p<0.05

**P<0.10

a: Stocker ADG (SADG, kg), Feedlot ADG (FADG, kg), final weight (FW, kg)

b: Hot carcass weight (HCW, kg), marbling number (MARB), ribfat thickness (RF, cm),

Longissimus dorsi muscle area (LMA, cm²), kidney, heart, and pelvic fat (KPH), internal fat (Intfat), and USDA yield grade (YG).

Table 6. Stepwise regression coefficients of phenotypic measurements^a, carcass ultrasound measurements^b, and molecular breeding values^c for carcass traits of Gelbvieh x Angus Steers

Carcass traits												
Hot Carcass Weight			Marbling Number			Longissimus Dorsi Muscle Area			Yield Grade			
Variable	Partial R-Square	Stepwise Coefficients	Variable	Partial R-Square	Stepwise Coefficients	Variable	Partial R-Square	Stepwise Coefficients	Variable	Partial R-Square	Stepwise Coefficients	
BW ^{3*}	0.764	0.592	ULMA ^{3*}	0.168	-12.50	ULMA ^{3*}	0.460	1.386	IMF ^{2*}	0.183	0.982	
STAY ^{m**}	0.022	11.816	ADG ^{m*}	0.223	71.10	HW ^{1*}	0.080	-0.637	HPR ^{m*}	0.114	-0.177	
IMF ^{2*}	0.030	32.062	HW ^{2*}	0.159	7.01	RF ^{2*}	0.071	32.312	STAY ^{m*}	0.193	0.208	
HPR ^{m**}	0.021	-4.658	PChoice ^{m**}	0.057	0.45	IMF ^{2†}	0.036	-0.747	HW ^{1*}	0.095	0.265	
ULMA ^{1†}	0.014	18.690	HH ^{3†}	0.028	2.22	HW ^{3**}	0.048	0.472	IMF ^{1†}	0.037	-0.302	
EV ^{1**}	0.018	-120.193	HH ^{1*}	0.053	-2.26				URF ^{2**}	0.042	-14.221	
IMF ^{1**}	0.018	-26.150										
EV ^{3*}	0.022	17.726										
Intercept		262.519			-18.83			5.607			-1.726	
R-Square Totals	0.908			0.69			0.695			0.665		

1 = d 0 of stocker

2 = d 93 of stocker

3 = d 154 of stocker

m = Molecular Breeding Values

* $p < 0.05$

** $P < 0.10$

† $p < 0.17$

a: Phenotypic measurements are body weight (BW; kg), hip height (HH; cm), hip width (HW; cm), exit velocity (EV: rate in s at which steers exited the squeeze chute and traversed 1.8 m)

b: Carcass ultrasound measurements are longissimus dorsi muscle area (LMA; cm^2), percent intramuscular fat (IMF; %), rump fat (RF; cm) and

c: Molecular breeding values include heifer pregnancy rate (HPR), stayability (STAY), percent choice (PCHOICE), and average daily gain (ADG).

Table 7. Stepwise coefficients in the forward direction that represent the best fit predictor modals for stocker and feedlot ADG using phenotypic measurements^a, carcass ultrasound measurements^b, and molecular breeding values^c of Gelbvieh x Angus Steers

	Stocker ADG			Feedlot ADG		
	Variable	Partial R-Square	Stepwise Coefficients	Variable	Partial R-Square	Stepwise Coefficients
	ULMA ^{1*}	0.115	-0.038	RF ^{2*}	0.179	16.433
	HH ^{2*}	0.194	0.029	HH ^{3***}	0.084	0.087
	STAY ^{m**}	0.067	0.009	STAY ^{m*}	0.114	0.130
	MARB ^{m**}	0.052	0.002	TEND ^{m**}	0.067	-0.549
	HH ^{1*}	0.068	0.009	EV ^{1**}	0.068	-1.375
	TEND ^{m†}	0.035	-0.080	MARB ^{m*}	0.078	-0.006
	BW ^{1**}	0.049	-0.005	ULMA ^{1**}	0.046	0.473
	BW ^{2*}	0.131	0.005	ULMA ^{2*}	0.094	-0.541
				RF ^{3*}	0.045	-6.184
				UPFAT ^{2**}	0.038	0.345
				DOC ^{m*}	0.0372	-0.019
				ADG ^{m†}	0.018	1.490
				RF ^{1**}	0.022	-3.331
Intercept			-1.082			-1.139
R-Square Totals		.711*			.890**	

