INFLUENCE OF BULL TRAITS AND BULL TO FEMALE RATIO ON

REPRODUCTIVE PERFORMANCE IN BEEF FEMALES AND OF

NUTRITION DURING GESTATION ON CALVING DIFFICULTY

IN PRIMIPAROUS BEEF FEMALES

A Thesis

by

BLAKE DAVID BLOOMBERG

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2010

Major Subject: Physiology of Reproduction

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Approved by:

Chair of Committee,	David Forrest
Committee Members,	Chris Skaggs
	Chris Boleman
Head of Department,	Gary Acuff

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ABSTRACT

Influence of Bull Traits and Bull to Female Ratio on Reproductive Performance in

Beef Females and of Nutrition During Gestation on Calving Difficulty

in Primiparous Beef Females.

(May 2010)

Blake David Bloomberg, B.S., Texas A&M University

Chair of Advisory Committee: Dr. David W Forrest

The current study involved two experiments that were conducted at the Texas A&M AgriLife Research and Extension Center in Uvalde, TX (semi-arid environment) from 2006 to 2008. In experiment one, Bonsmara bulls (n = 39; 20-24 mo of age) were joined with multiparous Bonsmara and Bonsmara-influenced females (n = 1013) during a 90-day breeding season in 2006, 2007, and 2008 to quantify the effects of a reduction in bull to female ratio on reproductive performance. Bulls were also placed with primiparous beef females (n = 142). Bulls were allotted by selected physical traits, social rank, serving capacity, and seminal traits to one of two bull to female (BFR) treatments: Low (1:30-1:45; n = 10 pastures) or Conventional (1:16-1:26; n = 12 pastures) BFR. Pregnancy rate (P = 0.36), calving date (P = 0.24), and calving rate (P = 0.25) did not differ between Conventional and Low BFR treatments. The current experiment demonstrates that Low BFR can be utilized in breeding pastures of up to 2,090 ha without negatively affecting reproductive performance.

In experiment two, Bonsmara heifers (3/4, 7/8, and full bloods) were exposed to Bonsmara bulls from April 15 to July 15 during each of the two years. Heifers were weighed, rectally palpated for pregnancy, and scored for BCS (1 thin – 9 fat) and frame score (1 short – 9 tall) in December (end of second trimester) during years 1 and 2. Heifers were stratified on expected calving date and randomly allotted to one of two levels of nutrition for the remainder of gestation. In year 1, heifers were allotted to range forage (n=31, low nutrition, LN) or to non-irrigated oat pasture (n=31, high nutrition, HN). In year 2, heifers were placed onto the same range environment as in year 1 (n=31, LN) or onto irrigated ryegrass pasture (n=31,HN). Heifers in the LN groups were supplemented with 20% CP cubes at the rate of 0.9 kg/heifer/day from January 2 until calving while HN heifers were not supplemented. Within 4 hr of birth, calves were weighed, and calf vigor and calving difficulty scores were recorded. Heifers were weighed within 72 hours of parturition.

From treatment initiation through calving, HN heifers gained 48.6 kg whereas the LN females lost 15 kg. Twice as many HN heifers required major assistance at calving as compared to LN heifers. Calves born to the HN females weighed 3.7 kg more at birth than those born to LN females. These differences resulted in HN heifers having ($P = 0.005$) more calving difficulty than LN heifers (mean calving difficutly of 2.3 for HN and 1.6 for LN). The calves of the HN females were also less vigorous ($P = 0.005$) after birth than the calves from LN females (calf vigor score of 2.2 for HN and 3.3 for LN). Consequently, the level of nutrition during the third trimester of gestation can affect calving difficulty, calf vigor, and female weight.

DEDICATION

This thesis is dedicated to several people. First of all, I would like to dedicate this thesis to my parents, James and Mary Bloomberg. They have made countless sacrifices for me throughout my life and without them I would not be the person that I am today. I would also like to dedicate this to my grandparents David and Editha Ray who are two of the most influential people that I know. I would also like to dedicate this to my biggest supporter and best friend, my lovely and talented wife, Wravenna. In addition, I would like to thank two men who showed me the true meaning of being an Aggie and belonging to Texas A&M, who always gave me great advice and steadfast leadership, and who I'm honored to call my friends: Dr. Chris Skaggs and Mr. Paul Maulsby.

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I must also thank my family and am especially indebted to my wonderful parents, James and Mary Bloomberg, who showed me that with hard work anything is possible. I am also grateful to my wife, Wravenna, who supported me in my quest to complete my advanced degree. Thank you to my siblings, Jamie and Jake, who are always there to listen and share their thoughts along the way. Words cannot express the appreciation that I have for my grandparents, David and Editha Ray, who have supported me no matter what throughout my life.

Dr. Chris Skaggs has served as a mentor to me throughout my time at Texas A&M and was always there to push and to guide me in the right direction. He defines true class and gave me a wonderful opportunity to work with some of the best young

livestock judges in the country. I will forever be grateful to you for the opportunities that you have given me.

I would also like to thank the 39 members of the three judging teams that I coached while at Texas A&M. Much of my time has been spent focused on coaching the livestock judging team. Your dedication, hard work, and character will not soon be forgotten. Because of you, I hope to continue to coach and educate young people. You truly were the best and I am grateful to each of you for believing in our team and myself.

Mr. Dan Hoge and Mr. Paul Maulsby deserve a huge thanks for their encouragement in my academic development as well.

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CHAPTER I

INTRODUCTION

Still, after many years, the beef cattle industry remains under constant economic

pressures. Beef cattle producers still strive to become as efficient as possible in the

production of consistent and quality product. The cattle industry continues to expand

across the world which is causing an extremely competitive market which heightens the

necessity for beef production efficiency. In the United States beef cattle industry today,

greater than 95% of the pregnancies achieved each year are a result of natural mating

(Godfrey and Lunstra, 1989).

Herd sire selection is one of the most important decisions that any beef cattle

producer makes for their cowherd. Bulls contribute half of the genetic material for the

cow herd. If replacement heifers are selected from within the herd, the bull will

influence the production of the herd for up to 10 years or more. Not only does selection

of a bull affect reproductive performance, but it also affects profitability of a cowherd.

Although a bull's physical attributes and performance records are significant, perhaps

the most important characteristic to select a potential herd sire is his ability to

impregnate a female. This can sometimes be a challenge because a breeding soundness

exam (BSE) does in fact give some indication of male fertility in relation to semen

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This thesis follows the style and form of the Journal of Animal Science.

quality and overall reproductive soundness, but does not guarantee that a bull is actually capable of serving a female.

According to Russell (1985) reproduction (production of a calf) in beef cattle has long been regarded as a lowly heritable trait and thus, it is not expected to respond rapidly to direct selection. However, there are several tools available to producers to aid them in selection for improved fertility. Russell (1985) further states that even with the low estimated heritability of reproduction, many producers and researchers have been cautious about allowing non-pregnant cows to remain in the herd. Reasons given for this reluctance have largely been economic; however, concerns about the genetic impact of such decisions have frequently been voiced. Under situations in which keeping a non-pregnant cow could be justified economically, what effect would this have on the genetic composition of the herd? This study will examine the influence of bull traits and bull to female ratio on reproductive performance in beef females and of nutrition during gestation on calving difficulty in primiparous beef females.

The cost of bulls per kilogram of calf produced greatly affects profitability of commercial cattle operations. The number of bulls that a producer buys affects the total cost. In addition, in multi-sire herds, fertility level, serving capacity, social dominance rank, and the expense of the bull impacts bull cost per calf. Usually, the traditional bull to female ratio is 1:20-1:30. There is no doubt that reducing bull demand by one-half will benefit the producer, as long as calf output remains the same. How much benefit can be expected? Taking into account death risk, salvage value, bull maintenance, and interest on a purchase price for a $2,500 bull, the estimated bull cost per calf is $28.83,

with a $1,500 bull, the estimated bull cost per calf is $19.91 (Greiner and Miller, 2008).

This is assuming a BFR of 1:30. With a 1:60 BFR ratio, the cost could be reduced to

$14.41 per calf and $9.95 per calf, respectively. This would allow a producer to not only

purchase fewer bulls, but he could also afford to utilize genetically superior cattle that

should prove to aid in the performance of his calf crop.   Proper management during the

breeding season should result in each cow being bred by a single fertile bull each time

she is in estrus. Bull overlap (more than one bull breeding a cow in heat) is not

desirable, primarily because it does not enhance pregnancy rates. Disadvantages of bull

overlap are increased risk of bull injury (through competition for estrous females),

additional pressure from social dominance and the extra costs incurred by purchasing

and maintaining more bulls.

CHAPTER II

OBJECTIVES

The objectives of Experiment 1 were to: 1) quantify the relationship of bull to female ratio with pregnancy rate, calving rate, and calving date in extensively-managed herds and 2) evaluate the repeatability of sperm motility, sperm morphology, and social dominance rank before and after the breeding season;

The objectives of Experiment 2 were to determine the effect of winter grazing of gestating heifers on either small grain pasture or native range on incidence of pregnancy loss, dystocia, and calf vigor.

