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Relationship of Underline Scores and Production Traits in Beefmaster Cattle

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Relationship of Underline Scores and Production Traits in Beefmaster Cattle

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by

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ABSTRACT

The objective of this study was to establish the relationship of underline scores (**UDLS**), production traits, and conformation scores in Beefmaster cattle born between 1976 through 2008. Records provided by Beefmaster Breeders United (**BBU**) were analyzed. Certified classifiers approved by the BBU recorded scores. Sizes and shapes of the underlines differentiated the scores (1-4). A score of one was used to designate the least amount of navel flap or sheath and a score of four represents the maximum amount of naval flap or sheath accepted for registration in the BBU. In this study the relationship of the traits was determined using the Pearson correlation analysis. The degree of relationship was then measured by regression procedure. No relationship ($P>0.05$) was detected between underline score and any carcass traits measured. Correlation of underline score with adjusted birth weight ($n = 22{,}256$, $r = 0.128$, $P<.01$), adjusted weaning weight ($n = 40{,}305$, $r = 0.090$, $P<.01$) and yearling weight ($n = 16{,}884$, $r = 0.185$, $P<.01$) were determined. For each increment increase in underline score, conformation score increased 0.051 score, adjusted birth weight increased 0.763kg, adjusted weaning weight increased 5.986kg, and yearling weight increased 16.488kg. In these data, the relationship of underline scores with maternal and growth traits suggest that underline score could be considered in performance programs. Because of these findings, a subsequent study was conducted to determine estimates of heritability for UDLS along with genetic, environmental, and phenotypic correlations of UDLS with conformation score (**CONS**), birth weight (**BRWT**), weaning weight (**WNWT**) and yearling weight (**YRWT**) in Beefmaster cattle. These data were analyzed using single- or 2-trait animal models with DFREML and DMU. The mixed model included fixed contemporary group effects constructed using herd, birth year, and sex information. Age of dam and animal age at inspection were included as covariates. Coefficients of heritability were 0.44 ± 0.01, 0.43 ± 0.01, 0.75 ± 0.04, 0.60 ± 0.02 and 0.85 ± 0.06 for UDLS, CONS, BRWT, WNWT and YRWT respectively, from the single-trait analyses. From the 2-trait analyses, coefficients of heritability for UDLS with CONS, BRWT, WNWT, and

YRWT were 0.43 ± 0.01, 0.35 ± 0.05, 0.39 ± 0.03, and 0.40 ± 0.06, respectively. Coefficient of r_g for UDLS with CONS was -0.16 ± 0.02, UDLS with BRWT was 0.02 ± 0.07, ULDS with WNWT was 0.05 ± 0.04, UDLS with YRWT was 0.13 ± 0.08 from the 2-trait analyses. Mean EBV of UDLS was 0.00 ± 0.40. These results suggest that artificial selection for UDLS would be effective in improving offspring of undesirable cattle and that sound selection should overcome any detriment to growth traits.

Key words: Underline score, heritability, correlation, Beefmaster cattle, birth weight, weaning weight, yearling weight

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CHAPTER I

INTRODUCTION

When Beefmaster cattle were in the development stages, the idea of taking a nuts and bolts approach to cattle business was born (Pettus, 1967). Pettus reported that Tom Lasater in 1931 was developing a beef machine. Disposition, fertility, weight, conformation, hardiness, and milk production are the six essentials that are still used today as the benchmark for producing the efficient machine that became a recognized breed by the U.S. Department of Agriculture in 1954 (www.beefmaster.org).

Beefmaster cattle are a three-way cross between Brahman, Shorthorn, and Hereford. Blood work on Beefmaster cattle is not an exact percentage. But the original breeding design would indicate that blood percentages would be a little less than one-half Brahman blood and the balance about evenly split between Hereford and Shorthorn (Pettus, 1967)

Beefmaster cattle represent the strengths of three breeds and commercial cattleman that purchase these bulls to improve the next generation desire the superior traits of this breed combination. Nonetheless, the excessive skin in the naval and sheath area represents a major problem due to the predisposition to injury (McMurry and Turner, 1989). Bull infertility is a major cause of production loss in many beef herds. Small scrotal circumference and large pendulous sheaths which are prone to injury are two major factors adversely affecting bull infertility (McCosker et al., 1989 and Hoogenboezem and Swanepoel, 1995). In Bos indicus bulls, the most common physical abnormality causing infertility is poor sheath structure. The structural faults include a sheath that is too pendulous and loosely attached to the body in the naval region, sheath too heavy and large and protruding prepuce. Roberson (2011) indicated that sheaths have a significant economic impact and that resistance to bulls with excessive skin appears to be caused by more than just a fear of impaired reproductive performance. Producers also want to minimize the appearance of having a large percentage of Brahman inheritance in their calves because of buyer resistance. Troxel and Barham (2012) reported that a major factor affecting the selling price of feeder cattle was perceived breed or breed type.

Because of the evident issues related to underlines and because of the importance of *Bos indicus* cattle to beef production especially in the southern U.S. region, a study of the relationship of underline scores to other traits of Beefmaster cattle seems appropriate. In most breeds of beef cattle, underline scores are not quantified and certainly not included in any genetic evaluation protocols. Ultimately, breeders need to know whether selection pressure for sheath and naval flap can be effective in breed improvement and whether selection for this trait will come at the expense of another economically important trait. Kriese et al. (1991) reported in Brangus cattle that weaning sheath and naval score heritability indicated that genetic change for the size and shape of the sheath and naval is possible. McMurry and Turner (1989) also provided evidence to establish that sheath scores are genetically controlled, and both sire and dam contribute to the sheath score of the calf. Mating types are important for improvement of calf underline score. Their research found that there was a small positive phenotypic correlation between calf sheath score and weaning weight. Positive correlations between sheath area and the bulls average daily live weight gain were reported by Hoogenboezem and Swanepoel (1995).

Brahman and Brahman-derivative cattle, such as Brangus, Beefmaster and Santa Gertrudis, are important beef cattle breeds in the southern and tropical regions of the United States. These cattle are heat- and disease resistant and have become fixtures in the U.S. beef cattle industry. An important breed characteristic of Brahman and Brahman-derivative cattle is the shape and size of the navel or sheath area. It is undesirable to have too little or too much skin because of the aforementioned problems associated with reproduction and yet insufficient skin represents a lack of breed character. The objective of these studies is designed to estimate the genetic parameters associated with underlines scores in Beefmaster cattle and the subsequent relationship with conformation, growth, carcass, and maternal traits.

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CHAPTER II

REVIEW OF LITERATURE

SHEATH, PREPUTIAL ORIFICE AND MATING ABILITY

Chronic prolapse of the parietal layer of the prepuce of bulls has been associated with increased incidence of preputial injuries, infections and subsequent permanent prolapse (Roberts, 1956; Donaldson and Aubrey, 1960) that may cause breeding difficulties. Damage to the prepuce can lead to restriction of the preputial orifice. Afflicted bulls are reluctant to mate because of pain caused by erection and protrusion of the penis (Zemjanis, 1962). The predisposition to prolapse apparently varies with breed. Hofmeyr (1968) stated that in South Africa the Hereford has a greater tendency to preputial prolapse than other breeds of *Bos taurus*. Roberts (1956) suggested that among breeds of *Bos taurus* in the United States preputial prolapse occurred with greatest frequency among Polled Hereford and Angus. However, several authors (Roberts, 1956; Donaldson and Aubrey, 1960; Hofmeyr, 1968) have agreed that chronic preputial prolapse was most commonly observed among *Bos indicus*, particularly those with long, pendulous sheaths. Lagos and Fitzhugh, Jr. (1970) reported a 0.33 correlation between sheath length and prepuce prolapse score that was independent of base breed, sire, and age. Bertram et al. (1997) assessed sheath characteristics in Santa Gertrudis bulls which may influence performance in a serving capacity. They found that there was a poor relationship between sheath depth and width and the number of mounts and serves that a bull achieved. In Santa Gertrudis Bulls, Smith et al. (1981) showed a negative relationship between prepuce length (distance from the ventral abdomen to the preputial orifice) or sheath depth and the percent of estrous females that became pregnant. They found no significant relationship between sheath length (distance from the front of the scrotum to preputial orifice) and either the percent pregnant of estrous females or the percent pregnant of females mated. However, a study in northern Australia by McGowan et al. (2002) showed that size and conformation of the umbilicus was associated with conformation of the sheath and influenced mating ability in 2-

year-old Brahman and 3-year-old Santa Gertrudis bulls. They reported that in 2-year-old Brahman bulls umbilical cord thickness was positively related to sheath depth, and negatively related to number of mounts and serves in a serving capacity test.

GENETIC PARAMETERS ASSOCIATED WITH SHEATH AND NAVAL FLAP AND CORRELATION WITH PERFORMANCE

McGowan et al. (2002) reported measures of sheath depth and sheath score were moderate to highly repeatable. Franke and Burns (1985) measured Brahman bull and heifer weaning sheath area and found a heritability estimate of 0.41 ± 0.16. This research also reported phenotypic correlations between sheath area and birth weight, preweaning average daily gain and weaning weight to be 0.17, 0.27, and 0.29, respectively. Genetic correlations between sheath area and these three preweaning growth traits were 0.23 ± 0.35, 0.58 ± 0.25, and 0.52 ± 0.27. Kriese et al. (1991) also indicated that both weaning sheath and navel score are under a moderate amount of additive genetic control and that improvement can be obtained for the size and shape of the sheath or naval. Similar research estimated calf sheath score at 0.37 ± 0.09 heritability (McMurry and Turner, 1989). They as well found a small positive phenotypic correlation between calf sheath score and weaning weight of 0.26. This would suggest that as sheath score improves or decreases so does weaning weight. This reduced weaning weight was reported to be approximately 3.5% or 20 pounds for each unit decrease in sheath or naval flap score (McMurry and Turner, 1989). Taylor (2007) studied the differences between performance tested Santa Gertrudis bulls with small (below 470 cm^2) and large (above 470 cm^2) sheaths and found that bulls with large sheaths possessed a fifteen percent heavier (66 kg) final weight and reported a significant phenotypic correlation with ADG (0.31, $P < 0.05$), initial weight (0.42, $P < 0.001$) and final weight (0.45, $P < 0.001$).

McMurry and Turner (1989) provided evidence that both sire and dam contribute to the sheath score of the calf and that mating types are important for progress. Kriese et al. (1988)

reported a genetic correlation of 0.51 between weaning sheath and navel score from bulls having both male and female progeny in the same contemporary group. This research indicates that the genes that control weaning sheath and naval flap are similar and suggests that the two are not identical traits in males and females (Kriese et al., 1991). This research also estimated a genetic correlation between additive and maternal effects to be rather large (-0.53). Kriese et al. (1991) suggests very little maternal control of these traits and indicates that the uterus influences the shape and size of the calf's sheath and naval areas during gestation. McMurry and Turner (1989) further explains that selection of breeding animals for cleaner sheaths only, without regard to growth, would result in lower weaning weights. Therefore, corrective mating plans appear to be relevant in improving sheath scores. However, the correlation is small enough that sound multiple trait selection should virtually negate any expected loss in performance at weaning as sheath and naval flap scores are improved. McMurry and Turner (1989) concluded that there is no need to recommend a sheath score of one as a breeding objective, but breeders can certainly eliminate the intolerable cattle that are subject to injury and market prejudice. Franke and Burns (1985) supports these findings and suggest that continued emphasis on increasing growth rate or weaning weight could generally be sustained with vigilant consideration to avoiding large sheath areas through independent culling levels or index selection procedures.