1 = d0 of stocker

2 = d93 of stocker

3 = d154 of stocker

* $p < 0.05$

** $P < 0.10$

† $p < 0.17$

a: Phenotypic measurements are body weight (BW; kg), hip height (HH; cm), hip width (HW; cm), exit velocity (EV: rate in s at which steers exited the squeeze chute and traversed 1.8 m).

b: Carcass ultrasound measurements are longissimus dorsi muscle area (ULMA; cm^2), percent intramuscular fat (IMF; %), rump fat (RF; cm)

c: Molecular breeding include values heifer pregnancy rate (HPR), stayability (STAY), percent choice (PCHOICE), marbling (MARB), average daily gain (ADG), and tenderness (TEND)

Appendix 1. Forage quality and forage density estimates on three sampling dates during the 154d grazing period

Sample Date	Crude Protein, %	ADF, %	NDF, %	TDN, %	Forage Density, kg/ ha
Dec. 18	8.08	32.4	52.9	53.3	6641
Mar. 16	9.24	39.4	65.2	51.4	3227
May 24	13.52	30.6	54.4	59.5	3469

Appendix 2: Feedlot receiving ration that is 65% concentrate and fed as part of a step up ration for the first 23 d to Gelbvieh x Angus steers in the feedyard.

Ration Composition		Nutrient Composition (DM Basis)	
Feedstuff	% Diet DM	Item	Amount
Rolled Corn	41.00	NEm, mcal/cwt	80.76
DDGS	15.00	NEg, mcal/cwt	49.95
B-109	6.00	TDN, %	79.35
Synergy 19-14	3.00	Crude Protein, %	14.26
Alfalfa	15.00	Crude Fat, %	4.76
Prairie Hay	20.00	NDF, %	31.05
Water	9.58	ADF, %	19.23
Total	100.00	Ca, %	0.96
		P, %	0.32

Appendix 3: Finishing ration for Gelbvieh x Angus steers for d 24 through 159 in the feedyard.

Ration Composition		Nutrient Composition (DM Basis)	
Feedstuff	% Diet DM	Item	Amount
Rolled Corn	70.00	NEm, mcal/cwt	96.94
DDGS	12.00	NEg, mcal/cwt	62.9
B-109	6.00	TDN, %	89.22
Synergy 19-14	6.00	Crude Protein, %	13.39
Prairie Hay	6.00	Crude Fat, %	5.79
Water	7.35	NDF, %	16.21
	100.00	ADF, %	7.64
		Ca, %	0.7
		P, %	0.35

Chapter IV:

Effects of Stocking Rate, Grazing Method, and Breed of Sire on Carcass Traits of Beef

Cattle Grazing Winter Annual Forages

Abstract

Environmental and managerial conditions are known to affect subsequent performance and carcass traits of beef cattle. The objective of this study was to document the effect of stocking rate (SR), grazing method (GM) and breed of sire on carcass traits. Steers and heifers (n = 460) grazed 'Maton' rye (*Secale cereale L.*) and 'TAM90' annual ryegrass (*Lolium multiflorum L.*) pastures from January to mid-May during 5 yr. Cattle were allotted to stocking rates (SR) of high (9 animals/ha), medium (6 animals/ha), or low (4 animals/ha), GM of continuous (CONT) or rotational (RT), and fed in commercial feedyards. Calves were sired by bulls from the following breeds; Angus (n = 171), Bonsmara (n = 108), Brahman (n = 109), Braunvieh (n = 31), Hereford (n = 12), and Simmental (n = 29). Body condition score (BCS); ultrasound measurements of intramuscular fat (UIMF), longissimus dorsi muscle area, and rump fat at end of grazing; ADG during grazing (119 d \pm 25) and feedyard (125 d \pm 28) phases; hot carcass weight (HCW); carcass ribfat (CRF); carcass LM area (CLMA); and yield grade (YG) were determined. Effects of year, gender, SR, GM, breed of sire, and interactions were determined by ANOVA. Simmental offspring had greater ($P < 0.01$) amounts of UIMF than Bonsmara and Brahman (0.11 ± 0.03 and 0.13 ± 0.03 , respectively). Stocking rate affected the HCW of cattle ($P < 0.05$) with high SR (314.1 ± 5.8 kg) cattle having lighter HCW than low SR (329.0 ± 4.9 kg). Stocking rates and breed of sire did affect carcass traits, and these variables can be managed to maximize carcass value.