CHAPTER III

REVIEW OF LITERATURE

Sire Fertility

Reproductive merit is five times more important economically than growth performance and at least 10 times more important than product quality to the beef cow-calf producer (Trenkle and Willham, 1977). Acceptable reproductive function in the bull is of paramount importance because natural service is, and will likely continue to be, used in the majority of beef breeding herds (Carpenter et al., 1992). Reproductive performance of beef bulls is influenced by many factors, including testicular development and seminal quality (Ott, 1986), libido and mating ability (Chenoweth, 1983) and physical soundness (Larson, 1986). Reproductive efficiency is a major determinant of cow-calf profitability. The bull's contribution to pregnancy rates is often overlooked. Breeding a large number of cows in a short breeding season requires fertile bulls. Fertility of the male is a major contributor to overall reproductive performance in mating systems that use natural service. Since beef cattle reproduction depends so heavily on natural service, assuring high bull fertility is crucial to successful breeding seasons with high pregnancy rates. The prediction of bull fertility has been an area of interest for some time and is ongoing.

Performing breeding soundness examinations (BSE) to identify sub-fertile yearling bulls has become common in the beef cattle industry (Smith et al., 1989).

According to Hopkins and Spitzer (1997), the breeding soundness evaluation provides a systematic format for identifying problems that could potentially limit bull fertility. However, BSE did not identify sub-fertile bulls or predict fertility potential of individual bulls (Bellin et al., 1998). The BSE is used to group bulls as either unsatisfactory or satisfactory for breeding purposes. This procedure does not evaluate a bull's ability to breed or breeding behavior such as libido. Some bulls that receive a satisfactory BSE classification are ineffective as breeders because they are incapable of mounting and breeding a cow or because they have low sex drive. Bulls should be observed in natural breeding situations to determine these factors. Genetic and phenotypic correlations among semen traits were favorable, as were those between scrotal circumference and semen producing ability in beef cattle (Abadia et al., 1976; Neely et al., 1982; Knights et al., 1984). Scrotal circumference, a main component of BSE, is becoming a common selection criterion (Smith et al., 1989). Scrotal circumference, when coupled with the standard BSE, gives an indication of a bull's semen quality and producing capacity (Elmore et al., 1976). Testicular growth, as estimated by scrotal circumference, is moderately to highly heritable, and is correlated with age, rate of gain, age of dam, birth weight, and frame score (Latimer et al., 1982; Knights et al., 1984; Bourdon and Brinks, 1986; Nelson et al., 1986). Of the measurements that are taken during the breeding soundness examination (BSE), scrotal circumference is most highly correlated with testicular volume and sperm production capacity (Ball et al., 1983).

Fertility of range bulls was successfully increased by performing yearly breeding soundness evaluations (BSE) to measure scrotal circumference and physical semen

characteristics (Chenoweth et al., 1992). Perry et al. (1989) discussed three categories that drive the greatest influence upon reproductive performance: semen characteristics, mating ability and sex drive, and social interactions between animals in the mating pastures. With the standard BSE, two of these traits are not evaluated at all. Assessment of spermatozoal morphology and scrotal circumference during a conventional breeding soundness evaluation is not well correlated with libido and serving capacity (Chenoweth et al., 1988). However, in some instances libido and SC may have marked effects on herd fertility (Blockey, 1978; Hawkins et al., 1988; Coulter and Kozub, 1989, but these relationships have not been consistently observed (Christensen et al., 1982; Post, 1982; Boyd et al., 1989).

Sexual performance rating systems have been developed for bulls that rewards bulls for exhibiting behaviors that reflect sexual interest (libido) in addition to successful inseminations (Hultras, 1959; Osborne et al., 1971; Chenoweth et al., 1979; Chenoweth, 1986). The use of scrotal circumference as another selection to aid in the increase of reproductive performance has been prompted by studies showing bulls with larger scrotal circumference produce more sperm (Almquist and Amann, 1961; Hahn et al., 1969; Almquist et al., 1976; Foote et al., 1977), produce higher quality semen (Cates, 1975; Chenoweth et al., 1977; Fields et al., 1982) and are younger at puberty (Lunstra et al., 1978). However, there have been other studies that have shown scrotal circumference of yearling bulls to be negatively correlated with age at puberty of closely related females (Brinks et al., 1978; Lunstra, 1982).

Sexual Behavior and Activity

Sexual behavior in the bull encompasses both mating ability and libido. Libido has been defined as the willingness and eagerness to mount and complete service of a female and mating ability as the ability to complete service. Mating behavior is behavior exhibited immediately before, during, and after service (Chenoweth, 1983). Bulls exhibit considerable differences in semen quality and libido, often without any external signs of illness, weakness, or abnormal condition (Foote et al., 1976). Both libido and mating ability are important in bulls, and there is ample evidence that these two traits are influenced strongly by genetic factors (Chenoweth, 1983). No relationships between testosterone, libido, and semen quality were determined (Foote et al., 1976).

Unsatisfactory reproductive rates of beef herds have always garnered significant attention, therefore the need to evaluate the mating performance of a bulls is extremely important. Serving capacity tests have been developed to assess the mating competence of male livestock prior to their use in breeding programs (Price, 1987). Chenoweth et al. (1979), Blockey (1981) and Crichton and Lishman (1985) have reported that restrained non-estrous cows provide a suitable alternative to estrous females in serving capacity tests with bulls because the primary stimulus for mounting is the immobility of the female. According to Wallach and Price (1988) bulls were simultaneously exposed to restrained estrous and non-estrous females to measure mating preferences directly and to determine the importance of the estrous state of females on sexual performance. This approach is believed to be a more vigorous test of estrous preferences and its effect on sexual performance than has been previously conducted with bulls. In addition, no

evidence was found to support that bulls prefer estrous to non-estrous females when both females are rendered immobile in serving crates or stanchions (Wallach and Price, 1988). These results support the conclusions of Chenoweth et al. (1979), Blockey (1981) and Crichton and Lishman (1985) that immobility, rather than the estrous state of the female, is the most important stimulus for mounting behavior by males of this species. The relevance of immobility is learned early in life through pre-pubertal mounting experience (Silver and Price, 1986). Bulls used in natural mating learn to associate olfactory and visual cues accompanying estrus in female cattle with immobility (Wallach and Price, 1988). The precedence of immobility over other estrus-related cues is demonstrated by the relatively rapid sexual responses of range bulls (i.e., bulls used in pasture mating) when first exposed to restrained non-estrous females (Price, 1987).

The administration of serving capacity tests to beef bulls requires less time and labor and fewer facilities when bulls are tested in groups rather than individually (Price and Wallach, 1991). Morris (1987) found no difference in the serving capacity of young Santa Gertrudis bulls tested individually (one bull and five restrained females) versus small groups (three bulls and four restrained, non-estrus females). However, in contrast, Lunstra (1981) reported the sexual performance of sexually inexperienced, 15-mo-old bulls was greater when tested in groups of three or five males when tested on an individual basis. 79% of the bulls mounted and 47% ejaculated, as compared to the groups with three males, 89% mounted and 73% ejaculated in individual tests administered by Lunstra (1981). Yet in another contrast, Lane et al. (1983) reported the sexual performance of bulls was greater when tested individually versus than in groups

of six males. It is also important to note that intermale aggression and interference was increased in their group tests due to spacing the stimulus females only 2 m apart.

Bos Indicus influenced bulls have actually been shown to exhibit great copulatory behavior in restrained pen test as compared to stanchion tests (Hawkins et al., 1988). The estrous condition of stimulus females may be more important for certain cattle breeds than for others. Chenoweth (1981) and Garcia et al. (1986) indicated estrous females are necessary when conducting serving capacity tests with bulls of *Bos indicus* breeding. It would seem more logical to use and unrestrained group pen test for bulls to be utilized in multiple-sire breeding groups as this would simulate natural breeding competition with sexually-active groups of cattle (Blockey, 1979). The unrestrained pen test used in this study involves placing a group of bulls with a group of unrestrained cows in standing estrus for a set time (usually 15-30 min). Price and Wallach (1991) suggested restrained female tests with multiple potential sires that the BFR be held constant at 1:1, but with unrestrained pen tests BFR have reported between 5:8 and 3:4 (Carpenter et al., 1992; Price and Wallach, 1991). The number of mounts (including any intromissions or ejaculations), intromissions (including any ejaculations) and ejaculations are generally recorded (Carpenter et al., 1992). Lunstra (1986) reported bulls tested individually had lower levels of sexual activity than bulls tested in groups of three or five. The number of services achieved by high SC bulls in the double-sire tests was almost double the number achieved by the low SC bulls. This fact suggests that in double-sire mating situations, a high SC bull will achieve more services than a low SC bull. This appears to be the case even when the high SC bull is less competitive

than the low SC bull (Godfrey and Lunstra, 1989). Blockey (1978) found high SC bulls produced a higher conception rate on the first detected estrus, but overall pregnancy rate during a 6-wk period was not different between SC groups. Lunstra (1986) found high and medium SC bulls had a higher pregnancy rate when mated to 50 heifers per bull over a 20-d period than did low SC bulls. Among the more competitive bulls of the pairs, the high SC bulls had more services and fewer mounts than the low SC bulls, which indicates sexual aggressiveness was more important than competitiveness in controlling the behavior of the bulls (Godfrey and Lunstra, 1989).