COMPARTIVE REPORT FOR REPRODUCTION, MATERNAL AND PRE- AND POST-WEANING PERFORMANCE RESEARCH ON BRAHMAN AND BRAHMAN DERIVATIVE CATTLE WITH RESPECT TO ENVIRONMENT

In any dialogue of beef cattle production in a particular environment the matter of climatic adaptability should be of prime consideration. Adaptation for beef cattle might be defined as the ability to reproduce, grow, and thrive under local environmental conditions. Much has been reported about the ability or inability of temperate zone breeds of cattle to adapt to hot, humid, subtropical environments. Crockett and Koger (1982) reported data that suggest temperate zone breeds, which have become adapted to subtropical conditions through natural selection and a period of intense artificial selection, can be made to perform competitively with breeds adapted to subtropical environments. However, this would involve a long-time adjustment. As a result, considerable effort has been directed toward evaluating Brahman and Brahman derivative cattle. Results indicate that in the hot, humid South-east and Gulf Coast areas, and even in more temperate areas of the United States, the weaning performance of Brahman cross calves are unmatched (Thrift et al., 2010). Nonetheless, this advantage in weaned performance does not come without problems that have been identified with Brahman derivative cattle. Docility, subpar reproductive performance, increased dystocia, or reduced survival rates expressed by Brahman sired calves and unfavorable carcass attributes, especially tenderness are problems associated with Brahman cattle (Thrift and Thrift, 2005). Several research papers have reported results that summarize sire breed comparisons involving economic important performance measures. Thrift et al. (2010) concluded that the use of Brahman as the standard *Bos indicus* sire breed results in progeny that weigh more at weaning, grow at a faster rate postweaning, and have heavier carcasses than the non-*Bos indicus* subtropically adapted sire breeds in the Gulf Coast.

In this review of literature most of the data suggests that the particular breeds used can have a significant impact upon production. Crockett et al. (1979) reported a highly significant effect ($P < 0.01$) on birth weight, 205-day weight, fat thickness, ribeye area, and yield grade. Breed of dam influenced more of the carcass traits than breed of sire. Chewning et al. (1990) also suggested that differences do exist between breeds for average daily gain, feed to gain ratio, daily feed intake on both an absolute and a percentage of body weight basis. However, the interaction of sire and dam breed did not have a significant impact on performance. This agrees with Smith et al. (1976) who reported data from Angus and Hereford females bred to different breeds of sires, including Limousin and Simmental. Chapman et al. (1978) also reported significant effects of sire and dam breed. The sire effect occurs when an animal with desirable attributes is bred repeatedly. This can cause undetected, undesirable genetic traits in the sire to spread rapidly within the gene pool. It can also reduce genetic diversity by the exclusion of other males.

COW TRAITS AND PREWEANING PERFORMANCE

Genetic diversity among breeds can be used in crossbreeding systems or composite population to utilize heterosis and genetic differences among breeds to optimize performance levels and match genetic potential to the climatic environment, feed resources, and consumer preferences. Output or weaning weight per cow has been greater for *Bos indicus* x *Bos taurus* than for *Bos taurus* x *Bos taurus* cows, especially in subtropical environments (Turner and McDonald, 1969; Olson et al.; 1991). With respect to temperature-humidity index on the east coast of Mexico, Mellado et al. (2010) reported that pregnancy rate was only mildly compromised by extreme heat load in Beefmaster cows and that cooler or warmer temperature prior or after artificial insemination had no consequences for pregnancy rate during the warmest seasons. Crockett et al. (1979) showed mixed results in a comparative performance study with Beefmaster, Brahman, Brangus, Limousin, Maine-Anjou, and Simmental sire breeds at Belle Glade, in what is considered a subtropical environment. In this study, each of the sire breeds ranked differently for the various stages of beef production. Beefmaster sires performed the most desirable for unassisted live births, survival rate, and relatively light birth weights. This is in agreement with Thrift (1997) who reported calves sired by Brangus and Beefmaster bulls were lighter at birth and weaning than calves sire by Brahman bulls. Wyatt et al. (2002) also reported calves sired by Brangus and Beefmaster bulls had lower birth weights, but also lower preweaning growth rates and weaning weights than calves sired by Gelbray and Sim-brah bulls. Nonetheless, in a study by Lawson et al. (1980), observed Beefmaster sired calves that were gestated 3.2 days longer, were heavier at birth and weaning, and had 10.4% more assisted births and more calf deaths at calving than Red Angus.

<u>POST-WEANING</u>

Beaver et al. (1989) reported Angus and Brangus were similar in post-weaning growth but indicated that Brangus steers were heavier at slaughter when compared with Angus steers. Steers from Brangus dams were heavier at slaughter when compared with steers from Hereford and Angus cows (Crocket et al., 1979). Crockett et al. (1979) found that Beefmaster steers grew faster than Brangus steers under tropical conditions and that final body weight was heavier in Beefmaster sired steers when compared to Brangus steers. Franke (1997) did not find any differences in feedlot daily gain between Beefmaster- and Brangus versus Brahman sired steers. Rahnefeld et al. (1977) reported Beefmaster and Red Angus were found to be very similar in feedlot and carcass weight. The slightly faster growth rate of Red Angus did not fully compensate for their lower average weaning weight, and their carcass weight per day of age was slightly less than that for Beefmaster progeny.

<u>CARCASS TRAITS</u>

Wheeler et al. (2005b) indicated that Hereford and Angus progeny had superior marbling scores in comparison with Beefmaster and Brangus inheritance. Cattle with an Angus background tend to have a greater marbling score when compared with other breeds (Marshall, 1994). Bidner et al. (2002) reported very little difference in marbling score when comparing, Brangus and Beefmaster. Additional data supports that steers by Brahman sires had heavier slaughter weights ($P < 0.05$) than Brangus and Beefmaster sired steers, but Brahman sired steer carcasses had less marbling ($P < 0.05$) than carcasses of Brangus and Santa Gertrudis sired steers (Damon et al., 1960; Turner, 1973; McElhenney, 1995; Cundiff et al., 1993).

Yield grade is an accurate predictor of carcass composition (Abraham et al., 1980). Bidner et al. (2002) indicate that Beefmaster and Brangus have similar yield grade. Similar results have been reported (Casas et al., 2010). Hot carcass weight is an important factor in determining yield grade. Bidner et al. (2002) reported that Brangus steers had heavier carcasses than Angus steers. Marshall (1994) pooled carcass information across studies and reported that Hereford and Angus had heavier carcass weights when compared with Brangus. Wheeler et al. (2005b) indicate that Brangus steers had similar hot carcass weight when compared with Hereford and Angus crossbred animals. Bidner et al. (2002) also compared carcass weight between Brangus and Beefmaster steers and found Beefmaster steers had similar carcass weights when compared with Brangus steers. Wheeler et al. (2005b) also found similar carcass weights between Brangus and Beefmaster steers.

Conflicting reports on fat thickness exist in the literature. Bidner et al. (2002) found that animals derived from Angus sires were fatter than Brangus and Beefmaster harvested at the same age. Crockett et al. (1979) also indicated a difference in fat thickness between animals produced from Angus and Brangus dams, where offspring from Brangus cows were leaner than offspring from Angus cows. However, Marshall (1994) indicated that fat thickness for animals with Angus, Hereford, Brangus, and Beefmaster influence were similar. Wheeler et al. (2005b) indicated that animals from Hereford and Angus have similar fat thickness as Beefmaster, but different than Brangus.

Damon et al. (1960), DeRouen et al. (1992), and Wheeler et al. (2001) reported that meat from Brahman cattle is less tender, had lower marbling scores, and consequently lower carcass quality grades than meat from non-Brahman cattle. Also, Luckett et al. (1975) and O'Connor et al. (1997) reported that sheer force of meat increased as the percentage of *Bos indicus* inheritance increased in crossbreds. This is probably due to the calpain gene and its specific inhibitor, calpastatin. This has been repeatedly investigated for their association with meat quality traits in cattle. Meat quality is determined by multiple factor, including tenderness, water holding capacity, color, nutritional value and safety, and the importance of these traits varies depending on both the type of product and the consumer profile (Koobmaraie and Geesink, 2006). Tenderness has been established as the most important quality trait in beef, and the amount of connective tissue, myofibrillar protein degradation and intramuscular fat content is the primary source (Houbak et al., 2008). Leal-Gutierrez et al. (2018) indicated that breed composition had a significant effect on tenderness where animal with more than 80% Angus composition had the most tender meat. Even so a study by Johnson et al. (1990b) indicated that steaks from steers with 25% or lower percentage Brahman breeding were more tender than steaks from steers with 50% or higher percentage Brahman. Braford, Red Brangus, and Simbrah cattle had similar tenderness value if aged for 21 days. A more recent palatability study (Bidner et al., 2002) with Angus, Beefmaster, Brangus, Gelbray, and Simbrah found only small differences in cutability and carcass quality among the four Brahman derivative breeds. This study concluded that these Brahman derivative breeds can be used successfully as purebreds or in a crossbreeding program in the Gulf Coast Region without sacrificing beef quality or cutability. However, in comparison with Angus, steaks from Beefmaster, Brangus, Gelbray, and Simbrah carcasses require additional aging time. However, the calpastatin inhibiting properties on calpain associated with *bos indicus* cattle prevent aging effectiveness O'Connor et al. (1997).

PHENOTYPIC EXPRESSION AND THEIR ASSOCIATION WITH PERFORMANCE

Subjectively evaluated traits are very important for animal progress. The idea that physical traits have an association or are correlated with some economically important traits brought about the importance of understanding type or phenotypic expression. Purebred breed associations have devised scoring systems for type traits they wish to improve upon as a result of database expansion in pursuit of more accurate genetic records. The extension service and various beef improvement organizations have also created some of the more widely used scoring systems in beef cattle systems today. The following is an overview of the numerous scoring systems most commonly used to assign value to the phenotypic expression observed in type traits thought to have economic relevance.

FRAME SCORE

The effect of frame size on the cow's reproductive traits is of great concern as it relates to production efficiency. Frame size is defined by hip height at a particular age and is correlated with growth rate. Although, selection pressure to increase frame score may result in increased growth rate, its impact on female fertility traits such as age at puberty and rebreeding efficiency while lactating may be negative. Vargas et al. (1999) reported that small and medium frame score females reached puberty at an earlier age, calved earlier, and had greater calving, survival, and weaning rates. The primary reason for low survival rates is a result of greater incidence of calving difficulty associated with large frame calves (Bellows and Short, 1994). Jenkins et al. (1991) also found a positive with-in breed phenotypic correlation between birth weight and adult hip height. Even though Gore et al. (1994) did not find a relationship between birth weight and maternal size, large cows tended to have calves of greater birth weight than cows of smaller size. Weight of calf weaned per cow exposed is more important than calf weaning weight and is a function of calving rate, calf survival rate, and calf weaning weight (Ferrell, 1982). The kilograms of calf weaned per cow exposed tended to be influenced by frame score in first parity dams Vargas et al. (1999). However, as cows with large frame scores reached maturity, they seemed to have overcome the negative effects imposed by frame size.