Key words: Bovine breeds, Grazing method, Real-time ultrasound

Introduction

Many factors contribute to performance, yield, and quality of cattle as they progress through the production cycle. Forage type has a large impact on the growth rate of cattle during the grazing phase. Winter annual forages are known to allow cattle to obtain gains of 1 kg/d or greater (Uttey et al., 1975; Worrell et al., 1990; Coffey et al., 2002). However, not all cattle have the opportunity to achieve optimal gains with limitations do to mismanagement, feed quality, or feed availability. Nutrient restriction during the developmental stage results in increased compensatory gains in the feedyard (Sainz et al., 1995; Neel et al., 2007). However, there is little research published that reflects the effects of management practices implemented to cattle during the grazing phase on subsequent carcass traits. Rouquette et al. (1983) reported that cattle managed at high stocking rates have lower carcass quality characteristics and lower yield grades than cattle managed at lower stocking rates. Current beef markets reward producers who deliver cattle with improved muscle yield and carcass quality. Research is needed to determine the most effective management practices that ensure cattle will produce a high yielding carcass while maintaining quality.

Cattle of different genetics are known to have various strengths and performance potential. Continental cattle genetics are later maturing, have heavier hot carcass weights, and larger longissimus dorsi muscle area (LMA), while cattle of British heritage are earlier maturing and have more subcutaneous fat with greater amounts of marbling (Marshall, 1994; Reinhardt et al., 2009; Williams et al., 2010). However, a majority of research defining trait differences between breeds was published in the 1970's and 1980's, and cattle breeders have emphasized more rigorous trait selection on certain breeds within the previous 30 to 40 years. Therefore, the

stereotypes of trait differences reported in previous research among breeds may not be representative of today's populations (Williams et al., 2010). It is crucial there be continued validation of trait differences between breeds, and an understanding of best management and marketing strategies associated with each gene pool of beef cattle.

Materials and Methods:

Cattle used in this study (n = 460) were located at the Texas AgriLife Research Center in Overton, TX. Cattle were allowed to graze 'Maton' rye (*Secale cereale L.*) and 'TAM90' annual ryegrass (*Lolium multiflorum L.*) pastures from January to mid-May of 1999 to 2003. Grazing was at one of three stocking rates (SR); high (9 animals/ha), medium (6 animals/ha), and low (4 animals/ha). Stocking rates were determined by calculating carrying capacity of the pasture based on 273.73 kg animal/ha, and adjusted based on forage availability. Two grazing methods (GM) also were evaluated during the grazing phase, cattle were either being managed as continuous grazing (CONT) or rotational (ROT); ROT was either 8 or 16 pastures to provide 2 to 3 d of grazing and 14 to 21 d of re-growth. Breed of sire also was evaluated in the current study including: Angus, Bonsmara, Brahman, Braunvieh, Hereford, and Simmental. Cattle were not supplemented during grazing. At the beginning and end of grazing, the following measurements were recorded; body weight (BW; kg), body condition score (BCS; 1 to 9 scale with 1 = emaciated and 9 = obese; Wagner et al., 1988). Longissimus dorsi muscle area (ULMA; cm²), percent intramuscular fat (UIMF), and rump fat (URF; cm) were recorded by a trained technician using ultrasonography (Aloka SSD-500V with a 3.5-MHz linear array transducer) and Biosoft Toolbox software (Biotronics Inc., Ames, IA). At completion of grazing, cattle were transported to commercial feedyards to be fed concentrate rations. Body weights also were recorded at the

