EVALUATION OF TRAITS ASSOCIATED WITH BUCKING BULL PERFORMANCE AND BEHAVIOR

A Thesis

by

NATASHA ELIZABETH ROMERO

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

December 2008

Major Subject: Animal Science

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Approved by:

Co-Chairs of Committee,	Andy D. Herring
	Theodore Friend
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ABSTRACT

Evaluation of Traits Associated with Bucking Bull Performance and Behavior.

(December 2008)

Natasha Elizabeth Romero, B.S., Texas A&M University

Co-Chairs of Advisory Committee: Dr. Andy D. Herring
Dr. Theodore Friend

Video and industry data were used to assess the inter-relationships of aggression, delivery, coat color, year of birth, number of outs, buckoff percent and score in rodeo bulls. An evaluation of laterality based on observations of how the individual animals were loaded into chutes at 11 bull riding events showed 63% left-handed delivery and 37% right-handed delivery across all observations (n = 525). There was a similar distribution for aggressiveness (based on whether or not the bull charged after the rider dismounted) with 64% of bulls being non-aggressive and 36% of bulls being aggressive.

Significant linear relationships existed between score and number of outs and score and buckoff percentage indicating that experience impacted performance. The correlation between number of outs and buckoff percentage was low to moderate (0.06 to 0.30), depending upon the subset of data evaluated.

The r-square value for the analysis of score among all bulls was 0.14; however, the r-square value in the subset of bulls with known sires with more than one son was 0.68 when sire was included in the model. Similar increases in r-square values were observed for 2006 average score, career average score, buckoff percentage, and career

buckoff percentage, indicating important genetic influences on these traits and/or their component traits.

Investigations into the relationship between performance and aggression may help bucking stock producers improve the selection criteria they use. The current trend within the industry is for several breeders to breed ‘hot’ or flighty, nervous cattle to achieve higher performing offspring. Given that there was no association between aggression and score based on chi-square test, aggression may be removed from the criteria for using certain animals for breeding purposes. Based on results from this work, if bucking stock breeders want to make genetic changes in these traits, documentation of pedigree information is vital.

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I would like to thank the American Bucking Bull Inc. for their support in providing me access to pedigree information from their registry. I would like to thank the Professional Bull Riders for allowing me access to rodeo events for data collection. Special thanks go to Bull Pen magazine that has stood behind me and made their resources available during this project. I would also like to thank the following ranches for their time and effort in this project: Guidry Land and Cattle Co., B-K Rodeo, Lufkin Ranch and Rodeo, Frontier Rodeo, Wilfong Rodeo, XS Ranch and Double R Rodeo.

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I would like to acknowledge my mom, Frances Bassett, and my aunt and uncle, Robert and Kim Romero, for all of their love and support during my academic career.

NOMENCLATURE

DAB	Dataset "All Bulls"
DBG	Dataset "Bull Groups"
DS	Dataset "Sires"
DS1	Dataset "Sires with more than 1 son"

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INTRODUCTION

The sport of bull riding has become the fastest growing professional sporting event in the United States (PBR, 2008) and showcases the combined athletic performance of both the bull and the rider. In addition to expanding to Brazil, Mexico, Canada and Australia, these sporting events are now broadcast in over 84 countries. The growing popularity of the sport has not only increased the value of the animals involved in this sport, but also the need to accurately identify desired sires and dams. Unfortunately, most of the criteria have been based on observations by producers. There are many different hypotheses as to what makes a good “bucker,” however these observations have not been subjected to empirical investigation.

Genetic technology has allowed the American Bucking Bull Inc., the official registry for rodeo stock, to implement DNA paternity testing. Unfortunately, the value of this registry is quite limited. While the paternity test is beneficial in guaranteeing the accuracy of the genetics of the animals, it does little in terms of identifying the performance ability or the breeding values of these animals. The registry has been useful in tracking pedigrees in a similar way race horse industry tracks pedigrees, with the emphasis on pedigrees being the predominant breeding criteria.

Today’s technology allows both beef and dairy cattle breeders to use semen from genetically superior bulls. Because bulls with higher genetic merit are the most heavily

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utilized, breeders receive semen of the greatest Breeding Worth (BW) (Foote, 1999).

This semen is selected from bulls that have been bred through selective breeding experiments and their BW is demonstrated through the production ratios achieved by their stock relative to other bulls. There are no analogous breeding criteria for animal behavioral or performance traits such as bucking; however, the same concept could be utilized to selectively breed for certain behavioral characteristics. In order to selectively breed cattle for bull riding, an understanding of the factors that influence bucking behavior is required.