Frame size is one factor that influences feeder cattle grading. Hammack and Gill (2009) state that frame size, thickness, and thriftiness should be used to predict at what weight steers are ready to be harvested. "Medium frame steers are projected to finish at 1,100 to 1,250 pounds. Small frames are projected to finish below that range and large frames above", (Hammack and Gill, 2009). They also outline the numerous studies on frame size and mature cow size to conclude that the Frame Score System is a more accurate predictor of weight at slaughter, onset of puberty and maturity pattern rather than actual body size which can best be quantified by weight in relation to body condition. Knox and Koger (1946) reported that larger framed "rangy" steers gained more and had a higher dressing percentage than steers of more compact type. The carcass grades were the same for the steers of the different types when fed to comparable backfat thickness. They summarized that if size is reduced, it will be difficult to develop cattle possessing rapid gaining ability. Romera et al. (1998) suggested that medium sized steers did not have a greater productivity per surface unit than small steers. Furthermore, Muwalla et al. (1983) found no significant difference between the small and large frame bulls in digestibility of dry matter, digestible energy, digestible starch, or fecal starch loss but there were significant effects of level of feed intake on variables relate to digestible energy and starch retention parameters.

Reinhardt et al. (2009) found that across sex, large- framed cattle had greater final body weight, loin muscle area, hot carcass weight, decreased mortality, marbling score, and quality grade. Although large-framed cattle had greater loin muscle area, they had smaller loin muscle area per unit of carcass weight. Tatum et al. (1988) reported that although small framed steers had greater carcass fat content than large framed steers, small framed steers also had a greater muscle to bone ratio, indicating that large framed steers carry an inordinate amount of non-muscle tissue relative to the actual amount of extra muscle that might exist along the extra frame. Camfield et al. (1997) also reported on the effects of frame size on carcass characteristics and found that large-framed steers had heavier ($P < 0.05$) hot carcass weights than medium-framed steers. Carcasses from medium-framed steers were fatter ($P < 0.05$) over the *longissimus* muscle at the 12^{th} and 13^{th} rib interface than carcasses from large-framed steers. Although medium-framed steers subsequently graded higher for marbling score and quality grade score than large-framed steers, these differences were not substantial enough to affect carcass grade. These results are in agreement with Camfield et al. (1994) that suggest large-framed, slow-maturing steers had poorer quality grades and marbling scores and heavier hot carcass weights than intermediate-frame, slow maturing steers. Lewis et al. (1993) and Galloway et al. (1993) also found similar results.

<u>BODY CONDITION SCORE</u>

Changes in body condition of cattle in production affects numerous traits relating to efficiency and profitability including length of post-partum interval, lactation, health of newborn calf, and calving difficulties for different fat depositions in beef cattle. Gadberry (2010) stated that the economic implications of poor body condition are the need for increased supplementation in critical periods of production when resources are scarce.

Body condition score (**BCS**) can be defined as a categorical numbering system used to suggest the relative fatness of the cow. Gadberry (2010) explains this system as very producer-friendly and practical in settings where recording weights is difficult or impossible. A one to nine-point scale is the most recognized scoring system where a score of one indicates emaciated cattle whose shoulders, ribs, and pin bones are easy to detect and a nine indicated extremely fat cattle whose bone structures are not visible, tail head is surrounded by fat, and they may even express reduced locomotive capabilities. Gadberry (2010) describes the industry accepted ideal range to be a five to seven.

Optimal reproductive performance of beef cows is largely dependent upon the duration of the postpartum anestrous interval. This period of anestrous can be influenced by nutrient intake and body energy reserves (Dunn and Kaltenbach, 1980; Randel, 1990). Improving body condition score with nutrient intake before and after calving has been shown to decrease the interval to first estrus and increase pregnancy rate (Wiltbank et al., 1962; Richards et al., 1986; Selk et al., 1988). Pryce et al. (1999) observed effects of BCS during early lactation and reported that cows are mobilizing body tissue to sustain milk production and that cows in negative energy balance in early lactation may be yielding milk at the expense of reproduction.

Conversely, cows detected in estrus during the breeding season are reduced when nutrient intake is limited and body condition score is decreased (Richards et al., 1986; Spitzer et al., 1995). Lents et al. (2008) reported that pregnancy rate was greater ($P < 0.05$) in cows of moderate body condition than in thin cows and that postpartum protein intake and body condition score at calving did influence the size of the dominant follicle at the first postpartum estrus. Greater body condition scores as a result of increased nutrient intake after calving resulted in greater concentrations of insulin in plasma that were associated with a larger dominant follicle (Ciccioli et al., 2003). Murphy et al. (1991) also reported that reduced intake results in more rapid turnover of the dominant follicle, and the increased rate of turnover decreases the size of the dominant follicle. Lents et al. (2008) also reported on the duration of estrus and found that neither body condition score nor amount of postpartum protein supplement influenced incidence of short luteal activity before or after the first estrus of mature suckled beef cows. This is in agreement with Corah et al., (1974) and Looper et al., (2003) that stated duration of the estrous cycle is of normal duration and is not influenced by body condition score or body weight.

CONFORMATION SCORE

MacDonald and Bogart (1954) made an extensive analysis in which they related scores and body measurements to rate and efficiency of gains. There appeared to be little relationship between conformation score at 362 kilograms of body weight and rate or efficiency of gains made between the weights of 226 and 362 kilograms. From this we could assume that selection for over-all merit would develop cattle that were rapid and economical gainers and desirable in conformation. However, selection for conformation alone would not be expected to improve cattle for rate and efficiency gains. Neither could selection for rate and efficiency alone be expected to improve cattle for conformation. The analysis concluded that the only body measurements which were related to gains were heart and chest depth, which showed a negative relationship and body length and rump measurement which were positively related to both rate and efficiency of gains.

HAIR SCORE

Smoliak and Peters (1955) observed that bison cattle hybrids were more willing to graze on open range under adverse winter conditions in western Canada than were Hereford, Angus, or Shorthorn cows. In subsequent research, Peters and Slen (1964) examined hair coat differences among cattle, bison and their hybrids and found that bison had much heavier, denser hair coats than did domestic cattle. This prompted a study by Gilbert and Bailey (1991) at the Agriculture Canada Research Station to look at hair coat characteristics and post weaning growth. They found that none of the hair coat characteristics or factors were strongly associated with 168-day postweaning gain and concluded that selection for one or more hair coat characters would be less effective than direct selection for gain. Falconer (1960) also reported little indirect selection response would be expected from selection for a hair coat character or factor to improve postweaning gain.

In contrast, in a much different climate of Australia, Schleger and Turner (1960) reported that simple correlations were significant between gain and subjective coat score (-0.72). Estimated genetic correlations between hair slickness scores (1= early shedding, 5= late shedding) and growth traits were reported by Williams et al. (2006). They found sires whose progeny were slick haired had higher weaning weights but lower post weaning gain than progeny of non-slick sires. The research from Gray et al. (2011) also found that cows that shed their winter coat earlier weaned off heavier calves. They also calculated heritability at 0.35 which suggests that hair coat shedding is a heritable trait and could be altered by selection. The benefits of hair coat shedding in commercial cow-calf systems located in hot and humid environment are clear according to Decker and Parish, 2017. Calves out of cows that shed their winter coats earlier weaned heavier calves. However, no effects on calf performance in operations located in temperate environments were observed.

TEMPERAMENT/DISPOSITION/CHUTE SCORE

Temperament, in cattle, is considered highly heritable and is determined by an interaction between a substantial genetic effect and environmental factors (Grandin and Deesing, 1998). In general, temperament is defined as an animal's reaction to human contact or handling (Fordyce et al., 1985). Transport, handling, mixing, and time off feed and water are all examples of alteration to an animal's homeostatic environment (Clark et al., 1997). Most of the research to date has assessed beef cattle temperament by recording the exit velocity of cattle as they are released from either the head gate restraint or scale (Burrow et al., 1988; Behrends et al., 2009; Curley et al., 2006). Subjective chute scores developed by Grandin (1993) have also been recorded for determining temperament. Assessment of beef cattle temperament has received warranted interest due to the connection between excitability, animal physiology, performance, and potential carcass merit. Animals possessing a more excitable temperament have been shown to elicit a response from the sympathetic nervous system and this additional stress will trigger a hormonal response through activation of the hypothalamic pituitary adrenal axis (Grandin, 1997). Stressful responses elicited from temperamental animals have negative impacts on production. Constant activation of the sympathetic nervous system is energy intensive and can be costly (Voisinet et al., 1997). Energy costs associated with reestablishing a homeostatic state will be realized in increased production costs and lost economic revenue (Clark et al., 1997). The lack of selection pressure on cattle temperament can be confounding because Nkrumah et al. (2007) found an estimate of 0.4 for the heritability for cattle disposition. Several studies have shown estimates of cattle temperament to be moderately heritable (Shrode and Hammack, 1971; Stricklin et al., 1980; Fordyce et al., 1988). In one study Temperament was found to be moderately to highly heritable (Wieckert, 1971).

Chute scores and visual flight-speed scores were negatively correlated with daily body weight gain (Hoppe et al., 2010). In a study by Reinhardt et al. (2009) that reported chute score and exit temperament as disposition, showed that cattle with greater disposition score (more excitable) had decreased initial body weight, final body weight, average daily gain, hot carcass weight, yield grade, quality grade, marbling score, and mortality ($P < 0.01$). These results concur with those of Voisinet et al. (1997) and Nkrumah et al. (2007), who found that feedlot cattle possessing an excitable temperament were correlated with reduced feedlot average daily gain. Previous research has also suggested that more excitable cattle have poorer body weight gain (Tulloh, 1961; Fordyce and Goddard, 1984). Nonetheless, in a study by Hall et al. (2011) where temperament was evaluated as exit velocity, chute score, and catch score observed no statistically significant relationship between any measures of animal temperament. Hoppe et al. (2010) reported that breed was a significant source of variation in chute scores and flight speed scores ($P < 0.001$) and that temperament scores differed significantly between male and female calves ($P < 0.01$), with females scoring better for both traits. One study reported that cows with calm temperaments had 25 to 30% increases in milk production (Drugociu et al. 1977).

More excitable cattle are linked to producing on average tougher beef steaks (King et al., 2006). Apple et al. (2005) also reported that steers subjected to isolation and restraint stress have been shown to have higher longissimus muscle pH and darker colored lean. This is in agreement with Voisinet et al. (1997) that indicated feedlot cattle with a more excitable temperament were more prone to develop dark cutting beef.

MUSCLE SCORE

Muscle score evaluated at feedlot arrival was correlated with some growth and carcass traits (Reinhardt et al., 2009). Compared with heavier muscled cattle, lighter muscled cattle had decreased initial body weight, hot carcass weight, loin muscle area, and greater marbling score and subsequent quality grade, but they had greater numerical yield grade ($P < 0.05$). They reported no effect of muscling score on average daily gain. Tatum et al. (1988) agreed that steers differing in muscle thickness responded consistently in relation to growth rate.