beginning and end of the feedyard phase. Average daily gain (ADG; kg/d) was calculated using the difference in BW at the beginning and end of the grazing (GADG; 115 d \pm 25) and feedyard (FADG; 125 d \pm 22) phases. Cattle were visually appraised to determine approximately 1 cm of ribfat and harvested at a commercial facility. Hot carcass weight (HCW; kg), carcass ribfat (CRF; cm), carcass longissimus dorsi muscle area (LMA; cm²), marbling number (MN), and yield grade (YG) were measured at harvest.

Statistical analyses:

Statistics were calculated using Statistical Analysis Software (SAS) version 9.1 with the MIXED procedure. Kenward-Rogers' was used to adjust degrees of freedom and Tukey estimation was used to determine significance between means. Variables of gender, breed of sire, SR, and GM served as main effects for GADG, FADG, body ultrasound measurements at the end of grazing, and carcass parameters. Chi Square analysis was used to determine the effects of breed of sire, SR, and gender on distribution of quality grades.

Results

Male cattle gained 0.07 kg/d more ($P < 0.01$) than female cattle (0.85 ± 0.04 and 0.78 ± 0.04 kg/d, respectively). The least square means of body ultrasound measurements, GADG and FADG, and carcass measurements by breed are presented in Table 2 and SR in Table 3. Brahman sired offspring had lower GADG ($P < 0.05$) than Angus, Bonsmara, Hereford, and Simmental progeny (0.68 ± 0.04 , 0.80 ± 0.04 , 0.96 ± 0.04 , 0.89 ± 0.09 , and 0.91 ± 0.08 kg/d, respectively). Bonsmara and Simmental sired cattle had greater GADG ($P < 0.05$) than Braunvieh offspring (0.96 ± 0.04 , 0.91 ± 0.08 , and 0.67 ± 0.09 kg/d, respectively). Braunvieh offspring also tended to gain less ($P \leq 0.06$) than Hereford progeny (0.67 ± 0.09 and 0.89 ± 0.09 kg/d). Cattle that were managed at a high SR achieved lower gains ($P < 0.0001$) than low or medium SR (0.45 ± 0.05 , 1.02 ± 0.04 , and 0.99 ± 0.08 kg/d, respectively). Continuous grazing tended to result in higher PADG ($P < 0.07$) than ROT grazing (0.86 ± 0.04 and 0.78 ± 0.05 kg/d).

Heifers had greater FADG ($P \leq 0.002$) than steers (1.84 ± 0.06 and 1.70 ± 0.04 kg/d). Brahman sired cattle gained less ($P < 0.05$; 1.67 ± 0.06 kg/d) than Angus progeny (1.81 ± 0.05 kg/d) and tended to gain less ($P < 0.10$) than Bonsmara offspring (1.92 ± 0.07 kg/d). Cattle that were managed at high SR during grazing had greater FADG ($P \leq 0.002$) than cattle managed at low SR (1.81 ± 0.05 and 1.68 ± 0.04 kg/d).

Angus sired cattle tended ($P < 0.07$) to have more IMF than Brahman (0.27 ± 0.01 and 0.25 ± 0.01) sired cattle and less ($P < 0.05$) than Simmental sired cattle (0.38 ± 0.03). Simmental offspring were recorded to have greater amounts of IMF ($P < 0.01$) than Bonsmara and Brahman (0.38 ± 0.03 , 0.26 ± 0.01 , and 0.27 ± 0.01 , respectively). Angus and Bonsmara sired cattle had

larger ($P \leq 0.001$) ULMA (58.3 ± 0.9 and 58.4 ± 1.2 cm², respectively) than Brahman sired cattle (52.3 ± 1.2 cm²), but smaller ($P < 0.05$) than Simmental progeny (68.3 ± 3.1 cm²). Brahman sired offspring had smaller ULMA ($P < 0.0001$) than Simmental sired calves (52.3 ± 1.2 and 68.3 ± 3.1 cm²). Hereford progeny also had smaller ULMA ($P < 0.05$) than Simmental offspring (54.1 ± 4.6 and 68.3 ± 3.1 cm²). Angus and Bonsmara progeny had more URF ($P < 0.05$; 0.11 ± 0.03 and 0.12 ± 0.04 cm) than Brahman offspring.