Reproduction Rates

In the United States beef cattle industry today, greater than 95% of the pregnancies achieved each year are a result of natural mating (Godfrey and Lunstra, 1989). Wide variation exists in the serving capacity of bulls of the same age and breed with acceptable semen quality and scrotal circumference of 36 cm (Blockey, 1978; Lunstra, 1986). The large majority of bulls used for natural mating are marketed as yearlings. One objective of this study was to quantify the relationship of semen quality, dominance rank, and bull to female ratio with pregnancy rate, calving rate, and calving date in extensively-managed herds.

Social Rank and Behavior

Similar to serving capacity tests, social behavior tests are rarely a standard component of any typical BSE. It has been written that social dominance is not always synonymous with libido or with BSE measurements (Ologun et al., 1981). The relationship between sexual activity and social rank is not clear (Godfrey and Lunstra,

1989). However, age and weight have been positively correlated to social dominance

rankings (Rupp et al., 1977; Fordyce et al., 2002). Rupp et al. (1977) reported dominant

bulls mounted more females than subordinate bulls, whereas Blockey (1979) found

social rank among a group of 2-yr-old bulls had no influence on sexual activity. Social

interactions between animals often have been differentiated into amicable and agonistic

categories. Amicable behavior is seen most commonly in young animals with a stable

dominance hierarchy and is expressed by such actions as sham fighting and butting,

mounting, and licking of the head, neck, and preputial regions (Blockey, 1975).

Agonistic behavior is more evident in older animals during the formation or

reestablishment of the social order and includes all those activities associated with

conflict (Scott, 1956).   Social hierarchies are established quickly (within 10 to 60 min)

in animals placed suddenly together in a group, and such hierarchies are more prominent

with animals that have had considerable experience with such encounters (generally

older animals) than in those which have not (Hafez and Boissou, 1975). Although horns

and physical size may influence achievement of dominance of an individual within a

group of bulls, age and seniority within the group appear to be of greatest importance in

mixed-age groups (Blockey, 1975; Chenoweth, 1981). Blockey (1979) observed that

mixed age groups of bulls achieved lower pregnancy rates than did groups of young,

similarly aged bulls.

Rupp et al. (1977) reported that dominant bulls marked an estrus female more

often, and mated a greater number of estrus females than subordinate bulls in a multi-sire

pasture setting. This implies that the dominant bull in a multi-sire group may actually

suppress pregnancy rate if he is sub-fertile or is deficient in sex drive because he discourages subordinate bulls from servicing females. In addition, the dominant bull may be of lesser visual quality and conformation or of lesser genetic value, which would cause calf crop value to be severely impacted because the inferior yet dominant bull sired the largest percentage of the calf crop. The social structure of the herd contributes to the uneven mating, because several studies have provided evidence that dominant bulls perform more matings than do subordinates (Rupp et al. 1977; Blockey, 1979; Mooring et al., 2006). Carpenter et al. (1990) rejected the typical theory that dominant bulls would consistently sire more calves than subordinate bulls in a study involving Angus and Braford bulls that were of equal equivalence for serving capacity and seminal quality. The results indicated that with a lower number of cows, the dominant bulls sired more calves. However, with a higher number of cows, the subordinate-paired bull sired more calves. By evidence of this study, it appears a threshold of 32 cows and higher is when the subordinate bulls tend to have a greater percentage calf crop. Breeding ratio is very important in the effectiveness of social dominance as a predictor of calf output. Social relationships also influence the expression of libido, because the presence of a more dominant male has been reported to inhibit or interfere, or both, with sexual behavior of other males (Rupp et al., 1977; Blockey, 1979).

Seminal Traits

The importance of the bull in a cattle breeding program often is underestimated. A cow is responsible for half the genetic material in only one calf each year, while the bull is responsible for half the genetic material in 10 to 60 calves. In general, seminal

traits appear to be lowly heritable. However, scrotal circumference (a main component of breeding soundness examination) is easily measured, highly heritable (.40) and favorably related (phenotypically) to measures of semen quality and growth traits (Smith et al., 1989). Semen quality can also be affected and influenced by temperature or stress (Anderson, 1945; Mercier and Salisbury, 1946; Branton et al., 1952.) According to Mickelson et al. (1981), Greyling and Grobbelaar (1983), and Wildeus et al. (1984), seasonal effects on semen quality have also been observed in several species. Sperm motility and morphology are two of the three traits used in a breeding soundness evaluation along with scrotal circumference to evaluate a bull's breeding potential (Society for Theriogenology, 1976). Scrotal circumference is easily measured and increases in linear fashion as young bulls mature from 6 to 12 mo of age, thus justifying it as a practical tool with which to compare potential bulls for breeding purposes (Elmore et al., 1976). Scrotal circumference is the most easily obtainable measure of the bull's ability to produce adequate numbers of spermatozoa because it is highly correlated with testicular volume and semen quality (Almquist et al., 1976; Gipson et al., 1985). Motility is a parameter recorded during microscopic examination of semen in the standardized breeding soundness evaluation quantifying spermatozoa movement, expressed as the percentage demonstrating forward progressive motility. Morphology is a parameter recorded during microscopic examination of semen in the standardized breeding soundness evaluation quantifying the visual characteristics of spermatozoa, expressed as the percentage that appear normal (BIF, 2005). Woods et al. (1986) reported that fertility of a bull could be predicted from sperm morphology. However,

Smith et al. (1981) found no relationship between any individual semen quality trait and fertility, but they indicated that fertility could be estimated by combining several factors.

Breed differences in semen quality also appear to be very evident and have been also been reported. Fields et al. (1979) reported that *Bos indicus* bulls had higher semen quality than Hereford bulls in summer in Florida. However, daily sperm production is lower in *Bos indicus* than in *Bos taurus* bulls (Amann et al., 1974; Weisgold and Almquist, 1979; Cardoso and Godinho, 1985). Godfrey et al. (1990) reported Brahman bulls have lower semen quality traits than Hereford bulls. Brahman bulls had lower motility ratings and more abnormal sperm than Hereford bulls. Ruttle et al. (1984) reported *Bos indicus* and *Bos indicus-cross* bulls had lower percentage of motility and sperm concentration than *Bos taurus* bulls in semen collected by electro-ejaculation.

Multiple-Sire Breeding Groups

According to Coulter and Kozub (1989), little selection pressure for fertility has been placed on beef bulls in North America. Multiple-sire breeding, used routinely by many commercial breeders, has made it difficult to identify sub-fertile sires. Many breeders have little or no information on the reproductive status of their bulls, particularly the yearlings. Problems associated with multiple-sire mating exist due to the social relationships between bulls, which include fighting, injuries, and the resulting losses of bulls from the herd at the end of a breeding season (Kilgour and Campin, 1973; Fordyce et al., 2002). Multiple-sire herds have also been called inefficient. Multiple-sire breeding of cow groups has not proven satisfactory when young sires were grouped with older sires (Blockey, 1979). In a study of 235 bulls mated in 37 multiple-sire

groups, 58% sired 10% or less of the calves in the group and 6% sired no calves at all (Holroyd et al., 2002). These findings are consistent with Neville et al. (1987). They used twenty-six, two-sire groups, the average proportion of calves sired by the high bull to female ratio bulls was .64 versus .36 for the low bull to female ratio bulls, with a range of .51 to .86 for the bulls with the highest proportion of calves.

According to Coulter and Kozub (1989) multiple-sire breeding, used routinely by many commercial breeders, has made it difficult to identify sub-fertile sires and many breeders lack confidence in methods used to predict a bull's potential fertility under multiple-sire range breeding conditions. Problems with dominant bulls have occurred when four or more bulls of different ages were included in a breeding group of cows (Rupp et al., 1977; Blockey, 1979). However, good results were obtained when two bulls of the same age were assigned to breeding groups of cows (Neville et al., 1987). Multiple-sire breeding of cow groups has not proven satisfactory when young sires were grouped with older sires (Blockey, 1979). Neville et al. (1987) states the most desirable multiple-sire breeding group may be with two sires of the same age and similar weight. The maintenance of sires in groups by ages for 3 to 4 wk or more prior to the breeding period should reduce injuries to bulls and possibly enhance breeding efficiency during the first part of the breeding period. This is because fighting among bulls to establish social dominance would take place prior to rather than during the outset of the breeding period.

There is much discussion regarding the influence of breeding overlap on fertility. Lunstra and Laster (1982) reported the pregnancy rate of heifers receiving one service

per estrus averaged 62.1% and pregnancy rate of heifers receiving multiple services (single-sire) per estrus averaged 62.9%. Pregnancy rate per estrus of heifers mated to three sires (multiple-sire, one service per sire; 74.0%, was significantly higher than that of heifers mated to a single sire (62.9%). Nelson et al. (1975) agrees with this concept demonstrated through a study where semen from several, normal fertility sires was mixed and then artificially inseminated. Pregnancy rates were typically higher than when semen from a single sire was used. It is important to note that fertilization rates never exceeded that of the most fertile bull alone. Rupp et al. (1977) states an increase in the number of bulls that mated a female in estrus did not increase the average conception rate of that female. Yet, Farin et al. (1982) found in fact an increase in first service pregnancy rate due to multiple services. So, it is quite possible that that social dominance and serving capacity difference could have very complex results.