Breeding criteria within the rodeo stock industry are based on observations and may not be statistically significant or correlated to performance. Selection is often based on the performance of the bull and the assumption that breeding the best bulls to the best cows will result in high-performing offspring. Analyses of data available on the performance of bulls do give some indication of the bull's merit, which can then be compared to other bulls. This comparison may not be an indication of the BW of the bull because many breeders have found that breeding the best bulls to the best cows does not always produce good "buckers."

The lack of empirical investigation into selective breeding or progeny testing in bucking stock provides no reliable data to show what performance traits are heritable and what performance traits result from environmental influences. It is well established that animal behavior is determined through a highly complex interaction between genetic and environmental factors (Grandin, 1994). The task then, is to identify how to adequately measure the heritability of performance traits and, ultimately, genetic merit in bucking bulls.

The objectives of the study were: 1) determine relationships between temperament and performance, 2) investigate the relationship between coat color and temperament, 3) explore the laterality of bulls during their performance and 4), to identify the genetic influences of the bucking traits.

LITERATURE REVIEW

Temperament and Behavior

The ability to identify and predict behaviors can have profound effects on the entire production system. Unfortunately, there is difficulty in assessing or quantifying temperament for statistical analysis (Schmutz et al., 2001). There are many factors that influence temperament, including genetic background, environment and the interaction of heredity and environment (Buchenauer, 1999). Fortunately, the amount of motor activity and excitability during handling (Schmutz et al., 2001) have been quantified and have proven to be persistent over time (Grandin, 1993). Also, the level of excitatory or inhibitory reactions, level of motor activity, persistent habits, emotionality, alertness and several other measurements related to temperament have been correlated to heart rate (Schmutz et al., 2001), a measurable physiological response.

Some animals are cautious and fearful while others are calm and placid. Boissy and Bouissou (1995) stated that “fearfulness is a basic psychological characteristic of the individual that predisposes it to perceive and react in a similar manner to a wide range of potentially frightening events.” Fear is the underlying factor determining human/animal interaction that is referred to as temperament.

It has been well documented that temperament has many implications in the beef and dairy cattle industries, including effects on average daily gain (ADG), carcass quality, performance and overall health. Burrow and Dillon (1997) and Voisinet et al. (1997) have shown cattle with poor temperament are associated with a decreased ADG and an increased incidence of dark cutting carcasses. Fell et al. (1999) examined the relationship between temperament and immune function and concluded that excitable cattle have depressed immune systems compared to calmer cattle.

While having excitable cattle has many disadvantages for the beef and dairy industries, it appears to have a positive effect on rodeo cattle. Bucking bull producers tend to have cows that are considered “hot” or highly excitable. This is partly based on the theory that the “hotter” the dam, the “hotter” the offspring and the more likely it is the offspring will buck. Excitability does not necessarily mean an animal will buck. From informal observations and conversations with bucking stock breeders, there are some highly excitable animals produced in these production systems that have no bucking ability. Also, there have been some calm bulls, such as the bull Promise Land, which appear to be calm and docile even though they are well known bucking bulls.

An important aspect of environment is the social environment in which animals are reared. In this regard, a difference between intensively managed dairy cattle and extensively managed beef cattle may inadvertently affect the temperament analyses between these two types of cattle (Schutz and Pajor, 2001). Rodeo-bred cattle tend to be raised under management systems much more similar to beef cattle, and this comparison appears to be more applicable to this project.

Evolution of Bucking Behavior

The predator-avoidance strategies in domestic animals are similar to wild animals (Coss, 1991) and may be an explanation for the bucking that occurs in rodeo bulls. Although not hypothesized scientifically, the evolutionary cause of bucking may have originated as a predation response. Russell et al. (2000) described Criollo cattle in the Sierra Madre region of Mexico and noticed their longevity relative to that of other breeds of cattle in that region. These Criollo cattle are also highly sought after rodeo cattle with an annual demand of 40,000 steers. The Sierra Madre region is described by Russell et al. (2000) as having limited forage and steep canyons. Also present in the Sierra Madre region are ocelots (*Leopardus pardalis*), mountain lions (*Puma concolor)* and jaguars (*Panthera onca*) (Grigione et al. 2007). Mountain lions and other large cats are known for attacks in mountains and canyons (Shaw, 1980). It is possible that cattle developed a predation response by "bucking" in order to dislodge predators off of their backs. Horses can also show similar bucking behaviors which may be the same type of predation response that evolved in feral horse populations.