Reinhardt et al. (2009) also reported less than one percent difference between muscle score 2 and 3 on loin muscle area relative to hot carcass weight which contradicts the report by Tatum et al. (1988) who found that muscle thickness influenced carcass composition primarily via its effect on weight of separable muscle, resulting in group differences in muscle to bone ratio, even between cattle of muscle score 1 versus 2. But Grona et al. (2002) reported that differences in muscle score did not correspond to differences in ultimate yield grade.

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CHAPTER III

RELATIONSHIP OF UNDERLINE SCORES TO PERFORMANCE TRAITS IN BEEFMASTER CATTLE: CORRELATION AND REGRESSION ANALYSES

ABSTRACT

The objective of this study was to determine the relationship between underline scores and growth traits and conformation score. Performance records of Beefmaster Breeders United (**BBU**) recorded from 1979 through 2007 were studied. The calf, the sire and dam of each calf were recorded in the registry of the Beefmaster Breeders United. Scores were recorded by classifiers approved by Beefmaster Breeders United. Underline scores (1-4) are based on the different sizes and shapes of sheaths in bulls and navels in heifers. A score of 1 is used to designate the least amount of navel or sheath and a score of 4 represents the maximum amount of navel or sheath accepted as a Beefmaster Breeders United registered Beefmaster. Relationship of the traits was determined using the Pearson correlation analysis. The degree of relationship was then measured by regression procedure. Inspector was included as a covariate and growth traits were adjusted for age of dam and sex of calf. Carcass traits were not ($P>0.05$) related to underline score. Correlation of underline score with adjusted birth weight (n=19,980, r=0.128, $P<.01$), adjusted weaning weight (n=36,354, r=0.090, $P<0.01$) and yearling weight (n=14,900, r=0.185, $P<0.01$) were determined. For each increment increase in underline score, conformation score increased 0.051 score, adjusted birth weight increased 0.76 kg, adjusted weaning weight increased 5.9 kg, and yearling weight increased 16.5 kg. In these data, the relationship of underline scores with maternal and growth traits suggest that underline score could be considered in performance programs.

Key words: Underline score, correlation, regression, Beefmaster cattle, growth traits

INTRODUCTION

Cattle producers that purchase Beefmaster cattle intend on capitalizing on the superior traits of this three-breed combination to improve the next generation and increase profit opportunities. Nonetheless, the excessive skin in the naval and sheath area represents a major problem due to the predisposition to injury (McMurry and Turner, 1989). Bull infertility is a major cause of production loss in many beef herds. In *Bos indicus* bulls, the most common physical abnormality causing infertility is poor sheath structure (McMurry and Turner, 1989). The structural challenges can include a sheath that is too pendulous and loosely attached to the body in the naval region, sheath too heavy and large and protruding prepuce. Roberson (2011) indicated that sheaths have a significant economic impact and that customer resistance to excessive sheath bulls appears to be caused by more than just a fear of impaired reproductive performance. Producers also want to minimize the appearance of having a large percentage of Brahman inheritance in their calves because of buyer resistance. Troxel and Barham (2012) reported that a major factor affecting the selling price of feeder cattle was perceived breed or breed type. Damon et al. (1960), DeRouen et al. (1992), and Wheeler et al. (2001) reported that meat from Brahman cattle is less tender, had lower marbling scores, and consequently lower carcass quality grades than meat from non-Brahman cattle. Also, Luckett et al. (1975) and O'Connor et al. (1997) reported that sheer force of meat increased as the percentage of *Bos indicus* inheritance increased in crossbreds. This is probably due to the calpain gene and its specific inhibitor, calpastatin.

Breeders need to know whether selection pressure for sheath and naval flap can be effective in breed improvement and whether selection for this trait will come at the expense of other economically important traits. Several authors (Roberts, 1956; Donaldson and Aubrey, 1960; Hofmeyr, 1968) have agreed that chronic preputial prolapse is most commonly observed among *Bos indicus* bulls, particularly those with long, pendulous sheaths. Lagos and Fitzhugh, Jr. (1970) reported a correlation between sheath length and prepuce prolapse score that was independent of base breed, sire, and age. Bertram et al. (1997) found that there was a poor relationship between sheath depth and width and the number of mounts and serves that a bull achieved. In Santa Gertrudis bulls, Smith et al. (1981) showed a relationship between prepuce length or sheath depth and the percent of estrous females that became pregnant. Kriese et. al. (1991) reported in Brangus cattle that genetic change for weaning sheath and naval score is possible. McMurry and Turner (1989) also provided evidence to establish that sheath scores are genetically controlled, and both sire and dam contribute to the sheath score of the calf.

Therefore, seedstock with underline related issues that are moderately heritable have the potential to pass on unacceptable underlines to their progeny. Beefmaster Breeders United has a classification system to describe variation in underline characteristics. Because of the evident issues related to underlines and because of the importance of *Bos indicus* cattle to beef production, especially in the southern U.S. region, the objective of these studies were to estimate the genetic parameters associated with underlines scores in Beefmaster cattle born between 1979 and 2007 and the subsequent relationship with conformation score, birth weight, weaning weight, and yearling weight.

MATERIALS AND METHODS

Field data (n = 76,972) for birth weight (**BW**), weaning weight (**WW**), yearling weight (**YW**), conformation score (**CONS**), and underline score (**UDLS**) were supplied by BBU (San Antonio, TX). There were no required Animal Care and Use Committee approval needed as these data were used from an existing database. Reporting observations began in 1976 and because the evaluation of phenotype for underlines by breeders was voluntary, there was considerable selection intensity for UDLS as well as other traits reported. This resulted in substantial variation in the number of ranches, animals, and years represented. A description of the data is provided in Table 1. Data were obtained on bulls and heifers in 23,757 herds by individual seed stock breeders and processed at BBU offices. Classification for UDLS and CONS were determined for each animal by evaluators trained and approved by BBU. Observations per inspector ranged from 765 – 33,144 animals. Underlines for both bulls and heifers were evaluated/classified on a scale of 1 through 5 with 1 = excessively clean, 2 = optimum, 3 = acceptable, 4 = marginal, and 5 = unacceptable. Presented in Table 2 are the underline scores and the description of the phenotype that pertain to each score. This scoring system was similar to that described for Brangus Cattle by Kriese et al. (1991) and Bertram et al. (1997). Conformation scores were from 1 through 5, with 1 being most desirable relative to type. In Table 3 are CONS and the description of the phenotype for each score. Available for analyses after reviewing the data for consistency, detection of errors and outliers and correction of errors were records for UDLS and CONS (n = 49,577 for each), BW (n = 19,980), WW (n = 36,354) and YRWT (n = 14,900). Beef Improvement Federation (**BIF**) Guideline (2016) equations and age of dam correction factors were used to adjust birth weight and weaning weight records. The 365-day weight equation was used to adjust yearling weight records. Adjusted 365-day weights are computed to adjust an actual yearling weight taken by the breeder to a standard animal age and age of dam. Acceptable calf ages for yearling measures are 320-440 days of age. Correlation and regression coefficients were determined by the standard GLM procedure of Statistical Analysis Systems (SAS 1985). Inspector and contemporary group generated as herd, birth year, and sex were included as fixed effects. Covariates were age of dam and age of animal at inspection.

RESULTS AND DISCUSSION

In Figure 1 are the frequencies of UDLS in Beefmaster cattle with birth year 1976 through 2008. Of the 5 UDLS, optimal and acceptable descriptions were more frequently observed (P<0.05) when compared to cattle with the other 3 scores. Fewer cattle (P<0.05) scored undesirable in comparison to cattle with the other 4 scores. The average for underline and conformation scores and associated standard errors are reported in Table 4. Underline score per inspector differed significantly (P<0.05) but still ranged in the optimum to acceptable score. Inspector 4 and 5 did not differ from one another but were different than inspectors 1, 2, 3 and 6. Inspectors 1, 2, 3 and 6 differed (P<0.05) from each other. These differences, although significant, were still small and likely due to subjective evaluation variations among inspectors. Average CONS ranged from 1.99 to 2.89. Inspectors 1 and 4 did not differ (P>0.05) from one another but were significantly different (P<0.05) from the other 4 inspectors. Presented in Table 5 are the gender least squares means for UDLS, CONS, BW, WW and YW. Confirmation score is the only trait that did not differ (P>0.05) among male and female animals. Description of CONS relative to phenotype is specific to each sex and therefore not compared visually against one another. However, differences for UDLS, BW, WW, and YW among male and female animals were reported. Bulls were 2.2 lbs., 23.9 lbs., and 60.2 lbs., heavier (P<0.01) for BW, WW, and YW respectively. Bulls also scored higher (P<0.01) for UDLS by 0.7. Franke and Burns (1985) also reported that sex of calf influenced (P<0.01) variation in sheath and underline score and that bulls were 8% heavier at birth and 9% heavier at weaning than heifers. Differences among bulls and heifers from these data also agree with research presented by Bures and Barton (2012) where bulls started the study at heavier weights, gained significantly faster (P<0.01), and were heavier at slaughter.

Correlation coefficients of UDLS with CONS, UDLS with BW, UDLS with WW, and UDLS with YW were 0.048, 0.128, 0.090, and 0.185, respectively (Table 6). Results in Table 6 show that UDLS is significantly correlated with CONS, BW, WW, and YW (P<0.01). However, these correlations are of low numerical value. Table 7 presents the results of the linear regression analysis for UDLS. For each increment increase in underline score, conformation score increased 0.051 (P<0.01) score, adjusted birth weight increased 0.763kg (P<0.01), adjusted weaning weight increased 5.986kg (P<0.01), and yearling weight increased 16.488kg (P<0.01).

From these results obtained in this study, it is evident that there is a significant relationship between UDLS and some relevant variation in performance traits. Franke and Burns (1985) reported that increased preweaning growth rate could result in a proportionate increase in sheath area at weaning. Other studies (Kidwell et al., 1959; Woodward et al., 1959; and Woldehawariat et al., 1977) showed little association of conformation traits with production traits. Kriese et al. (1991) reported that Brangus sheath and navel scores could be improved through artificial selection. The results in this study along with the findings of Franke and Burns (1985), McMurry and Turner (1990) and Kriese et al. (1985) indicates that placing some selection pressure on underline score is justified because of the possibility that underline soundness is associated with growth but animal health and animal welfare as well. However, it could have an effect on pre- and post-weaning growth. The significant, although low numerical correlation for BW, WW, and YW with UDLS, suggest that continued emphasis on improving naval and sheath area could be maintained with careful attention to culling bulls with poor growth traits. Franke and Burns (1985) reported similar results on the relationship of sheath area with growth traits in Brahman calves. Kriese et al. (1991) support the idea that selection could be used to improve naval and sheath area along with growth traits. Therefore, Beefmaster breeding stock with acceptable naval and sheath scores can be used in breeding programs without necessarily sacrificing economic relevant performance.