Nutrition

Extremely low energy intake beginning early in life can delay puberty (Bratton et al., 1959; VanDemark and Mauger, 1964) and, if severe enough, can permanently impair sperm output (VanDemark et al., 1964) of bulls. The use of scrotal circumference of yearling beef bulls as a selection tool to increase reproductive performance has been prompted by several studies showing that those with larger scrotal circumference produce more sperm (Almquist and Amann, 1961; Hahn et al., 1969; Almquist et al., 1976; Foote et al., 1977), produce higher quality semen (Cates, 1975; Chenoweth et al., 1977; Fields et al., 1982) and are younger at puberty (Lunstra et al., 1978). Scrotal circumference at a given age can be affected by energy intake (VanDemark and Mauger,

1964). Pruitt et al. (1986) claimed that in general, the fatter bulls decreased in scrotal

circumference and the thinner bulls maintained or increased slightly. These results

indicate that nutritional effects on scrotal circumference need to be considered when

evaluating bulls for reproductive soundness or when using scrotal circumference as a

selection trait.   High levels of energy intake could affect reproductive performance of

young bulls used for natural mating by a direct effect on rate of sexual development, or

by an indirect effect through degree of fatness or weight change during the breeding

season (Pruitt and Corah et al., 1985). High levels of energy (Morrow et al., 1981) and

diets resulting in extreme weight loss (Meacham et al., 1963) can adversely affect libido

of yearling and mature beef bulls (Wodzicka-Tomaszewska et al., 1981). According to

Pruitt and Corah et al. (1985) low levels of energy intake could be detrimental

to reproductive performance of young bulls by delaying puberty or reducing libido. It is

very evident that energy intake and plain of nutrition is important in bulls and how it

relates to sexual development and sexual characteristics.

Examining only birth weight and calving difficulty is not realistic because

pre-calving feed level can also affect subsequent fertility in the dam (Dunn et al.,

1969). However, most research on the influence of plane of nutrition during

gestation on calving difficulty has shown little to no relationship (Laster et al., 1973;

Laster, 1974; Bellows and Short, 1978; Naazie et al., 1989).

Bull to Female Ratio

Since variations exist between bulls in their desire to mate (libido),

recommendations for bull-to-cow ratios range from 1:10 up to 1:60 (Perry, 2008). There

are a multitude of factors that account for the exact bull to female ratio that is desirable. Some of the factors to consider are distribution of the breeding females, terrain, water availability, carrying capacity of the land, pasture adaptation, and pasture size. Bull variation is also a major concern when it comes to looking at a proper BFR. Age, mating ability, condition, libido, fertility, social behavior, and injury are all factors that contribute to bull variation and the difficult task of maximizing BFR. If the dominant bull is sub-fertile or infertile, poor conception rates may occur despite an adequate or excessive bull to female ratio. In contrast, an inadequate bull to female ratio can exhaust the breeding capacity of a bull. Most cattleman use a bull to female ratio (BFR) ranging from 1:20 to 1:30. However, there have been several researchers who have challenged and investigated this common thought. Bull age also affects bull-to-cow ratios. Yearling bulls have a lower serving capacity than older bulls. Therefore, it is important to remember that young bulls should be utilized at a lower bull-to-cow ratio than older bulls (Perry, 2008). No differences were detected between a bull to female ratio of 1:25 and 1:60 for estrous detection or pregnancy rates in the first 21 days of the breeding season, provided the bulls were mature, highly fertile, and had large scrotal circumferences (Rupp et al., 1977). Furthermore, Rupp et al. (1977) demonstrated overall pregnancy rates could still be maintained when the BFR was increased from 1:25 to 1:44 and past 1:60, and stated the fertility, libido, and mating ability of each bull were more important than the BFR or multi- vs. single sire situation, when based on conception rates.

Reproductive Tract Scoring

The selection and development of replacement heifers is a major economic burden to the beef cattle industry. Reproductive tract scoring or RTS is a useful tool for measuring the physiological readiness of replacement heifers for breeding. The reproductive efficiency of any cowherd is greatly dependent on several factors such as female selection, heifer development, management, and even genetics. In the past, conformation, BW, body condition score (BCS), and calculated indices such as Kleiber ratio (KR; Kleiber, 1947; Scholtz and Roux, 1988) have been used to select heifers for breeding purposes. However, selection based on age at puberty (AP) is desirable due to its correlation with fertility outcomes, and ultimately with lifetime production of the cow through repeated early calving dates (Anderson et al., 1991). Researchers at Colorado State University (CSU) (LeFever and Odde, 1986; Anderson et al., 1991) developed a five-point scoring system to measure the pubertal status of virgin beef heifers prior to the start of the breeding season.   This method involves palpation of the reproductive tract and ovarian structures per rectum and is scored from 1 to 5. A RTS classified as 1 has no uterine tone or no palpable ovarian structures. A RTS of 2 is classified by a 20 to 25 mm uterine horn diameter without tone and ovarian follicles of less than 8 mm in diameter. Heifers possessing a RTS 3 have uterine horn diameter of 25 to 30 mm, slight uterine tone, and 8 to 10 mm diameter ovarian follicles. RTS 4 heifers have a 30 mm uterine horn diameter with tone, ovarian follicles with a diameter greater than 10 mm, and possible corpus luteum. RTS 5 females have greater than a 30 mm uterine horn diameter, and the presence of a palpable CL. Heifers with a RTS of 1-3 are considered

prepubertal, while heifers with a RTS of 4 and 5 are considered postpubertal (LeFever and Odde, 1986). Three possible applications of the RTS system have been recommended: firstly as a screening test to determine the pubertal status of heifers before the breeding season (Anderson et al., 1991), secondly as an indication of the nutritional requirements of heifers when sufficient time is allowed before the breeding season (Anderson et al., 1991), and thirdly as a selection tool for AP (Pence and Bredahl, 1998; Pence et al., 2007).

Reproductive Tract Scoring (RTS) is a very subjective examination and reproductive tract scoring is a repeatable (between and within veterinarian) and accurate measure of pubertal status (Rosenkrans and Hardin, 2003). Rosenkrans and Hardin (2003) study involved one hundred and seventy-four rectal examinations (n=174) performed on 29 predominantly Angus heifers by two veterinarians (A and B) and assigned individual reproductive tract scores (RTS) during monthly examinations over a 3-month period. Heifers were examined in the morning by both veterinarians, randomized, and re-examined in the afternoon. The size and location of ovarian structures of each heifer were determined by ultrasonography. Heifers with follicles >10mm in diameter or corpora lutea were classified as pubertal. Serum progesterone concentrations at the time of the examination and 10 days later were determined by radioimmunoassay and used to classify heifers as prepubertal (<1 ng/ml in both samples) or pubertal (at least one sample >or=1 ng/ml). Kappa, which describes degree of agreement beyond chance, was used to determine repeatability of the RTS system. Multi-category Kappa for agreement was 0.64 within veterinarian, 0.46 between

veterinarian, and 0.35 between palpation per rectum and transrectal ultrasonography. Sensitivity and specificity of palpation per rectum for diagnosis of pubertal status compared to serum progesterone levels were higher (82 and 69%, respectively) than sensitivity and specificity of ultrasonography (79 and 59%, respectively). This study validates the RTS system as a repeatable and accurate screening test to evaluate pubertal status in groups of heifers prior to the onset of the breeding season.

For the RTS exam to be utilized appropriately for management decisions, the timing of the first exam is extremely critical. Byerley et al. (1987) reported pregnancy rates of beef heifers bred at first estrus (57%) were lower than pregnancy rates of heifers bred at third estrus (78%). Beef heifers that calve at 2 yr of age produce more calves in their lifetime than heifers that calve first at 3 yr of age or older (Donaldson, 1968). Heifers that conceive early in their first breeding season calve earlier and wean heavier calves than those that conceive late in their first breeding season (Short and Bellows, 1971; Lesmeister et al., 1973). Furthermore, Lesmeister et al. (1973) indicated heifers which conceived early in the breeding season maintained this production advantage throughout their lifetime. Studies such as these have led to the current management recommendation that beef heifers be bred as early as possible in their first breeding season. However, this may result in heifers being bred at pubertal estrus and too early in their life. According to Patterson et al. (2005) heifers should reach puberty one to three months prior to breeding to ensure that a high percentage of heifers are cycling and that the effects of lowered fertility at first estrus are minimized. It is usually proposed that RTS exams should be administered 30-60 days prior to the

scheduled start of the breeding season or synchronization treatment or when half of the heifers are thought to by cycling (Torell et al., 1996). With regards to management, RTS scores can be utilized to aid a producer in culling decisions, to decide whether an adjustment needs to be made in the nutritional plane of females prior to the breeding season to increase pregnancy rate, and to determine when to start a synchronization program (Torell et al., 1996; Patterson et al., 2005).