Maternal Behavior

While maternal behavior was not directly addressed in this study, maternal behavior is an important element that should be considered in future research. This is due, in part, to the long held belief within the bucking bull community that maternal influence contributes more to the overall performance of the offspring than the sire. Because bucking appears to be a reactionary response rather than a learned behavior the maternal influence on behavior could play a role in the reactionary responses. This could provide a more accurate assessment of the heritability of the behavior and assist in the selection of sires and dams for breeding purposes.

Beckman et al. (2007) evaluated maternal influence on docility scores in Limousin cattle and evaluated its influence on phenotypic variance and heritability. Direct heritability estimates were 0.29 ± 0.02 to 0.38 ± 0.03. The amount of phenotypic variation due to maternal influence was found to be 8%. While the authors concluded that the overall applicability of selecting for maternal ability in Limousin cattle was not warranted since it was a small contribution in overall behavior, it may still influence bucking behavior in rodeo cattle.

The most meaningful comparison to bucking bulls in terms of large animals would be performance horses. Race horses and hunter/jumper type horses are bred to perform athletic events in a similar manner as bucking bulls. There are numerous advantages to utilizing equine performance studies as a basis for understanding bovine performance. Equine pedigrees have been studied for many centuries (Estes, 1952), and the equine industry has developed several different performance measurements and quantifications. Due to the fact that horse racing in America has occurred since at least the eighteenth century (Gorn and Goldstein, 2004) the industry has grown large enough to warrant sufficient research on performance.

One hypothesis previously mentioned among bucking bull producers is the theory that the "hotter," or more excitable the dam is, the better her offspring will perform. This temperament-performance relationship was studied in Thoroughbred horses by Estes (1952). Much like the bucking bull industry, the Thoroughbred industry had long held the notion that "'nervous mares,' in general, are better broodmares. That is, they are more likely to produce high-class offspring than their more phlegmatic pasture mates." The study was conducted using 50 high-spirited mares and 50 phlegmatic mares held under comparable environmental differences and bred to comparable sires (as based on their average earnings index). Comparisons were made between the two groups of dams in addition to the offspring of the two groups of dams. Estes (1952) concluded that the temperament of the dam did not affect the performance of the offspring.

Another study, involving rats, was conducted to measure cross-fostering effects of maternal behavior (Broadhurst, 1960). The study involved two strains of rats that were genetically different for reactivity, or nervousness: Maudsley Reactive (MR) and Non-Reactive (MNR). Those lines of rats were bred and the pups were cross-fostered with different mothers after birth to identify whether maternal behavior could overcome the genetic predisposition for reactivity. The results showed that the maternal effects were not great enough to completely mask the temperamental differences between the two lines. However, maternal effects can affect temperament even if they are not great enough to completely change the temperament of a cross-fostered animal.

Coat Color and Temperament

Bucking bulls come in a wide variety of coat colors. Varied colors exist more so in these type of cattle than in typical cattle "breeds." This is due to generations of cattle being bred to various breeds, thus creating bucking bulls that are an amalgamation of many different breeds. There are many reasons for this that have been mentioned by breeders, including personal preference for unique color patterns, attempts to breed "rank" cattle by using non-traditional breeds such as British White, Mexican fighting bulls, Nellore and Longhorns and selection criteria that are based on behavior rather than the desired uniformity that is a goal of the beef cattle industry.

Relationships between coat color and temperament have been found in several species including cats, dogs, mink, rats, foxes, and fallow deer (e.g. Hemmer, 1990; Keeler and Moore, 1961; Trut, 1999; Trapezov, 1997). The relationship between coat color and temperament was first described by Keeler and King, in 1942, in a study of the coat color-temperament interaction in Norway rats (Keeler and King, 1942). Five years later Keeler expanded on his previous research further exploring the correlation between coat color and temperament and concluded that there was, in fact, a relationship between the two (Keeler, 1947).

More recently, Hemmer (1990) and Tozer et al. (2003) have examined coat color and temperament. Hemmer (1990) noted that it was easier to tame light colored fallow deer than those with wild-type coloration. In 2003, Tozer evaluated cows and bulls for temperament. T study contained 51 Angus bull calves at comparable ages and body weights and analyzed temperament using the Flight Speed Test (Tozer et al., 2003). The Flight Speed Test is a test of the time it takes an animal to cover 1.7 m after leaving a weight scale or stanchion (Burrow et al., 1988). The 51 bulls were divided between black and red bulls, having 28 and 23 bulls respectively. Tozer et al. (2003) concluded that red bulls exited faster than black bulls (1.43 seconds for red and 2.56 seconds for black, respectively) and the results reinforced Hemmer's hypothesis that "coat colour and behaviour are connected via a common biochemical synthesis pathway the pigments determining colour – the melanins and the catecholamine group of neurotransmitters forming the basis of the information-processing system" (Hemmer, 1990).