Cattle allotted to high SR had less IMF ($P < 0.05$) than low SR (0.28 ± 0.02 and 0.33 ± 0.01). Cattle that were managed at high SR had smaller ULMA ($P < 0.0001$) than cattle allotted to low SR (-6.33 ± 1.15 cm²) and tended to be smaller ($P < 0.06$) than cattle managed at medium SR (-4.64 ± 2.01 cm²). High SR cattle had less URF ($P < 0.0001$) than both low and medium SR (-0.20 ± 0.03 and -0.22 ± 0.05 cm, respectively). Continuous GM resulted in cattle with larger ULMA ($P < 0.05$) than ROT (2.51 ± 0.97 cm²).

Heifers had smaller carcasses ($P < 0.05$) than steers (321.1 ± 6.3 and 332.2 ± 4.6 kg, respectively). Angus sired cattle had heavier HCW ($P < 0.0001$; 343.1 ± 5.3 kg) than Brahman progeny (315.5 ± 6.2 kg). Angus offspring had higher MN ($P < 0.05$) than Hereford sired calves (416.8 ± 9.4 and 344.1 ± 22.4). Bonsmara tended to have lower MN ($P < 0.10$) than Brahman offspring (381.3 ± 11.4 and 414.6 ± 10.9). Hereford progeny did have lower MN ($P < 0.05$) than Brahman sired calves (344.1 ± 22.4 and 414.6 ± 10.9). Angus progeny had greater RF ($P \leq 0.001$) depth than offspring from Bonsmara, Brahman, Braunvieh, and Simmental sires (1.39 ± 0.06 , 0.93 ± 0.07 , 1.08 ± 0.07 , 0.91 ± 0.12 and 0.96 ± 0.10 cm, respectively). Angus offspring tended to have greater LMA ($P \leq 0.06$) than Brahman progeny (82.4 ± 1.2 and 78.2 ± 1.5 cm²) and had larger LMA ($P < 0.05$) than Hereford sired calves (72.9 ± 3.1 cm²). Bonsmara,

Braunvieh, and Simmental had greater LMA ($P < 0.05$) than Brahman sired calves (85.2 ± 1.5 , 86.5 ± 2.6 , 86.6 ± 2.3 , and 78.2 ± 3.1 cm², respectively). Hereford sired offspring have less LMA ($P < 0.01$; 72.9 ± 3.1 cm²) than Simmental or Braunvieh sires (86.6 ± 2.3 and 86.5 ± 2.6 cm², respectively). Angus, Brahman, and Hereford sired offspring had greater YG ($P < 0.03$) than Bonsmara progeny (3.24 ± 0.09 , 2.92 ± 0.13 , 3.23 ± 0.22 and 2.43 ± 0.12 , respectively). Stocking rate impacted the HCW of cattle ($P < 0.05$) with high SR having lighter HCW than low SR (314.1 ± 5.8 and 329.0 ± 4.9 kg, respectively).

Breed of sire resulted in animals having different distributions of quality grades ($P < 0.0001$; Table 4). Angus, Brahman, and Braunvieh progeny had the greatest percentage of animals that graded Choice and Select. Bonsmara, Hereford, and Simmental progeny were of predominately Select and Standard quality grades. Stocking rate affected ($P < 0.0001$) the distribution of quality grades. Cattle grazed at high SR had the largest percentage of Choice quality grade, with medium SR cattle the least percentage of Choice quality grade. Gender affected ($P < 0.05$) the distribution of quality grades. Less steer carcasses were Choice compared with heifer carcasses.