Selecting for RTS leads to a reduction in days to calving, which allows heifers more time to recover from the stress of calving and to become prepared for the next breeding season (Holm et al., 2009). First-calf cows are known to be the group under most pressure to reconceive in the subsequent breeding season, due to the fact that they are still growing and also nursing a calf, which puts tremendous pressure on their energy and protein metabolism, to the detriment of fertility (Chenoweth and Sanderson, 2001). In a study by Holm et al. (2009), the association of pre-breeding RTS with the pregnancy rate to the second breeding season was not direct, but was confounded by the association between RTS and days to calving during this first calving season. The proportion of heifers with RTS 4 and 5 that remained in the herd until their second breeding season was 77% (80 of 104), while proportion for heifers with RTS 1 to 3 was 54% (90 of 167), demonstrating an increased production life of heifers with a higher RTS. RTS values have proven to be predictive of reproductive performance in yearling heifers used for breeding purposes.

Calving Difficulty (Dystocia)

Dystocia is an undesirable phenomenon that may arise from several environmental and genetic causes (Burfening et al., 1981). Calving difficulty or dystocia is the major cause of perinatal calf losses (Anderson and Bellows, 1967) and large birth weights are the major cause of calving difficulty (Rice and Wiltbank, 1972). Calving difficulty has long been known to have pervasive effects on the beef production process with large, negative impacts on the economics of production (Laster, 1974). Dystocia results in increased calf mortality (Anderson and Bellows, 1967; Laster and Gregory, 1973) and lowers postpartum conception rate in females (Brinks et al., 1973; Laster et al., 1973). Considerable effort has been expended to identify the factors influencing calving difficulty. Parity has been shown to be the most important factor influencing this trait (Philipsson, 1976). In 2-yr-old heifers, dam weight at calving was reported to be the most important factor influencing calving difficulty, whereas pelvic area appeared to have a threshold effect (Makarechian et al., 1982; Makarechian and Berg, 1983). In contrast, studies by Morrison et al. (1985) and Johnson et al. (1988) indicated that calf birth weight was the most important factor. According to Naazie et al. (1989), results indicated that although calf birth weight is the most important variable influencing dystocia in heifers, the ratio of the calf birth to the dam's weight at calving is even more critical. All of these effects have been shown to influence lifetime cow efficiency and productivity (Holloway et al., 2005).

Body Condition Scoring

Body condition in cattle affects reproduction and pregnancy rates. Low pregnancy rates are caused by improper nutrition in ninety percent or more cases (Sprott et al., 1988). In all cattle production systems, the ultimate goal of the producer is to have a positive economic return. The lowest conception rates in cows occur most often when a female is thin or when she is in excessive body condition. Body condition scoring provides a measure of an animal's nutrition reserves, which is more useful and reliable than live weight alone (Lowman et al., 1976). The body condition of a cow at breeding is crucial for reproductive success. Reproduction of cows is influenced by nutrient intake and subsequent changes in body energy reserves (Richards et al., 1986; Randel, 1990). Cows in thin body condition at calving have an extended postpartum anestrous period and may not become pregnant during the breeding season (Richards et al., 1986; Selk et al., 1988). Although several scoring systems have been developed, the most commonly used system is based on a numeric scoring scale. This system begins at one which represents the thinnest cattle. It ranges to a nine which represents the heaviest conditioned cattle. Body condition score at parturition has been implicated as the single most important factor affecting postpartum intervals to estrus pregnancy rates in cows (Richards et al., 1986; Selk et al., 1988). Trials have shown that the percent of cows that had been in estrus within 80 days after calving was lower for cows with a body condition score of less than five versus cows that scored more than five (Sprott et al., 1988). Studies have shown that cows calving in body condition of 4, 5, or 6 have had calves with progressively heavier (P<.05) birth weights, but dystocia scores did not seem to be

influenced by BCS. Birth weights, dystocia score, and actual 205-day adjusted weaning

weights were only affected by location. Greater BCS at calving resulted in more cows in

estrus and more cows pregnant by day 40 and day 60 of a breeding season (Spitzer et al.,

1995). The change in weight at postpartum seems to have an added effect on estrus

response and pregnancy rates while increasing actual and adjusted 205-day weaning

weights of calves. Corah et al. (1975) found nutrient intake during the last 100 days of

gestation influenced percentage of first-calf cows in estrus by 40 days postpartum.

Condition is vital to reproductive success, but the plain of nutrition and progression of

increased nutrition and body condition, should increase efficiency. The body condition

of a cow at breeding is crucial for reproductive success.

Pelvic Measurement

Studies that have examined yearling female pelvic height, width, and area have

indicated moderate to high heritability estimates for these particular traits (Benyshek and

Little, 1982; and Green et al., 1988). There has long been question of whether or not

pelvic areas should be a main selection criterion for replacement females and is a large

amount of debate exists about this topic. In addition, the question has also been raised

about whether or not pelvic measurement could be used in bulls to reduce dystocia in

replacement females. Green et al. (1986) reported a genetic correlation of .61 between

female and male pelvic area and concluded that selection for increased male pelvic area

should produce female offspring with larger pelvic areas. Pelvic area has been shown to

be one of the most important cow variables that effects calving difficulty. Deutscher

(1978) concluded that selection for an increase in pelvic area in heifers would yield a

decrease in the incidence of dystocia. Calving difficulty in first calf females is primarily the result of mismatching calf size and pelvic dimensions in the heifer. Cook et al. (1993) suggests sire selection based on low birth weight expected progeny differences with high accuracy will be much more effective than selection of replacement heifers based on large yearling pelvic area in reducing calving difficulty in first calf heifers.

CHAPTER IV

INFLUENCE OF BULL TRAITS AND BULL TO FEMALE RATIO

ON REPRODUCTIVE PERFORMANCE IN BEEF FEMALES

Materials and Methods

This study was conducted at the Texas A&M AgriLife Research and Extension

Center in Uvalde, TX. Range conditions at the ranch (6,780 ha) are extensive and the

environment is semi-arid. The current study involved 90-d breeding seasons (April 15-

July 15) during each of the three years and the information on the resulting calf crops.

Bonsmara bulls (n= 13 for year 1; n= 14 for year 2; n= 12 for year 3; 20-24 months of

age) were delivered from George Chapman in McClean, TX at least 3 wk prior to the

beginning of each breeding season.   Bulls received *ad libitum* water and sorghum hay

until allotment to their respective breeding group. Breeding soundness evaluations

(BSE) were performed and social dominance rankings were determined at the start of the

breeding season. Serving capacity tests were conducted prior to the breeding season due

to the availability of non-pregnant females for synchronization of estrus. Pre-breeding

evaluations were performed the day before the start of the season, and post-breeding

evaluations were performed from 2-4 weeks after the conclusion of the breeding season.

Based on the results of these evaluations, bulls were allotted to multiple- or single-sire

pastures with BFR ranging from 1:20 to 1:45. Sixty to 75 days following the conclusion

of the breeding season, the females were palpated per rectum to determine pregnancy

status. Three measures of reproductive performance were evaluated for each breeding group: pregnancy rate, calving rate, and calving date.

BSE

The standards used to determine if a bull was a satisfactory potential breeder followed the Society for Theriogenology's guidelines (Hopkins and Spitzer, 1997). However, sperm morphology was not assessed prior to identifying bulls which would be utilized in this study. Physical traits measured included frame score (FS), scrotal circumference (SC), body weight (BW), and body condition score (BCS). With one being emaciated and nine being obese, body condition score was based on a scale of one to nine (BIF, 2005) Frame score was based on a scale of one to nine, with one being the smallest framed and nine being the largest framed (BIF, 2005) Only three bulls used did not achieve a satisfactory BSE each year.

The semen samples were collected by electro-ejaculation (Electrojac II, Chicago, IL). A sample of each collection was immediately placed upon a slide, covered with a cover slip, and observed at 400 X magnification with a light microscope to determine the percentage of progressively motile spermatozoa. A drop of semen was placed on a slide and mixed with a commercially available eosin-nigrosin stain (Semen Analysis Kit, A.J.P. Scientific, Inc., Clifton, NJ), and smeared on the slide. Each slide was air dried and then transported to a lab at Texas A&M University, (College Station) for morphological assessment. Percentage of normal sperm morphology, percentage of primary abnormalities, and percentage of secondary sperm abnormalities were classified according to the standards set by Barth and Oko.

Social Dominance

Social ranking of the bull was determined by observation. The bulls were randomly sorted into groups (n= 4 to 8 bulls) and allowed to compete for a feed source. Following the methods described by Carpenter et al. (1990), each encounter between the bulls was recorded as a win, loss, or tie. A win was defined as one bull yielding or acting submissive to another bull. An initial social ranking was determined among the bulls within each group (aggressive, average, or submissive) and then bulls were redistributed into like groups. A second social rank was determined among bulls within each contemporary group. Final social rank was based upon social dominance hierarchy among the entire group of bulls. Furthermore, assessment of post-breeding social dominance rank was also conducted each year.