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TABLES

Table 1. Description of the data set for underline scores in Beefmaster cattle

Characteristic	Value
Calves, no.	76,972
Sires, no.	9,560
Herds, no.	23,757
Males, no.	12,863
Females, no.	64,109
Calves/sire, range	1-3039
Years of birth of calves	1976-2008
Observations / inspector, range	765 – 33,144
Birth weight observations	19,980
Weaning weight observations	36,354
Yearling weight observations	14,900

Table 2. Underline scores and their description in Beefmaster cattle[1]

	Description	
Score	**Sheath**	**Navel**
1 Excessively clean	Tight-hided overall. Lacking sheath in bulls. Displays a lack of breed character.	No evidence of naval in cows. Tight-hided overall. Displays a lack of breed character.
2 Optimum	The sheath is of moderate size and free from excess leather. The preputial opening is held tight and at a 45° angle to the body wall.	The navel in cows is evident but free from excess leather.
3 Acceptable	Leather in navel area is slightly in excess of desired amounts. The preputial opening is > 45° but < 90 angle to the body wall.	Definite evidence of naval with Leather in excess of desired amounts.
4 Marginal	Excessive loose leather in navel area. Sheath is slightly pendulous. Weak preputial opening is at a 90° angle to the body wall.	Naval is large with excessive loose leather in navel area.
5 Unacceptable	Sheath is long and pendulous. Leather in navel area and is greatly in excess of desired amounts. Prepucial opening may be large and very weak.	Leather in navel is greatly in excess of desired amounts.

[1]Source: based on Beefmaster Breeders Universal (1990) published Voluntary Classification brochure.

Table 3. Description of conformation scores in Beefmaster cattle[1]

Conformation 1	Both female and male exemplify exceptional Beefmaster breed characteristics. The male displays masculinity and strong, straight lines while the female is very feminine clean fronted and blends smooth. They are strong in their top line, are provided with great depth and width of body and are correct on their feet and legs. The udder and testicles are well developed and has ample pliable skin. These traits combined with their overall conformation place them within the parameters of a number one conformation.
Conformation 2	This male or female is lacking in overall body length and balance. They are thicker and coarser through the front end and lack depth in the hindquarters.
Conformation 3	The male is lacking in overall thickness and a masculine appearance. He needs more body capacity. The female needs to be more angular in overall appearance. She lacks balance.
Conformation 4	Both male and female are shorter in length, coarse and thick through the front end and lack body capacity. They need more breed character strength.
Conformation 5	Both male and female are plain, coarse shouldered and extremely short and round in their rump structure. They are frail in bone and foot shape and are very low volume. They lack muscling and body capacity and are very weak in breed character.

[1]Source: Based on Beefmaster Breeders Universal (1990) published Voluntary Classification brochure.

Table 4. Inspector least squares means and standard errors for underline and conformation scores

		Trait[a]	
Item	**No.**	**Underline Score**	**Conformation Score**
μ	76,972	2.389	2.312
Inspector			
1	14,433	2.6976 ± .0065[B]	2.6570 ± .0070[B]
2	33,144	2.5831 ± .0047[D]	2.1411 ± .0051[D]
3	19,306	2.6450 ± .0058[C]	2.4493 ± .0063[C]
4	765	2.8542 ± .0268[A]	2.6595 ± .0291[B]
5	1182	2.8618 ± .0216[A]	2.8934 ± .0234[A]
6	8142	2.5368 ± .0085[E]	1.9973 ± .0093[E]
SE[b]		0.0123	0.0133

[a] Underline and conformation scores range from 1 to 5
[b] Average ± standard error for least squares means across all inspectors
Columns with differing superscript letter are different ($P<0.05$).

Table 5. Gender least squares means and standard errors for underline and conformation scores and growth traits

		Trait[a]				
Item	**No.**	**UDLS**	**CONS**	**BW**	**WW**	**YW**
No.		49,577	49,577	19,980	36,354	14,900
μ		2.3	2.3	33.6	251.1	349.5
Gender						
Female	64,109	2.3[B]	2.4[A]	33.5[B]	245.6[B]	336.4[B]
Male	12,863	3.0[A]	2.4[A]	35.8[A]	269.6[A]	396.6[A]
SE[b]		0.0073	0.0079	0.2899	1.1287	2.5233

[a] UDLS= Underline Score (1-5), CONS = Conformation Score (1-5), BW = Birth Weight, WW = Weaning Weight, YW = Yearling Weight

[b] Average standard error for least squares inspector associated with each row

Columns with differing superscript letter are different (P<0.01)

Table 6. Correlation Coefficients in Beefmaster Cattle – 1979-2007

	Sex	Age	Dam age	Inspector	CONS	UDLS	BW	WW	YW
Sex	1.000	-0.158*	0.003	-0.011**	0.025*	0.336*	0.220*	0.248*	0.454*
Age		1.000	0.008***	-0.041*	-0.056*	-0.068*	-0.059*	-0.009	-0.032*
Dam age			1.000	-0.006	0.026*	-0.004	0.039*	0.096*	0.037*
Inspector				1.000	-0.110*	-0.029*	0.010	0.029*	0.001
CONS					1.000	0.048*	0.006	-0.169*	-0.200*
UDLS						1.000	0.128*	0.090*	0.185*
BW							1.000	0.167*	0.197*
WW								1.000	0.616*
YW									1.000

*P = < .001
**P = < .003
***P = <.05
Abbreviations
Sex = Gender
Age = Age at Inspection
Dam age = Age of Dam
CONS = Conformation Score
UDLS = Underline Score
BW = Birth weight
WW = Weaning weight
YW = Yearling weight

Table 7. Linear Regression of Underline scores with conformation scores and growth traits

		Independent Variable: Underline			
Trait[a]	**Intercept**	**Slope**	**R^2**	**F Value**	**P<**
CONS	2.190	0.051	.021	179.78 `	<0.01
BW	71.12	0.763	.016	332.62	<0.01
WW	531.003	5.986	.008	299.54	<0.01
YW	701.89	16.488	.034	530.45	<0.01
DA	1997.68	-4.76	0.0	1.24	0.26
INSP	999.92	-34.27	.004	353.55	<0.01

[a]CONS = Conformation Score (1-5), BW = Birth Weight, WW = Weaning Weight, YW = Yearling Weight, DA = Age of dam, INSP = Age at inspection

FIGURES

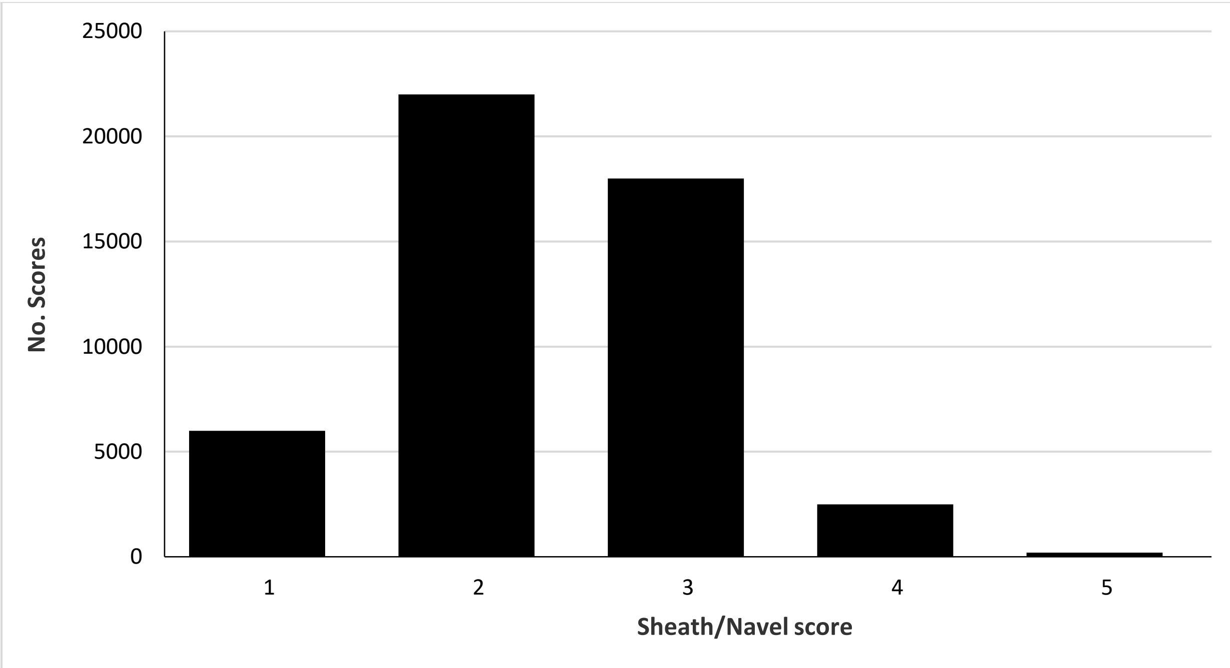

Figure 1. Frequency of Sheath and Navel scores in Beefmaster cattle with birth years 1979 through 2007

CHAPTER IV

DIRECT ADDITIVE, ENVIRONMENTAL, AND PHENOTYPIC VARIANCES AND COVARIANCES AND COEFFICIENTS AND COEFFICIENTS OF HERITABILITY FOR UNDERLINE SCORE IN BEEFMASTER CATTLE

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ABSTRACT

The objective of this study was to determine estimates of heritability for underline score (**UDLS**), genetic, environmental, and phenotypic correlations (r_g, r_e, r_p, respectively) of UDLS with conformation score (**CONS**), birth weight (**BRWT**), weaning weight (**WNWT**), and yearling weight (**YRWT**) in Beefmaster cattle born between 1976 through 2008. Records provided by Beefmaster Breeders United (n = 49,533) for UDLS and CONS and BRWT (n = 10,698), WNWT (n = 22,503), and YRWT (n = 8,316) were studied. Data were analyzed using single- or 2-trait animal models with DFREML and DMU. The mixed model included fixed contemporary group effects constructed using herd, birth year, and sex information. Age of dam and animal age at inspection were included as covariates. Coefficients of heritability were 0.44 ± 0.01, 0.43 ± 0.01, 0.75 ± 0.04, 0.60 ± 0.02, and 0.85 ± 0.06 for UDLS, CONS, BRWT, WNWT and YRWT, respectively from the single-trait analyses. From the 2-trait analyses, coefficients of heritability for UDLS with CONS, BRWT, WNWT, and YRWT were 0.43 ± 0.01, 0.35 ± 0.05, 0.39 ± 0.03, and 0.40 ± 0.06, respectively. Coefficient of r_g for UDLS with CONS was -0.16 ± 0.02, UDLS with BRWT was 0.02 ± 0.07, ULDS with WNWT was 0.05 ± 0.04, UDLS with YRWT was 0.13 ± 0.08 from the 2-trait analyses. Mean EBV of UDLS was 0.00 ± 0.40. These results suggest that artificial selection for UDLS would be effective in beef breeding programs.