Discussion

Breed of sire affected the performance, muscle yield, and carcass quality of cattle in this study. It is known that Continental cattle have greater ADG and muscle yield than cattle of English heritage (Marshall, 1994; Reinhardt et al., 2009; Williams et al., 2010). *Bos indicus* lineage has been found to be associated with reduced performance, muscle yield, and carcass quality compared with *Bos taurus* (Marshall, 1994; Thrift et al., 2010; Williams et al., 2010). However current results conflicted with traditional associations for marbling. Cattle sired by

Brahman bulls had the highest marbling scores of the sire breeds represented in the current study. This may be a result of the climate, as Brahman genetics are suited for the tropic and sub-tropic weather conditions found in the Southern United States (Finch, 1985).

Brahman genetics have been incorporated in the subtropical climates of the Southern United States because of their ability to dissipate heat more effectively than *Bos taurus* cattle (Finch, 1985). However, Brahman influenced cattle have reduced performance potential when compared with *Bos taurus* (Williams et al., 2010), resulting in a desire to identify alternative heat tolerant genetics. Bonsmara originated in South Africa, developed for increased performance and reproductive efficiency compared to native cattle while still being acclimated to the tropical climate found in the area. Compared to other sire breed groups in this study, Bonsmara sired offspring were greatest for PADG and FADG, moderate in ULMA, LMA, URF, and RF measurements, and lowest for UIMF, MN, and YG compared with other breeds. Minimal research has been published comparing the Bonsmara breed to other breeds in United States production system. In a literature review by Thrift et al. (2010) comparing subtropical adapted non-*Bos indicus* breeds to Brahman, Brahman influenced, and traditional *Bos taurus* breeds, Bonsmara genetics were considerably lower in marbling score, HCW, and YG. However, Bonsmara sired cattle were not significantly different from Angus, Hereford, and Gelbvieh sires for post-weaning ADG. These findings are consistent with the present study, as the Bonsmara progeny were similar in body measurements to British sired cattle and achieved increased ADG in comparison to other sire groups. In the present study, Bonsmara offspring were low in marbling compared to other breed groups, which is consistent with Thrift et al. (2010). Bonsmara genetics may be a viable option for adequate performance in areas of extreme climate;

however, marketing Bonsmara offspring to acquire carcass quality premiums may be unadvisable due to their inability to deposit IMF.

Simmental sired cattle had the most UIMF and second most URF at the end of grazing compared to other breed sire groups. This is inconsistent with ultrasound data collected at the end of grazing annual rye pastures (Aiken et al., 2004) and traditional data published with Simmental cattle (Williams et al., 2010). There is no clear explanation to this observation. It could be a result of the Simmental breed selecting for increased intramuscular fat, or not enough Simmental sired cattle ($n = 29$) in this study to accurately represent the population. However, at harvest Simmental sired cattle were representative of traditional populations compared to Angus contemporaries having lower MN. Braunvieh offspring were similar to Simmental progeny in previous reports (Marshall, 1994) as well as the current study, with the exception of PADG, gaining less than Simmental sired cattle. This may be a result of a greater population of Simmental cattle in the United States as compared to Braunvieh, resulting in more genetic progress.

British genetics are not traditionally represented as the highest performing breed type (Marshall, 1994; Williams et al, 2010). However, Reinhardt et al. (2009) reported as percentage of Angus increased, ADG also increased. Results of this study support that Angus genetics have more potential for improved gains over other breeds. Populations of Braunvieh, Hereford, and Simmental sired offspring in the current study were small, and may have skewed results. Further research with larger populations of these breed types is needed.

Cattle managed at low SR during the grazing phase had the most UIMF, URF, largest ULMA and highest PADG. This is likely due to adequate available forage as compared to high

SR. Increased available forage also affected HCW with low SR cattle having the heaviest HCW at harvest. However, cattle at high SR had the greatest FADG. This is due to compensatory gains after having limited access to feedstuffs in the grazing phase (Sainz et al., 1995; Neel et al., 2007). High SR cattle had the most animals grade Choice, while medium SR cattle had the least Choice. These data are confounded because cattle represented in the medium SR were predominantly of Bonsmara sires (Table 1), which were among the lowest quality grades in this study. More heifer carcasses were Choice quality grade than steers, which is in compliance with Reinhardt et al. (2009). This is expected as heifers are earlier maturing compared to male contemporaries.