It appears that coat color does not directly cause a difference in temperament, but rather the physiological mechanisms that underlie coat color may be responsible for temperament. There are many hormones and neurotransmitters common in stress response which is linked with pigment production. For instance, dopamine, a neurotransmitter, and the hormones adrenaline and noradrenalin have an identical biochemical precursor to melanin pigments (Ferry and Zimmerman, 1964). Furthermore, Burchill et al. (1986) found that dopamine directly influences the production of pigment by binding to receptors in the pigment-producing cells. Dopamine also indirectly influences pigment production in an inhibitory function. By inhibiting pituitary melanotropin, or melanocyte stimulating hormone (MSH), dopamine stimulates pigment cells to produce pigment (Tilders and Smelik, 1978). Consequently, a change in coat color may be a byproduct of selection against reactiveness (Keeler, 1947).

Physiology of Stress

In all animals, genetic factors predispose animals to react to situations that arouse fear (Davis, 1992; Boissy and Bouissou, 1995); therefore, temperament is partially determined by an individual animal's fearfulness. There are some physical markers commonly used in the cattle industry that are associated with certain behavioral traits. Casual observations indicate that the most excitable, flighty cattle have a long, slender body with fine bones (Grandin and Deesing, 1998). Supporting that observation is a study conducted by Lanier and Grandin (2002), in which the relationship between temperament and cannon bone measurements indicated that cannon bone length might help identify certain temperaments. The study found steer cannon bone thickness and width were related to the speed of exit from the squeeze chute. Steers with thicker and wider bones exited the chute at a walk while those that trotted or ran out of the chute had thinner and narrower cannon bones. Heifers with wider and thicker bones tended to be less likely to balk at the head restraint. Both steers and heifers with larger cannon bones were calmer than those with smaller bones.

Laterality

Bucking bulls have distinct observable laterality preferences in terms of how they exit the bucking chute. The way the bulls leave the chutes is referred to as their "delivery," so they either have a left delivery or a right delivery for each event performance. This is an easily documented side-bias which may lead to a better understanding of the neurological functions of the bulls in question and may have implications for performance. The delivery they exit from typically results in them turning back, or beginning their spinning, in the same direction. Most bucking bull producers evaluate the bulls out of both deliveries when they are young in order to identify which delivery the bull prefers. Once the bull has shown his preference he generally is bucked using that delivery side in rodeo events. This delivery style is an aspect of laterality in cattle that has not been reported before.

Laterality preference has been shown in almost all vertebrates including fish (Bisazza et al., 2000), snakes (Roth, 2003), birds (Rogers, 1996), rodents (Neveu and Moya, 1997) and other mammals and humans (Warren, 1980). Studies have also shown that even some invertebrates show left-right lateralization (Halpern et al., 2005). In vertebrates this can be explained by the cerebral hemispheric lateralization in the brain leading to expressed side bias (Rogers and Andrews, 2002). The cerebral hemispheres are the left and the right hemisphere. The hemispheres work together although each serves a separate function. In terms of emotionality, the left hemisphere, also referred to as left brain, has been associated with positive emotional stimuli (Wittling and Roschmann, 1993) whereas increased activity in the right hemisphere, or right brain, is associated with more negative emotional stimuli (Bogen, 1985). Furthermore, Neveu and Moya (1997) suggested that a heightened activity of the hypothalamic-pituitary-adrenal axis plays a role in right brain stress response by increasing corticosterone levels. In addition to emotionality the left hemisphere is responsible for analytical thinking and processing, logic, sequential and linear processing and pattern perception.

When a side preference is shown the processes are caused by the contralateral hemisphere (Dharmaretnam and Rogers, 2005). This is important to understand because when a lateral preference is shown it can easily be determined which cerebral hemisphere is active. It can also assist animal handlers in training or working with the animal through the understanding of the mindset of that animal. For example, studies on horse training have been conducted to evaluate learning behavior based on laterality and hemispheric dominance (McGreevy and Thomson, 2006). They concluded in one study that selection or training may be the cause of the left-leg bias, in which a horse grazes with one leg more forward than the other, which may reinforce the interhemispheric transfer that occurs in higher mammals. It is worth noting that this many not necessarily be conclusive because of the interhemispheric transfer that occurs when the hemispheres of the brain interact with each other to coordinate activity (Berne and Levy, 2008). McGreevy and Thomson (2006)

Physical laterality in cattle has not been well studied. In dairy cattle laterality for stall lying tendencies (Arave and Walters, 1980) was shown. Arave and Walters reported that cows lied on their left side 64.7 $\pm$ 1.1% of the time and heifers lied on their left side 61.8 $\pm$ 2.7% of the time. This study actually showed laterality preference based on an activity whereas most other studies involving cattle focus on behavioral laterality. Another study evaluating laterality for lying found a 56% preference for the left side in heifers (Wagnon and Rollins, 1972).