Serving Capacity

Nine days prior to conducting the serving capacity tests, an implant containing norgestomet was inserted (SC) in the ear of the cows and heifers. The implant was removed after 7 d and females were administered an injection (IM) of Lutalyse (25 mg). On the day of the test, (0645 to 0730), females in standing estrus were identified. The bulls were placed with estrus females at a ratio of .75-1.75 for 30 min. The BFR varied depending upon the availability of estrus females. Copulatory behavior was then assessed by recording the number of mounts (M), intromissions (I), and ejaculations (E). Determination of ejaculation was based on whether or not a bull displayed pelvic thrust. Each bull was assigned a serving capacity score based on the total number of E, and was

accordingly classified as low (2 or fewer E), medium (3 E), and high (4 or more E).

These data were also used to calculate serving efficiency (SE) ((M+I+E)/ E).

Bull Allotment

Over the course of three breeding seasons,(Appendix Tables 1-3), Bonsmara

bulls (n = 39) were allotted by spermatozoa motility, serving capacity, and social rank to

nineteen different breeding pastures. The bulls were joined with crossbred females of

varying percentages of Bonsmara. In 2006, seven breeding groups (n = 348; 2-14 yr of

age) were utilized at BFR that ranged from 1:19 to 1:32. In 2007, six mature female

breeding groups (n = 217; 2-14 yr of age) and one heifer group (n = 68; 11-14 mo of

age) were utilized at BFR that ranged from 1:16 to 1:34. In 2008, seven mature breeding

groups (n = 303; 2-14 yr of age) and one heifer group (n = 72; 11-14 mo of age) were

utilized at BFR that ranged from 1:20 to 1:45. The bulls were assigned to each pasture

based on their serving capacity (number of ejaculates, intromissions, and mounts),

average progressive sperm motility, and social dominance of the group. The average

values of the above characteristics were similar for bull groups across the pastures.

Statistical Analysis

The SAS program (SAS Inst. Inc., Cary, NC) was utilized to analyze all of the

data. Least square (LS) means by BFR group were derived by the GLM procedure to

determine treatment differences for pregnancy rate, calving rate, and calving date. Since

the data included pregnancy rate and calving rate as a percentage of the total, these data

were adjusted to fit a normal, independent distribution by an arcsine transformation for

the purpose of statistical analysis. The GLM procedure was used to compare LS means

for physical, behavioral, and reproductive traits of bulls allotted to either Low or Conventional BFR groups. Again, since normal morphology and spermatozoal motility data were recorded as a percentage of the total, these data were adjusted to fit a normal, independent distribution by an arcsine transformation for the purpose of statistical analysis.

The repeatability of BW, BCS, FS, SC, social rank, percentage of primary sperm abnormalities, percentage of secondary sperm abnormalities, and percentage of normal spermatozoal morphology was determined from pre- to post breeding season in year 1 (n=13), year 2 (n=14), and year 3 (n = 12). All of the bulls from each of the three years were evaluated (Conventional vs. Low BFR groups) and change in percentage of normal morphology was documented (n = 39). To account for variability in the number of bulls each year, social dominance rankings were converted into percentages and reported using a scale of one to ten.

Results

Conventional vs. Low Bull to Female Ratio

Cattle breeding groups were sorted to either a Conventional BFR (ranged from 1:16 to 1:26) or a Low BFR (ranged from 1:30 to 1:45). A total of twelve conventional and ten low BFR groups across year 1, year 2, and year 3 were compared for differences in pregnancy rate, calving rate, and calving date. Only reproductive data for mature females were analyzed statistically. Assignment of bulls to BFR treatment groups was based upon physical, reproductive, and sexual behavior traits. The mean values for BW, BCS, FS, SC, spermatozoa motility, normal sperm morphology, serving capacity,

serving efficiency, and social rank did not differ (P >.05) between Conventional and

Low groups (Table 1).

Table 1. Means for physical, reproductive, and behavioral traits of bulls allotted to
either Conventional or Low bull to female ratio (BFR) groups

| | BFR | | | |
	Conventional (n=22)	Low (n=17)	SEM	P-Value
Weight (kg)	527	538	15	0.338
Body condition score	4.57	4.77	0.22	0.318
Frame score	6.21	5.83	0.21	0.828
Scrotal circumference (cm)	37.79	37.49	0.99	0.644
Spermatozoal motility (%)	45.19	48.88	3.58	0.531
Normal morphology (%)	66.04	70.35	1.58	0.069
Serving capacity	2.4	2.7	0.2	0.702
Serving efficiency	5.05	4.31	0.38	0.287
Social rank[a]	5.9	5.3	0.6	0.554

[a] Adjusted to a scale of 1 to 10

Table 2. Reproductive performance of mature female groups assigned to Conventional or Low bull to female ratio (BFR) groups

| | BFR | | | |
	Conventional (n=407)	Low (n=464)	SEM	P-Value
Pregnancy Rate (%)	89.69	91.58	0.61	0.36
Calving Rate (%)	89.12	91.48	0.61	0.25
Mean Calving Date[a] (d)	306	310	3.03	0.24

[a] Interval from start of breeding until calving

Table 2 represents the reproductive performance of mature female groups assigned to either Low or Conventional bull to female ratio (BFR) groups. Pregnancy rate, calving rate, and mean calving date did not differ ($P > 0.36$, 0.25, and 0.24, respectively) between BFR treatments (Table 2).

Physical, seminal, and behavioral traits for each bull before and after the breeding season are presented by year in Appendix Tables 4-6. Mean pre- and post-breeding values for physical, seminal, and behavioral traits of bulls are depicted in Table 3. Only body weight ($r = 0.71$), scrotal circumference ($r = 0.78$) and social rank ($r = .50$) were significantly repeatable (Table 4). The other factors were not significantly correlated with their respective values after the breeding season including body condition score, sperm morphology and motility, and primary and secondary abnormalities.

Table 3. Mean pre- vs. post-breeding value for each trait across all 3 years

Body Weight (kg)		Scrotal Circumference (cm)		BCS[c]		Sperm Motility (%)		Normal Morphology (%)		Primary Abnorm. (%)		Secondary Abnorm. (%)		Social Rank	
1[a]	2[b]	1	2	1	2	1	2	1	2	1	2	1	2	1	2
525	536	36.8	38.5	4.4	4.8	52.3	40.5	70.2	73.6	16.3	12.6	7.4	10.2	7	7

Table 4. Repeatability (r) of physical and reproductive traits of bulls pre- and post-breeding season

	Body Weight	BCS[a]	SC[b]	Spermatozoa %		Primary Abnorm. %	Secondary Abnorm. %	Social Rank
				Motile	Normal			
r	0.71**	0.24	0.78*	0.18	0.38	0.33	0.28	0.50***

*P < 0.05
**P < 0.01
***P< 0.001
[a] Body condition score
[b] Scrotal circumference

Discussion

In most parts of the country, the typical bull-to-female ratio used by cow-calf producers ranges from 1:15 to 1:30. Increasing the efficiency of natural mating offers enormous potential for lowering the costs of production.

Several studies have been conducted where lowering the BFR had no adverse affects on pregnancy rates. Rupp et al. (1977) demonstrated that overall pregnancy rates could still be maintained when the BFR was increased from 1:25 to 1:44 and 1:60, and he stated that the fertility, libido, and mating ability of each bull were more important than the BFR or multi- vs. single sire situation, when based on conception rates.   The findings in our study reveal much of the same findings and are in agreement with this author for both multiple- and single-sire breeding groups. According to Rupp et al. (1977) conception rates are not influenced by dominant or subordinate social classifications of bulls in single- or multiple- sire breeding groups but a breeding soundness examination plus a Social Ranking of a potential sire can prove to be beneficial in deciding what sort of breeding program is optimum for a specific producer. Further studies that continue to evaluate precise conception rates among mixed Social Ranked sires should be conducted to quantify the effects of sires with varied social rank combinations on pregnancy rates.

Healy et al. (1990) completed a study designed to determine the optimal bull-to-female ratio required for maximum reproductive performance on both estrus-synchronized and naturally cycling heifers. The results of Healy's study indicates most ranches could lower the bull-to-female ration used, maintain the herd's productivity, and

lower their bull costs per pregnant female. However, if you use a lower bull-to-female ratio, a breeding soundness examination performed 30-60 days before the breeding season is critical to success of the breeding program. According to Perry (2008), maximum bull-to-cow ratios will vary depending on the mating ability, semen quality, and libido of individual bulls. Bull-to-female ratios can usually be increased in single-sire breeding groups; however, bulls should be observed closely during the breeding season to ensure that they continue to mate successfully. Poor performance of a bull in a single-sire breeding group will affect the pregnancy rate of that group.

In our current experiment, we concluded that the bull-to-female ratio could be stretched to 1:45 and reproductive performance could still be maintained without being adversely affected.