Key words: Underline score, heritability, genetic correlation

INTRODUCTION

Breed associations and consequently breeders are continuously trying to identify and develop new polygenic traits. The purpose of new trait development is to provide a more complete description of seedstock for artificial selection. How much emphasis to place on conformation traits in selection programs has been, and continues to be, controversial. Earlier studies (Kidwell et al., 1959; Woodward et al., 1959; and Woldehawariat et al., 1977) suggested little association of conformation traits with production traits. Franke and Burns (1985) reported that increased preweaning growth rate or WNWT could result in a proportionate increase in sheath area at weaning. In a more recent experiment, Kriese et al. (1991) reported that Brangus sheath and navel scores could be improved through artificial selection. Placing some selection pressure on underline score is justified because of the possibility that underline soundness is associated with growth and reproduction but animal health and animal welfare as well. Also, too little skin in the underline area may result in the loss of breed character (Kriese et al., 1991). The impetus for genetic improvement of underline soundness likely results from the cattle industry discriminating against long pendulous sheaths on bulls because of the associated propensity for injury (Franke and Burns, 1985) and because offspring of such bulls are often the target of discrimination in the market place (Troxel and Barham, 2012). Many producers also believe that bulls with extremely long sheaths lack the physical control for intromission during natural mating (Franke and Burns, 1985). Therefore, seedstock with large pendulous sheaths or deep naval flaps that are moderately heritable have the potential to produce progeny with unacceptable underlines. Selection programs should include evaluation of both heifers and bulls for underline soundness. The Beefmaster Breeders United (BBU) has a classification system to describe variation in underline characteristics. Critical to artificial selection are reliable heritabilities for and genetic correlations between relevant polygenic traits. Thus, the objectives of this study were to estimate heritabilities for and genetic correlations between underline score, conformation score, birth weight, weaning weight, and yearling weight in Beefmaster cattle born between 1979 and 2007.

MATERIALS AND METHODS

This study used data from an existing database and required no Animal Care and Use Committee approval. Field data (n = 92,818) were provided by Beefmaster Breeders United (**BBU**), San Antonio, TX. Data were primarily records for birth weight (**BRWT**), weaning weight (**WNWT**), yearling weight (**YRWT**), conformation score (**CONS**), underline score (**UDLS**), and a limited amount of ultrasound carcass data. In 1979, BBU began voluntarily reporting observations for UDLS. Because the evaluation and reporting of phenotype for underlines by individual breeders was voluntary, there was high selection intensity for UDLS and consequently for other traits reported which resulted in considerable variation in the number of ranches and farms, animals, and years represented. Data were obtained by individual seedstock breeders and sent for central processing at BBU offices. Both UDLS and CONS were determined for each animal by a trained evaluator/classifier approved by BBU. Underlines for both bulls and heifers were evaluated/classified on a scale of 1 through 5 with 1 = excessively clean, 2 = optimum, 3 = acceptable, 4 = marginal, and 5 = unacceptable. Presented in Table 1 are the underline scores and the description of the phenotype for each score. This scoring system was similar to that described for Brangus Cattle by Kriese et al. (1991). Conformation scores were from 1 through 5 with 1 being most desirable relative to type. In Table 2 are CONS and the description of the phenotype for each score. In Figure 1 are the frequencies of UDLS in Beefmaster cattle with birth year 1979 through 2007. Of the 5 UDLS, optimal and acceptable descriptions were more frequently observed when compared to cattle with the other 3 scores, and fewer cattle scored undesirable in comparison with cattle with the other 4 scores.

Available for analyses after editing were records for UDLS and CONS (n = 49,577 for each), BRWT (n = 10,618), WNWT (n = 22,503), and YRWT (n = 8,316). A distribution of observations for UDLS is presented in Figure 2. The largest annual recordings of ULDS occurred in 1986 through 2007. These records represented bulls and heifers of 6,348 BBU breeders. Coefficients of heritability and genetic, environmental and phenotype correlations were estimated using an animal model and single- or multiple-trait **DFREML** (Boldman and Van Vleck, 1991; Boldman et al., 1993) and DMU (Madsen and Jensen, 2013). Fixed effects of classifier or inspector and contemporary group generated as herd, birth year, and sex were included in the mixed model. Age of dam and age of animal at inspection were included as fixed covariates. Random effects were animal and residual. Pedigrees of 80,583 animals were included in the additive relationship matrix. The total, minimum, and maximum numbers of contemporary groups for each trait is presented in Table 3. Phenotypic correlations were estimated using animal additive genetic and residual variance components computed using REML (Boldman et al., 1993). Standard errors of variance components are obtained as square roots of the inverse of the information matrix. Standard errors of heritabilities and correlations were estimated using a Taylor series approximation. Breeding values were estimated according to procedures in DMU5 (Madsen and Jensen, 2010). Breeding values in a mixed animal model are given by the predictions of random animal effects.

RESULTS AND DISCUSSION

Direct additive, environmental, and phenotypic variances and coefficients of heritability for UDLS, CONS, BRWT, WNWT, and YRWT in Beefmaster cattle with birth years 1979 through 2007 from the single-trait analyses are shown in Table 4. Trait CONS had smaller estimates of additive, environmental, and phenotypic variances than UDLS. Considering the 3 growth traits in the single-trait analyses, YRWT had the greatest additive variance, and the environmental variance was greater for WNWT. Of the 3 growth traits, BRWT had the smallest estimates of additive, environmental, and phenotypic variance. The additive proportion of the total variance for growth was greater than the environmental proportion of the total variance.

Coefficients of heritability were 0.44 ± 0.01, 0.43 ± 0.01, 0.75 ± 0.04, 0.60 ± 0.02, and 0.85 ± 0.06 for UDLS, CONS, BRWT, WNWT, and YRWT, respectively from the single-trait analyses.

In general, coefficients of heritability for UDLS, CONS, BRWT, WNWT, and YRWT, were similar from the single- and 2-trait analyses because estimates of covariances between UDLS and the other 4 traits were all near zero (Table 5). Thus, information from one trait had little to no effect on the estimation of the heritability of another trait. Estimates of heritability from the 2-trait analyses in Table 5 of UDLS with CONS, UDLS with BRWT, UDLS with WNWT, and UDLS with YRWT were 0.43 ± 0.01, 0.35 ± 0.05, 0.39 ± 0.03, and 0.40 ± 0.06, respectively. Coefficients of heritability of UDLS in these data are in agreement with estimate of heritability of sheath and naval score in Beefmaster cattle reported by Franke and Burns, 1985. The coefficients of heritability determined from these data for UDLS of Beefmaster cattle is greater than the estimates of sheath (0.20) and naval scores (0.24) in the Brahman influenced breed of Brangus (Kriese et al., 1988). There is a paucity of data on heritability of CONS in beef cattle. Shelby et al., (1955) reported that no estimates of heritability were available for CONS. However, some type traits are indicative of CONS. In these data, from the single-trait analysis, a coefficient of heritability for CONS was 0.43 ± 0.01. From the 2-trait analysis of these data, a coefficient of heritability of 0.44 ± 0.01 was found for CONS. Although less than the coefficient found in these data, a coefficient of heritability (0.25) averaged over 9 type traits was reported for beef cattle using 12 breeds in the Czech Republic (Veselá et al., 2006). A greater coefficient of heritability than the 0.44 ± 0.01 in these data was found for a subjective visual weaning type score of 0.50 in an Angus herd, from a parent offspring regression (Kroger and Knox, 1952). However, a coefficient of heritability of 0.30 was found by Kroger and Knox (1952) for the same subjective visual weaning type score. Knapp and Clark (1950) reported a coefficient of heritability for a subjective visual weaning score of 0.28. In Charolais cattle in Spain, El-Saied et al., (2006) found a direct heritability estimate of 0.52 for the conformation trait of general appearance. In a study of beef type characteristics, Christian et al. (1965) found average estimates of heritability across these traits of 0.88 and 0.73 using identical and fraternal twins' data, respectively.

Estimates of heritability for growth traits in these data from the single- and 2-trait analyses are high. Other researchers have found high coefficients of heritability for BRWT in beef cattle. The coefficients of heritability of 0.75 for BRWT in these data for Beefmaster cattle are in agreement with those of other workers: Andries et al. (1994) reported 0.87 in crosses of Angus, Brahman, Charolais, and Hereford; Brown et al. (1990) reported 0.68 in Hereford; and Mackinnon et al. (1991) reported 0.61 in Zebu crosses. Coefficients of heritability for BRWT obtained in these data are greater than those reported by Bourdon (2000) of 0.40 across breeds, by Kriese et al. (1991) of 0.22, 0.34, 0.37, and 0.28 in Beefmaster, Santa Gertrudis, Brahman, and Brangus, respectively; by Brown et al. (1990) reported 0.42 in Angus, El-Saied et al. (2006) 0.36 in Charolais; Norris et al. (2004) of 0.36 in Nguni; by van Niekerk and Neser (2006) of 0.09 in Limousin; and BIF (2016) of 0.14 in Beefmaster. The coefficient of heritability of 0.60 for WNWT in these data is in agreement with those reported by other researchers: Kriese et al. (1991) of 0.72 in Beefmaster and 0.63 in Brahman; Brown et al. (1990) of 0.66 in Hereford; and Lopes et al. (2013) of 0.61 in Polled Nellore. The coefficient of heritability of 0.60 for WNWT was greater than coefficients of heritability reported by other workers: Bourdon (2000), 0.40 across breeds; Kriese et al. (1991), 0.44 in Santa Gertrudis and 0.48 in Brangus. Likewise Andries et al. (1994) reported 0.48 in crosses of Angus, Brahman, Charolais, and Hereford; Mackinnon et al. (1991), 0.20 in crossbreeds; van Niekerk and Neser (2006), 0.19 in Limousin; El-Saied et al. (2006), 0.36 in Charolais; Norris et al. (2004), 0.29 in Nguni; and BIF (2016), 0.18 in Beefmaster cattle. The coefficient of heritability of 0.85 for YRWT found in these data for Beefmaster cattle is in agreement with the estimate of 0.72 in Polled Nellore cattle (Lopes et al., 2013). These data are not in agreement with heritability estimates of 0.40

reported by Bourdon (2000) across breed, 0.25 reported by Mackinnon et al. (1991) for *Bos indicus* crossbreds, 0.16 by van Niekerk and Neser (2006) for Limousin, and 0.75 reported by Norris et al. (2004) in Nguni cattle.

In general, growth traits are quite heritable; however, coefficients of heritability for all traits in these data are greater than those reported for Beefmaster and other Brahman-derivative breeds. It is not clear as to why estimates of heritability for traits in these data are greater than those previously reported. The following comments may provide some clarity as to why estimates for growth traits in these data are high in comparison to those previously reported. First, these data represent a highly selected population. Breeder discretion resulted in high selection intensity for UDLS which means that breeders were very careful in selecting only the best for evaluation of UDLS, resulting in high aggregate breeding value for UDLS, CONS, BRWT, WNWT, and YRWT. Secondly, the approach to the analysis of data is generally an acceptable one. The use of contemporary groups and mathematical adjustment of records resulted in a lower environmental variance, which subsequently increased heritability estimates. The small SE of the estimates are indicative of precision of the estimates (Falconer and Mackay, 1996). Third, there were good genetic ties across contemporary groups. Finally, heritability is not fixed; it varies from population to population and environment to environment (Bourdon, 2000).