Implications

Management strategies' during the grazing phase of the production cycle did affect the performance of cattle in the feedyard. This is predominantly a result of compensatory gains; as cattle that were placed on treatments of high stocking rate had less forage availability and gained more rapidly when feed concentrates. Low stocking rate resulted in cattle with greater average daily gain while on pasture and had more ultrasound ribfat and ultrasound intramuscular fat at the conclusion of grazing. Cattle given adequate amounts of feedstuffs during the grazing phase may carry this advantage to the rail as they have heavier hot carcass weight when compared to higher stocking densities. Bonsmara genetics may be a viable alternative to *Bos indicus* influence in sub-tropic regions of the United States, as they had similar gains and muscle yields compared with British-sired cattle.

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Table 1: Distribution of breed of sire over various stocking rates^a of cattle that grazed ‘Maton’ rye (*Secale cereale L.*) and ‘TAM90’ annual ryegrass (*Lolium multiflorum L.*) while in the stocker phase.

	Breed of Sire						Total
	Angus	Bonsmara	Brahman	Braunvieh	Hereford	Simmental	
High	83	0	48	8	6	13	158
Medium	0	63	13	10	0	0	94
Low	80	45	48	11	6	16	206

a: Grazing was commenced at one of three stocking rates (SR); high (9 animals/ha), medium (6 animals/ha), and low (4 animals/ha)

Table 2: The LSmeans for body ultrasound measurements, average daily gain, and carcass measurements of Angus, Bonsmara, Brahman, Braunvieh, Hereford, and Simmental sired cattle that grazed ‘Maton’ rye (*Secale cereale L.*) and ‘TAM90’ annual ryegrass (*Lolium multiflorum L.*) while in the stocker phase.

Breeds	N	Body Ultrasound Measurements			ADG		Carcass Measurements				
		Intramuscular Fat, %	Longissimus Muscle Area, cm ²	Rump Fat, cm	Pasture, kg/d	Feedlot, kg/d	Hot Carcass Fat, kg	Marbling Score ^a	Rib Fat, cm	Longissimus Muscle Area, cm ²	Yield Grade
Angus	171	0.27 ^b	58.30 ^b	0.55 ^a	0.80 ^a	1.81 ^a	343 ^a	417 ^a	1.39 ^a	82.35 ^a	3.24 ^a
Bonsmara	108	0.26 ^{bc}	58.42 ^b	0.56 ^a	0.96 ^a	1.92 ^{a†}	323 ^{ab}	381 ^{ab}	0.93 ^b	85.17 ^a	2.43 ^c
Brahman	109	0.25 ^c	52.67 ^c	0.44 ^b	0.68 ^b	1.67 ^b	316 ^b	415 ^a	1.08 ^b	78.19 ^{b†}	2.92 ^b
Braunvieh	31	0.32 ^{abc}	62.50 ^{ac}	0.74 ^{ab}	0.67 ^{ab}	1.87 ^{ab}	328 ^{ab}	384 ^a	0.91 ^b	86.47 ^a	2.78 ^{abc}
Hereford	12	0.35 ^{abc}	54.09 ^b	0.69 ^{ab}	0.89 ^{ab}	1.71 ^{ab}	316 ^{ab}	344 ^b	1.02 ^b	72.95 ^b	3.23 ^a
Simmental	29	0.38 ^a	68.33 ^a	0.61 ^{ab}	0.91 ^{ab}	1.66 ^{ab}	334 ^{ab}	382 ^a	0.96 ^b	86.62 ^a	2.76 ^{bc†}
Pooled SE		0.02	2.61	0.07	0.06	0.08	9	15	0.10	2.05	.15

^a Marbling Score = USDA Quality Grade (< 200 = Utility, 200 to 299 = Standard, 300 to 399 = Select, 400 to 699 = Choice, 700 ≤ = Prime)

Numbers without superscripts were not different from other variables.

†; (p < 0.10)

Table 3: The least square means for body ultrasound measurements, average daily gain, and carcass measurements of cattle that grazed ‘Maton’ rye (*Secale cereale L.*) and ‘TAM90’ annual ryegrass (*Lolium multiflorum L.*) while in the stocker phase at one of three stocking rate^{††}.