CHAPTER V

INFLUENCE OF NUTRITION DURING GESTATION

ON CALVING DIFFICULTY IN PRIMIPAROUS BEEF FEMALES

Materials and Methods

Heifers were exposed to Bonsmara bulls from April 15 to July 15 of each year. A total of 142 heifers of Bonsmara breeding (3/4, 7/8, and full bloods) were weighed, rectally palpated for pregnancy, and scored for BCS (1 thin – 9 fat) and frame score (1 short – 9 tall) in December during years 1 and 2. Within each year all females were maintained as a single herd after weaning. Once pregnancy status had been determined, an expected calving date was predicted for each heifer. Heifers were stratified on expected calving date, and randomly allotted to two levels of nutrition for the remainder of gestation. In year 1, heifers were allotted to range forage (n=31, low nutrition, LN) or to non-irrigated oat pasture (n=31, high nutrition, HN). In year 2, heifers were placed onto the same range environment as in year 1 (n=31, LN) or onto irrigated ryegrass pasture (n=31, HN). Heifers grazing range were supplemented with 20% CP cubes at the rate of 0.9 kg/heifer/day from January 2 until calving while heifers grazing oats or ryegrass pastures were not supplemented. One week prior to expected calving date, heifers were placed in a dry lot and given access to free choice haygrazer (year 2) or coastal Bermuda grass (year 3) hay and supplemented with 20% CP cubes at the rate of 0.8 kg/heifer/day.

During the calving season (January 15-May 1), heifers were observed continuously every day from 0730 to 1630 hr. Heifers were not routinely observed during the night, however, vigilance was maintained for any heifer exhibiting signs of imminent parturition until calving occurred. If stage II of parturition was not completed within 2 hours, the heifer was placed into a working chute and assisted with the calving process (including, if needed, the use of a mechanical apparatus or Caesarean section by a licensed veterinarian). Within 4 hr of birth, calves were weighed, and calf vigor and calving difficulty scores were recorded. Calving difficulty was scored as follows: 1=No Difficulty, no assistance, 2=Minor Difficulty, some assistance, 3=Major Difficulty, usually mechanical assistance, 4=Caesarian section or surgery, 5=Abnornal presentation (BIF, 2005). Calf vigor scores were scored as follows: 0=dead, 1=weak, not alert, unable to stand, 2=weak, alert, able to stand, 3=healthy, alert, slow to nurse, 4=healthy, vigorous, nurse within 2 hr of birth. Heifers were weighed within 72 hours of parturition.

Statistical Analysis

The SAS software program (SAS Inst. Inc., Cary, NC) was utilized to analyze all data. Regression analysis was performed to produce least square means for plane of nutrition treatment contrasts on calving data of heifers. The model used was Y= calf birth date, dam birth date, calf sex, dam breed (full blood Bonsmara, 15/16, 7/8, ¾ blood Bonsmara), year, treatment (high or low nutrition during last trimester of pregnancy), year x treatment, calf birth date x treatment, calf sex x treatment, and dam breed x treatment.

Results

According to allotment protocol, measurements made at the beginning of the trial were not different (P > 0.5) between heifers assigned to the two gestational nutrition treatments. All of the heifers met the management target for 20 to 22 mo-old females entering the last trimester of gestation (450 kg, Frame and BCS Score of 6.3, Table 5). The incidence of heifers that miscarried or died at calving is depicted in Table 6. In this study, twice as many HN heifers required major assistance at calving as compared to LN heifers (Table 7). Table 7 depicts the percentage of the heifers displaying calving difficulty. Calf vigor score distribution by heifer treatment is presented in Table 8. Nearly twice as many calves born to HN heifers were healthy and vigorous at birth as compared to those born to LN females (Table 8). HN Heifers gained 48.6 kg whereas the LN females lost 15 kg during the trial which includes weight lost at calving (Tables 5 and 9). Calves born to HN females averaged 3.7 kg more at birth than calves born to LN heifers (Table 9). These differences resulted in heifers that had been on the HIGH treatment prior to calving having (P = 0.005) more calving difficulty than those on the LOW treatment (Table 9). The calves of the HN females were also less vigorous after birth than that of the calves from LN females (Table 9).

Discussion

Corah et al. (1975) reported increased calf birth weights caused by increased digestible energy content of the diet beginning 100 d prepartum. Bellows and Short (1978) produced a 5-kg average increase in calf birth weight by feeding heifers 94 kg of crude protein/d rather than .56 kg crude protein/d for 82 d prepartum, even though the diets were isocaloric. The findings in the current experiment are in agreement with these authors findings. In this current experiment, calves born to HN females weighed 3.7 kg more at birth than did that of calves born to LN females. As expected, increased birth weight, the calving difficulty was higher in HN females than in LN females. According to Garry (1995) poor maternal nutrition reduces calf vigor. This is not observed in our experiment. The average calf vigor score was 3.3 for LN females and 2.2 for the HN females.

Table 5. Mean $\pm$ SE heifer traits at initiation of trial

Variable	LOW	HIGH	Significance P > t P value
Heifer weight, kg	453 $\pm$ 6	447 $\pm$ 6	0.50
Body Condition (1-9)	6.2 $\pm$ 0.15	6.3 $\pm$ 0.15	0.51
Frame Score (1-9)	6.3 $\pm$ 0.15	6.3 $\pm$ 0.15	0.98
Heifer pelvic width, cm	13.1 $\pm$ 0.02	13.2 $\pm$ 0.02	0.52
Heifer pelvic height, cm	16.0 $\pm$ 0.02	15.7 $\pm$ 0.02	0.29
Heifer pelvic area, cm^2	208.3 $\pm$ 3.7	208.0 $\pm$ 9.1	0.93

Table 6. Number of heifers that were pregnant, calved, miscarried, or died at calving by treatment group for years 1 and 2

Variable	Yr=1		Yr=2		Total
Treatment	LOW=Range (n)	HIGH=Oats (n)	LOW=Range (n)	High=Ryegrass (n)	
Pregnant	31	31	31	31	124
Calved	30	29	30	28	117
Apparent miscarries	1	2	1	3	7
Died at calving	0	1	2	1	4

Table 7. Distribution of calving difficulty score, % within treatment[1]

	Treatment[2]	
Calving Difficulty Score[3]	LOW	HIGH
1	65	47
2	14	7
3	21	42
4	0	4
5	0	0

[1]Two levels on nutritional grazing for last trimester of pregnancy.
[2]Treatment 1 = South Texas range, Treatment 2 = Oats (2007), ryegrass (2008).
[3]Calving Difficulty Scores: 1=No Difficulty, no assistance. 2=Minor difficulty, some assistance, 3=Major difficulty, usually mechanical assistance, 4=Caesarian section or surgery, 5=Abnormal presentation, BIF (2005).

Table 8. Distribution of calf vigor score, % within treatment[1]

	Treatment[2]	
Calf Vigor Score[3]	LOW	HIGH
0	10	28
1	4	9
2	7	16
3	14	14
4	65	33

[1]Two levels of nutritional grazing for the last trimester of pregnancy.
[2]Treatment LOW = South Texas range, HIGH = Oats (2007), Ryegrass (2008).
[3]Calf Vigor Scores: 0=dead, 1=weak, not alert, unable to stand, 2=weak, alert, able to stand, 3=healthy, alert, slow to nurse, 4=healthy, vigorous, nurse within 2 hr of birth.

Table 9. Influence of nutrition during gestation on measurements made at calving (heifer measurements made between 4-72 hr after calving)

Variable	LOW	HIGH	Significance P < t
Heifer weight, kg	437.7 ± 7.0	495.5 ± 6.8	< 0.0001
Calf birth weight, kg	32.7 ± 0.8	36.4 ± 0.7	0.001
Calving difficulty score	1.6 ± 0.16	2.3 ± 0.16	0.005
Calf vigor score	3.3 ± 0.27	2.2 ± 0.26	0.005

CHAPTER VI

SUMMARY

In experiment one, Bonsmara bulls (n = 39; 20-24 mo of age)

were joined with multiparous Bonsmara and Bonsmara-influenced females (n = 1013)

during a 90-day breeding season in 2006, 2007, and 2008 to quantify the effects of a

reduction in bull to female ratio on reproductive performance. Bulls were also placed

with primiparous beef females (n = 142). Bulls were allotted by selected physical traits,

social rank, serving capacity, and seminal traits to one of two bull to female (BFR)

treatments: Low (1:30-1:45; n = 10 pastures) or Conventional (1:16-1:26;

n = 12 pastures) BFR. Pregnancy rate (P = 0.36), calving date (P = 0.24), and calving

rate (P = 0.25) did not differ between Conventional and Low BFR treatments. The

current experiment demonstrates that Low BFR can be utilized in breeding pastures

of up to 2,090 ha without negatively affecting reproductive performance.

In experiment two, Bonsmara heifers (3/4, 7/8, and full bloods) were exposed to

Bonsmara bulls from April 15 to July 15 during each of the two years. Heifers were

weighed, rectally palpated for pregnancy, and scored for BCS (1 thin – 9 fat) and frame

score (1 short – 9 tall) in December (end of second trimester) during years 1 and 2.