The coefficients of genetic correlation of UDLS with CONS, UDLS with BRWT, UDLS with WNWT, and UDLS with YRWT were -0.16 $\pm$ 0.02, 0.02 $\pm$ 0.07, 0.05 $\pm$ 0.04, and 0.13 $\pm$ 0.08, respectively (Table 5). The genetic correlation of UDLS with CONS was small and negative indicating that some genes influencing the expression of UDLS and CONS work in the opposite direction. As the expression of UDLS increased, the expression in CONS decreased. This relationship may be the result of the scale for scoring these traits, in that 1 is the better CONS and 5 is the poorer UDLS. The genetic correlations between UDLS and the growth traits of BRWT, WNWT, and YRWT were small and positive indicating that a few of the genes that influence the expression of these growth traits also influenced the expression of UDLS. The genetic correlations found in these data between UDLS and CONS are smaller than the genetic correlations between general appearance type score and muscularity (0.88) score and skeletal size score (0.86) in Charolais cattle. The genetic correlation coefficients between general appearance type score with BRWT and WNWT were 0.09 and 0.47, respectively, in Charolais cattle. The coefficient of genetic correlation between BRWT and WNWT reported by Abdullah and Olutogun (2006) was 0.53. Andries et al., (1994) found that the genetic correlation between BRWT and WNWT was 0.79.

In Table 6 are the estimates of environmental variances and covariances and environmental correlations for UDLS with CONS, BRWT, WNWT, and YRWT in Beefmaster cattle with birth years 1979 through 2007 from the 2-trait analyses. Estimates of environmental correlation were -0.03 $\pm$ 0.02, 0.10 $\pm$ 0.07, 0.04 $\pm$ 0.03, and -0.06 $\pm$ 0.13 for UDLS with CONS, UDLS with BRWT, UDLS with WNWT, and UDLS with YRWT, respectively, from the 2-trait analyses. Of the 3 growth traits, WNWT had the highest estimate of environmental variance (2326.02), followed by YRWT (1450.35) and BRWT (20.20) from the 2-trait analysis. From the 2-trait analyses, environmental variances were similar among the 3 growth traits of BRWT (0.33), WNWT (0.32), and YRWT (0.32) and similar to those of UDLS (0.31) as a second trait and CONS (0.27) as a first trait. Environmental variances are not often reported but given that the estimates of heritability reported here are greater than some reported in the literature, reporting them here seems appropriate. When heritability is estimated as a ratio of variances, reducing environmental variance increases the estimate of heritability.

Estimates of phenotypic variances, covariances and phenotypic correlations from the 2-trait analyses for UDLS, CONS, BRWT, WNWT, and YRWT in Beefmaster cattle with birth years 1979 through 2007 are presented in Table 7. From the 2-trait analyses, the estimate of phenotypic variance for the 3 growth traits was highest for YRWT (9,791.80) followed by WNWT (5,874.80) and then BRWT (81.94), and estimates of UDLS with CONS, BRWT, WNWT, and YRWT varied from 0.51 through 0.55. The phenotypic correlations between UDLS and CONS was low and negative (-0.08 ± 0.01). This negative correlation indicated that as UDLS increases, CONS decreases and vice versa. Again, this is the result of the scale of scores used in the evaluation of these traits. El-Saied et al. (2006) reported coefficients of phenotypic correlation of 0.10 between muscle score and BRWT, 0.60 between muscle score and WNWT, 0.11 of skeletal size score and BRWT, 0.55 between skeletal score and WNWT, 0.85 between skeletal size score and muscularity score, of 0.04 between BRWT and general appearance type score, 0.45 between general appearance type score and WNWT, 0.78 between general appearance type score and muscularity score, and 0.77 between general appearance type score and skeletal size score in Charolais cattle. The coefficients of phenotypic correlation are in agreement with coefficient of phenotypic correlation found in these data. Andries et al. (1994) found coefficients of phenotypic correlation between BRWT and WNWT of 0.50.

The distribution of estimated breeding values (**EBV**) for UDLS is presented in Figure 3. Mean EBV for UDLS was 0.00 ± 0.04. The EBV for UDLS varied from -1.1 through 1.1. Based on these EBV for UDLS, UDLS can be changed through the use of artificial selection. Selection for UDLS should be based on the desired directional change relative to the breeding objective of each producer. Additionally, from the results obtained in this study, it is evident that UDLS accounted for very little variation in pre- and postweaning growth traits. The relatively low order of the genetic and phenotypic correlations in this study indicate that selection for improved UDLS could be practiced independent of selection for CONS, BRWT, WNWT, and YRWT. Selection practiced for increased growth traits should not result in proportionate increase in UDLS. Selection could be emphasized for growth traits along with some emphasis on UDLS. Because of the prepotency to injury as a result of large sheaths, selective attention to underlines of males selected at weaning or yearling age could improve problems associated with natural mating without reducing significantly selection for growth traits. Estimated breeding values do not predict performance per se, and because EBV is used primarily in artificial selection, it is the differences in EBV that are informative.

IMPLICATIONS

Underline traits can be improved through artificial selection because these data clearly show that this trait is highly heritable. The genetic association of UDLS and CONS suggest that producers should consider both traits in selection. These data also show that there are limited environmental effects for UDLS. Estimates of genetic and phenotypic correlations between UDLS and CONS, BRWT, WNWT, and YRWT were low enough that sound selection should overcome any expected detriment to growth traits as underline scores are improved. Regardless of the breeder's objectives, one can improve the offspring of undesirable cattle that are subject to injury and market discrimination.

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TABLES

Table 1. Sheath and Navel scores and their description in Beefmaster cattle[1]

Score	Description: Sheath	Description: Navel
1 Excessively clean	Tight-hided overall. Lacking sheath in bulls. Displays a lack of breed character.	No evidence of navel in cows. Tight-hided overall. Displays a lack of breed character.
2 Optimum	The sheath is of moderate size and free from excess leather. The preputial opening is held tight and at a 45° angle to the body wall.	The navel in cows is evident but free from excess leather.
3 Acceptable	Leather in navel area is slightly in excess of desired mounts. The preputial opening is > 45° but < 90° to the body wall.	Definite evidence of navel with leather in excess of desired amounts.
4 Marginal	Excessive loose leather in navel area. Sheath is slightly pendulous. Weak preputial opening is at a 90° angle to the body wall.	Navel is large with excessive loose leather in navel area.
5 Unacceptable	Sheath is long and pendulous. Leather in navel area and is greatly in excess of desired amounts. Preputial opening may be large and very weak.	Leather in navel is greatly in excess of desired amounts.

[1]Source: based on Beefmaster Breeders Universal (1990) published Voluntary Classification brochure.

Table 2. Description of conformation scores in Beefmaster cattle[1]

Conformation 1	Both female and male exemplify exceptional Beefmaster breed characteristics. The male displays masculinity and strong, straight lines, and the female is very feminine, clean fronted and blends smooth. They are strong in their top line, are provided with great depth and width of body, and are correct on their feet and legs. The udder and testicles are well developed and have ample pliable skin. These traits combined with their overall conformation place them within the parameters of a number 1 conformation.
Conformation 2	This male or female is lacking in overall body length and balance. They are thicker and coarser through the front end and lack depth in the hindquarters.
Conformation 3	The male is lacking in overall thickness and a masculine appearance. He needs more body capacity. The female needs to be more angular in overall appearance. She lacks balance.
Conformation 4	Both male and female are shorter in length, coarse and thick through the front end and lack body capacity. They need more breed character strength.
Conformation 5	Both male and female are plain, coarse shouldered and extremely short and round in their rump structure. They are frail in bone and foot shape and are very low volume. They lack muscling and body capacity and are very weak in breed character.

[1]Source: based on Beefmaster Breeders Universal (1990) published Voluntary Classification brochure.

Table 3. Total, minimum, and maximum numbers of animal records in contemporary groups by trait studied in Beefmaster cattle with birth years 1979 through 2007

		Contemporary Groups	
Trait	Total	Minimum	Maximum
Underline score	10,836	2	45
Conformation score	10,836	2	45
Birth weight	2,467	2	15
Weaning weight	5,398	2	20
Yearling weight	1,701	2	11

Table 4. Estimates of direct additive, environmental, and phenotypic variances, and coefficients of heritabilities for underline score, conformation score, birth weight, weaning weight and yearling weight in Beefmaster cattle with birth years 1979 through 2007 from the single-trait analyses

	Estimates of variances			
Performance Traits	Additive	Environmental	Phenotypic	Coefficient of heritability
Underline score	0.24	0.31	0.55	0.44 ± 0.01
Conformation score	0.21	0.27	0.49	0.43 ± 0.01
Birth weight	61.74	20.20	81.94	0.75 ± 0.04
Weaning weight	3,550.63	2,324.62	5,875.25	0.60 ± 0.02
Yearling weight	8,352.19	1,441.12	9,793.31	0.85 ± 0.06

Table 5. Estimates of direct genetic variances and covariances, genetic correlations, and heritability for underline score, conformation score, birth weight, weaning weight, and yearling weight in Beefmaster Cattle with birth years 1979 through 2007 from the 2-trait analyses

		Genetic estimate					
Trait 1	Trait 2	Variance trait 1	Variance trait 2	Covariance	Genetic correlation	Heritability trait 1	Heritability trait 2
Conformation Score	Underline Score	0.22	0.24	-0.04	-0.16 ± 0.02	0.44 ± 0.01	0.43 ± 0.01
Birth Weight	Underline Score	61.74	0.18	0.06	0.02 ± 0.07	0.75 ± 0.04	0.35 ± 0.05
Weaning Weight	Underline Score	3,548.78	0.20	1.24	0.05 ± 0.04	0.60 ± 0.02	0.39 ± 0.03
Yearling Weight	Underline Score	8,341.46	0.21	5.26	0.13 ± 0.08	0.85 ± 0.06	0.40 ± 0.06

Table 6. Estimates of direct environmental variances and covariances and environmental correlations for underline score, conformation score, birth weight, weaning weight, and yearling weight in Beefmaster Cattle with birth years 1979 through 2007 from the 2-trait analyses

Trait 1	Trait 2	Environmental estimates: Variance trait 1	Variance trait 2	Covariance	Environmental correlation
Conformation Score	Underline Score	0.27	0.31	-0.01	-0.03 ± 0.02
Birth Weight	Underline Score	20.20	0.33	0.26	0.10 ± 0.07
Weaning Weight	Underline Score	2,326.02	0.32	1.10	0.04 ± 0.03
Yearling Weight	Underline Score	1,450.35	0.32	-1.36	-0.06 ± 0.13

Table 7. Estimates of direct phenotype variance and covariances and phenotype correlation for underline score, conformation score, birth weight, weaning weight, and yearling weight in Beefmaster Cattle with birth years 1979 through 2007 from the 2-trait analyses

Trait 1	Trait 2	Variance trait 1	Variance trait 2	Covariance	Correlation
Conformation Score	Underline Score	0.49	0.55	-0.04	-0.08 ± 0.01
Birth Weight	Underline Score	81.94	0.51	0.32	0.05 ± 0.01
Weaning Weight	Underline Score	5,874.80	0.52	2.34	0.04 ± 0.00
Yearling Weight	Underline Score	9,791.80	0.53	3.90	0.06 ± 0.02