		Body Ultrasound Measurements			ADG		Carcass Measurements				
Stocking Rate	N	Intramuscular Fat, %	Longissimus Muscle Area, cm ²	Rump Fat, cm	Pasture, kg/d	Feedlot, kg/d	Hot Carcass Fat, kg	Marbling Score ^a	Rib Fat, cm	Longissimus Muscle Area, cm ²	Yield Grade
Low	206	0.33 ^a	61.66 ^a	0.66 ^a	1.02 ^a	1.68 ^b	329 ^a	391 ^a	1.11 ^a	81.24	3.0
Medium	94	0.30 ^{ab}	59.97 ^{a†}	0.68 ^a	0.99 ^a	1.81 ^{ab}	337 ^{ab}	375 ^a	1.06 ^a	84.12	2.9
High	131	0.28 ^b	55.33 ^b	0.46 ^b	0.45 ^b	1.81 ^a	314 ^b	395 ^a	0.98 ^a	80.52	2.8
Pooled SE		0.02	1.68	0.05	0.05	0.07	7	12	0.08	1.64	0.1

^a; Marbling Score = USDA Quality Grade (< 200 = Utility, 200 to 299 = Standard, 300 to 399 = Select, 400 to 699 = Choice, 700 ≤ =

Prime)

[†]; (p < 0.10)

^{††}: Grazing was commenced at one of three stocking rates (SR); high (9 animals/ha), medium (6 animals/ha), and low (4 animals/ha).

Table 4: Chi Square analysis of breed of sire, stocking rate^a, and sex by the percentage that were of choice, select, and standard quality grade of cattle that grazed ‘Maton’ rye (*Secale cereale L.*) and ‘TAM90’ annual ryegrass (*Lolium multiflorum L.*) while in the stocker phase (p < 0.05).

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	Breed of Sire						Stocking Rate			Sex	
	Angus	Bonsmara	Brahman	Braunvieh	Hereford	Simmental	Low	Medium	High	Male	Female
Choice	64.33	24.07	58.72	58.06	16.67	24.14	48.06	32.98	60.13	47.18	61.43
Select	35.09	55.56	40.37	38.71	66.67	75.86	47.09	51.06	38.61	46.15	37.14
Standard	0.58	20.37	0.92	16.67	16.67	0.00	4.85	15.96	1.27	6.67	1.43

a: Grazing was commenced at one of three stocking rates (SR); high (9 animals/ha), medium (6 animals/ha), and low (4 animals/ha).

Conclusion

Molecular breeding values were moderately related with body measurements of cattle. As predictors of performance and carcass parameters, MBV held little value when interpreted with regression analysis. Reproductive MBV were consistently correlated with various growth measurements through the production cycle of growing steers. This indicated that SNP may need to be re-evaluated as to which trait they have the most impact. Average daily gain MBV were not related with steer performance, but were consistently correlated with larger cattle. Predicting steer performance and carcass parameters with MBV or ultrasound was not effective. The best predictive tool was to weigh cattle at the beginning of each stage. In conclusion, current MBV for Gelbvieh Angus genetics serve as minor aids as a management tool for growing crossbred steers and more work needs to be completed in better determining the relationship between SNP and subsequent cattle performance in various production settings.

Management strategies' during the grazing phase of the production cycle did affect the performance of cattle in the feedyard. This is predominantly a result of compensatory gains; as cattle that were placed on treatments of high stocking rate had less forage availability and gained more rapidly when feed concentrates. Low stocking rate resulted in cattle with greater average daily gain while on pasture and had more ultrasound ribfat and ultrasound intramuscular fat at the conclusion of grazing. Cattle given adequate amounts of feedstuffs during the grazing phase may carry this advantage to the rail as they have heavier hot carcass weight when compared to higher stocking densities. Bonsmara genetics may be a viable alternative to *Bos indicus* influence in sub-tropic regions of the United States, as they had similar gains and muscle yields compared with British-sired cattle.