Heifers were stratified on expected calving date and randomly allotted to one of two

levels of nutrition for the remainder of gestation. In year 1, heifers were allotted to

range forage (n=31, low nutrition, LN) or to non-irrigated oat pasture (n=31, high

nutrition, HN). In year 2, heifers were placed onto the same range environment as in

year 1 (n=31, LN) or onto irrigated ryegrass pasture (n=31,HN). Heifers in the LN

groups were supplemented with 20% CP cubes at the rate of 0.9 kg/heifer/day from

January 2 until calving while HN heifers were not supplemented. Within 4 hr of birth,

calves were weighed, and calf vigor and calving difficulty scores were recorded.

Heifers were weighed within 72 hours of parturition. From treatment initiation through

calving, HN heifers gained 48.6 kg whereas the LN females lost 15 kg. Twice as many

HN heifers required major assistance at calving as compared to LN heifers. Calves born

to the HN females weighed 3.7 kg more at birth than those born to LN females. These

differences resulted in HN heifers having (P = 0.005) more calving difficulty than LN

heifers (mean calving difficutly of 2.3 for HN and 1.6 for LN). The calves of the HN

females were also less vigorous (P = 0.005) after birth than the calves from LN females

(calf vigor score of 2.2 for HN and 3.3 for LN). Consequently, the level of nutrition

during the third trimester of gestation can affect calving difficulty, calf vigor, and female

weight.

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APPENDIX

Table A1. Number of bulls, number of females, bull to female ratio (BFR), and
BFR treatment by pasture for 2006 breeding season

Female Composition	Pasture ID	Number of Bulls	Number of females	BFR	BFR[a] Treatment
Mature	YB/Mustang	2	42	1:21	C
	House	2	38	1:19	C
	Reed Ranch	1	25	1:25	C
	Prairie/BS	4	125	1:32	L
	VAT/China	2	56	1:28	L
	Dure	1	32	1:32	L
	Hill Farm	1	30	1:30	L

[a]C = conventional; L = low

Table A2. Number of bulls, number of females, bull to female ratio (BFR), and
BFR treatment by pasture for 2007 breeding season

Female Composition	Pasture ID	Number of Bulls	Number of females	BFR	BFR[a] Treatment
Mature	YB/Mustang	2	42	1:21	C
	House	2	38	1:19	C
	Black Sulphur	2	35	1:17	C
	Prairie/BS	2	35	1:17	C
	VAT/China	2	35	1:17	C
	Dure	2	35	1:17	C
Heifer	Center	2	69	1:34	L

[a]C = conventional; L = low

Table A3. Number of bulls, number of females, bull to female ratio (BFR), and
BFR treatment by pasture for 2008 breeding season

Female Composition	Pasture ID	Number of Bulls	Number of females	BFR	BFR[a] Treatment
Mature	YB/Mustang	2	40	1:20	C
	House	2	52	1:26	C
	Reed Ranch	1	25	1:25	C
	Prairie/BS	2	90	1:35	L
	VAT/China	1	35	1:35	L
	Hill Farm	1	30	1:30	L
	Dure	1	31	1:31	L
Heifer	Center	2	73	1:36	L

[a]C = conventional; L = low

Table A4. 2006 pre- and post- breeding physical, seminal, and behavioral bull traits

Bull ID	Body Weight (kg)		Scrotal Circumference (cm)		BCS		Sperm Motility (%)		Normal Morphology (%)		Primary Abnorm. (%)		Secondary Abnorm. (%)		Social Rank	
	1[a]	2[b]	1	2	1	2	1	2	1	2	1	2	1	2	1	2
20	590	538.6	39.5	36	5	5	70	50	56.5	75.5	33.5	7.5	10	17	2	2
34	513.6	486.4	35	35.5	5	5	60	30	73.5	76	20	14	6.5	10	7	9
40	575	600	42	38.5	6	6	40	10	70	52	18	39.5	12	8.5	6	3
53	540.9	586.4	37.5	38	5	5	30	0	44.5	45.5	14	17	41.5	37.5	11	7
54	477.3	506.8	31	33.5	5	5	40	70	68	73.5	30	11	2	15.5	1	1
57	511.4	515.9	36.5	37	5	5	50	40	64.5	55	24.5	4.5	11	40.5	3	4
58	495.5	550	39.5	38.5	5	5	50	60	71.5	76.5	20	14.5	8.5	9	8	11
59	443.2	465.9	35	38.5	4	4	40	30	64	69	30	8	6	23	5	8
62	479.5	490.9	36	33	5	5	30	60	67.5	45.5	21.5	31.5	11	23	4	5
67	454.5	481.8	37	37	5	5	40	20	82.5	80.5	14.5	13.5	3	6	9	6
403	631.8	622.7	39	37.5	5	6	60	50	78.5	71.5	16.5	20.5	5	8	12	13
416	556.8	522.7	35	33.5	5	3	0	20	79	58	13	15	8	27	10	12
446	550	536.4	37.25	34.5	5	5	80	60	64	76.5	20	15.5	16	8	13	10

[a] Pre-breeding value
[b] Post-breeding value
[c] Body Condition Score

Table A5. 2007 pre- and post- breeding physical, seminal, and behavioral bull traits

Bull ID	Body Weight (kg)		Scrotal Circumference (cm)		BCS		Sperm Motility (%)		Normal Morphology (%)		Primary Abnorm. (%)		Secondary Abnorm. (%)		Social Rank	
	1[a]	2[b]	1	2	1	2	1	2	1	2	1	2	1	2	1	2
3	545.5	559.1	39	40	3	5	30	80	76.5	55	14.5	4	9	8	9	7
78	604.5	597.7	40	43	4	5	80	80	57	72	38.5	19	4.5	9	10	3
86	586.4	606.8	30.25	37	3	5	0	0	0	0	0	0	0	0	11	12
94	490.9	475	37	42	3	5	60	40	81	67	14.5	26	4.5	7	7	10
96	529.5	547.7	41.5	40	4	4	70	20	50	81.5	17	6.5	13	12	6	8
138	506.8	509.1	37	39	3	5	80	70	53.5	71.5	43	24.5	3.5	4	3	4
141	563.6	636.4	37.75	40	4	5	70	70	84	88	8	4	3.5	5	1	1
505	552.3	579.6	43.5	44	4	4	50	50	75	83.5	22.5	15	2.5	1.5	5	2
517	488.6	477.3	36	39	4	5	30	60	68.5	70.5	21.5	22	2.5	7.5	14	13
522	545.5	572.7	39	39	3	5	70	50	71.5	75	25.5	12.5	3	13	2	6
554	545.5	529.5	38.25	42	4	5	70	20	77.5	79	13	7.5	9.5	14	8	5
557	522.7	527.7	38.25	38	4	5	50	70	37	69	51	16.5	12	15	12	9
601	581.8	561.3	38	41	4	5	40	0	66	67	20	20	12	14	13	11
602	547.7	511.4	37.5	40	4	6	0	40	0	67	0	22	0	8	4	14

[a] Pre-breeding value
[b] Post-breeding value
[c] Body Condition Score

Table A6. 2008 pre- and post- breeding physical, seminal, and behavioral bull traits

Bull ID	Body Weight (kg)		Scrotal Circumference (cm)		BCS		Sperm Motility (%)		Normal Morphology (%)		Primary Abnorm. (%)		Secondary Abnorm. (%)		Social Rank	
	1a	2b	1	2	1	2	1	2	1	2	1	2	1	2	1	2
52	457.3	491	35	36	5	5	50	30	94.5	90	2	5	3.5	5	1	1
62	552.7	556	37	38	5	5	40	60	90.5	89.5	7	8	2.5	3.5	2	3
66	526.4	521	36.5	40	5	5	80	30	87	90	8	7	5	3	10	12
83	540.9	541	35.5	42	5	4	70	0	88	87	5.5	8.5	6.5	4.5	6	8
88	451.8	497	35	41	5	4	80	70	86.5	86.5	8	9	5.5	4.5	7	6
310	542.7	586	34	36	5	5	60	0	84.5	86	8	9	7.5	5	5	2
321	444.5	468	33	36	5	5	60	40	86.5	88	7	6	6.5	6	8	4
330	493.6	545	34.5	41.25	4	4	70	60	88	91	5	5.5	7	3.5	4	5
333	486.4	543	37	38	4	5	40	20	85	90	5.5	5	9.5	5	9	7
334	442.7	509	32	41	5	5	70	30	89	92.5	7.5	5.5	3.5	2	11	10
357	510.9	521	34.5	40	4	4	50	40	87.5	93	6	4.5	6.5	2.5	12	11
637	593.6	536	39	39.5	6	5	80	50	89.5	87.5	3	7	7	5.5	3	9

[a] Pre-breeding value
[b] Post-breeding value
[c] Body Condition Score

VITA

Blake David Bloomberg was born in Galesburg, IL to James and Mary Bloomberg. He grew up in the West-central Illinois town of Berwick on his family's diversified livestock operation. He earned his associate's degree in May 2005 from Black Hawk East Community College in Kewanee, IL, a B.S. degree in Animal Science from Texas A&M University in August 2007, and a Master of Science in Reproduction from Texas A&M University in May 2010. He then coached the Texas A&M Livestock Judging Team from August 2007 to November 2009. He was named the National Collegiate Coach of the Year in 2008 and 2009. He married Wravenna Phipps on August 22, 2009.

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