FIGURES

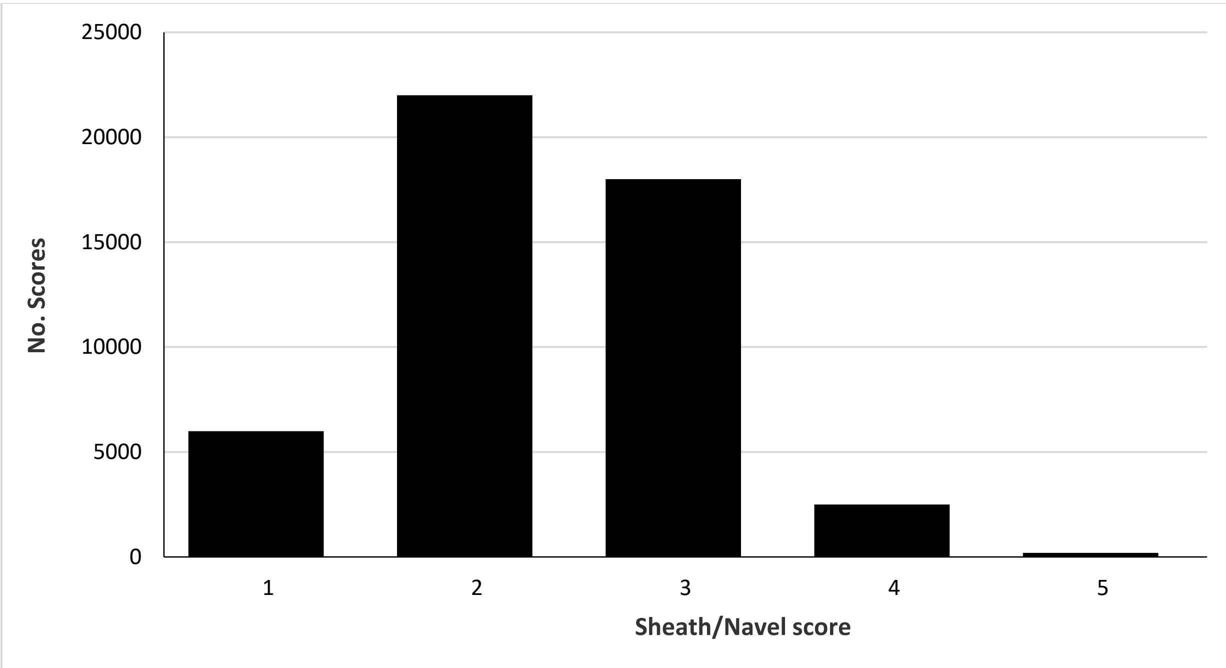

Figure 1. Frequency of sheath and navel scores in Beefmaster cattle with birth years 1979 through 2007

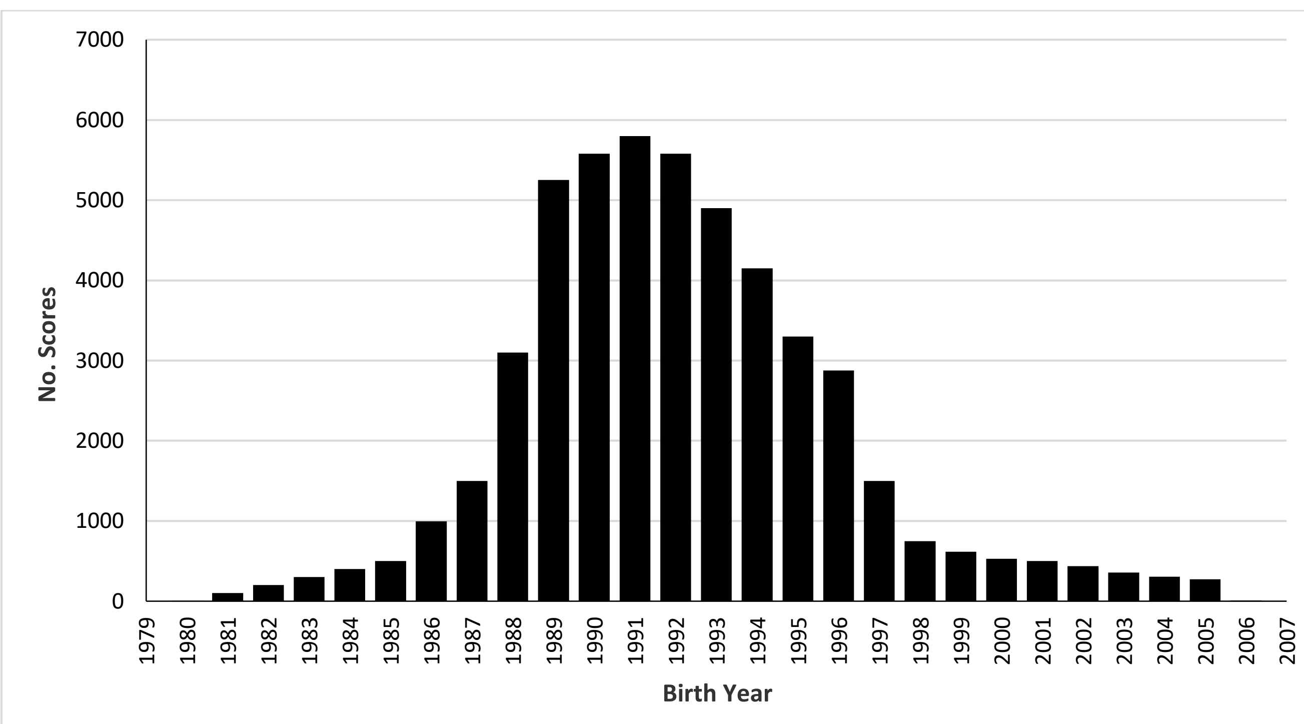

Figure 2. Distribution of sheath and navel scores by birth year in Beefmaster cattle with birth years 1979 through 2007

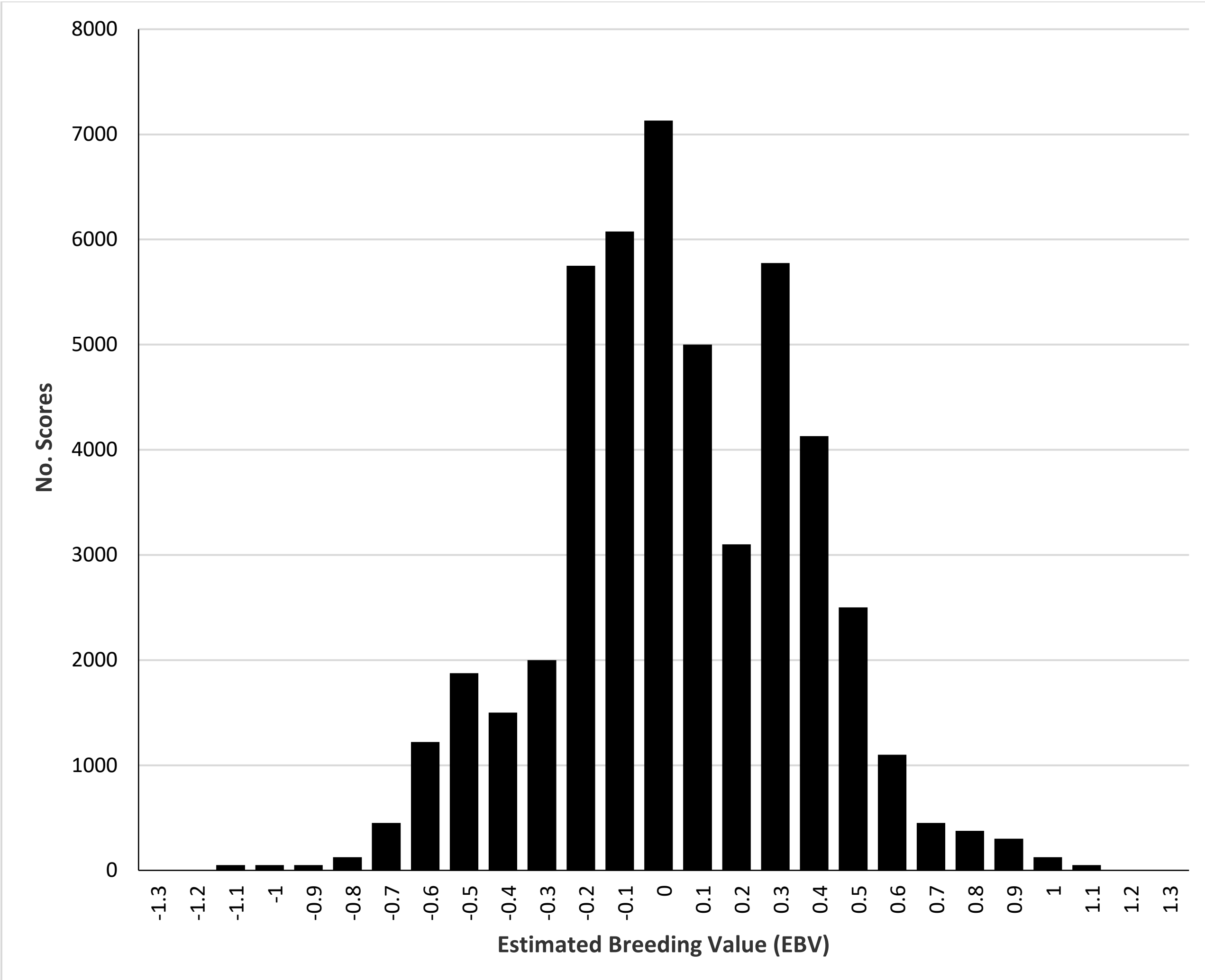

Figure 3. Distribution of estimated breeding values (EBVs) for underline score (UDLS). Mean EBV ± SE for UDLS = 0.00 ± 0.4

CHAPTER V

CONCLUSION

Numeric scoring systems have been used for many years as a means of perfecting selection decisions. The numerous scoring systems most commonly used to assign value to the phenotypic expression observed in type traits will remain relevant in the beef cattle industry. The question arises whether there is an associated performance level related to these numeric scores. This could help add a powerful management tools to the cattleman's arsenal. Results obtained in this study show a significant relationship between UDLS and some relevant variation in performance traits. The results in this study indicate that placing some selection pressure on underline score is justified because of the possibility that underline soundness is associated with growth and perhaps animal health and animal welfare as well. It is also clear that underline traits can be improved through artificial selection because results from this study indicate that this trait is moderate to highly heritable. The genetic association of UDLS and CONS suggest that producers should consider both traits in selection. This study also shows that there are limited environmental effects for UDLS. Estimates of genetic and phenotypic correlations between UDLS and CONS, BRWT, WNWT and YRWT were low enough that sound selection should overcome any expected detriment to growth traits as underline scores are improved. Regardless of the breeder's objectives, one can improve the offspring of undesirable cattle that are subject to injury and market discrimination. Brahman and Brahman-derivative cattle, such as Brangus, Beefmaster and Santa Gertrudis, are important beef cattle breeds in the southern and tropical regions of the United States. These cattle are heat- and disease resistant and have become fixtures in the U.S. beef cattle industry. Beefmaster breeding stock with acceptable naval and sheath scores can be used in breeding programs without necessarily sacrificing economic relevant performance.