Because horses have been more extensively studied for laterality, these studies might provide a better comparison to bucking bulls than lying in dairy cattle. Williams and Norrist (2007) evaluated stride pattern in horses for three different traits: lead stride pattern preference for trot-to-gallop transition, breaking from the starting gate and evaluation of multiple observations from individual horses. There were three different breeds of horse involved in this study including Arabians, Quarter Horses and Thoroughbreds. The authors concluded that 90% of horses in this study had a right laterality preference and 10% had a left laterality preference.

McGreevy and Rogers (2005) studied 106 Thoroughbreds and compared the laterality bias in the position of the forelimbs. An olfactory stimulus was then introduced to test the nostril preference. The modality and nostril preferences were compared to establish whether a brain sidedness expression of behavior occurred. The study found that the two laterality preferences were not correlated and the authors suggested that "lateralization of the equine brain occurs on at least two levels of neural organization—sensory and motor" (McGreevy and Rogers 2005).

Influence of the Flank Strap

The flank strap is "soft rope that is loosely tied around the bull's midsection in the flank area and slipped onto the bull when it enters the alley to the chute. The slack is taken out of it before the ride, but not tied too tight, and the strap is removed immediately after the ride" (PBR, 2008). The purpose of the flank rope is to produce an annoyance to the bull. This results in the bull kicking out with their hind legs while bucking in an effort to dislodge it. This kicking action results in a performance that is less erratic and provides more consistency for the rider (PBR, 2008). Contrary to a belief among many casual observers of bull riding, the flank strap is not attached to the testicles of the bull as this would severely limit the range of motion a bull could achieve due to the pain it would cause.

While the role of the flank strap is a necessary part of the bull ride, it is highly difficult to gauge its influence on the performance of the bull. It is a fair argument that the flank strap can help or hinder the performance of a bull. A common adage in the rodeo community is that if a flank strap is too loose the bull will not buck and if it is too tight it cannot buck. This is a self-limiting tool that prevents misuse. Fortunately, bull owners and stock contractors familiar with their stock know the degree of flanking that produces the best performance from their bulls.

OBJECTIVES

The overall goal of this study was to determine relationships between animal aggressiveness, performance scores, coat color, delivery, and buckoff percentages. The objectives of the study were: 1) determine relationships between temperament and performance, 2) investigate the relationship between coat color and temperament, 3) explore the laterality of bulls during their performance and 4), to identify the genetic influences of the bucking traits. The goal is to be able to use this information in future studies to further identify heritabilities of traits that affect performance of bucking bulls.

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MATERIALS AND METHODS

Animals

A group of 294 bulls were viewed and videotaped at 11 events and producing a total of 525 observations. The events attended included the Professional Bull Riders, Inc. (PBR) and Championship Bull Riders (CBR) sanctioned bull ridings. These organizations were selected because of the quality of bulls being used and the accessibility of the records on the individual animals. These bulls ranged in age from 3 years to 10 years. Each rodeo event presented a random group of bulls to video, and there was no selection use of animals for this project although some bulls ended up competing in multiple events. All animals were owned by individual contractors. Travel times prior to events were unknown, and therefore were not considered in the analyses. Additionally, the previous nutrition and management of the bulls were also unknown.

Video Collection

The bulls were video recorded during their normal rodeo performance beginning shortly before the bucking gate opened until a few seconds after the rider was bucked off. The video was obtained on a handheld Sanyo digital camcorder, and the files were uploaded onto a computer for playback and analysis. The point of view for the videotaping varied from event to event due to the inconsistency of the venue. However, most of the video was obtained directly across the arena from the bucking chutes. The video was viewed and information was obtained for the color of the bull, the delivery direction and the temperament of the bull.

Rodeo Events Attended

There were five rodeo events that were attended in order to collect the video for this study. Some of the events were held on multiple days and each day was coded as an individual event. Therefore, there were a total of 11 event days in which data collection occurred corresponding to:

Championship Bull Riding (CBR) event in Dallas, TX March 11-12, 2006.

Professional Bull Rider (PBR) event in Liberty, TX June 19, 2006

Professional Bull Riding (PBR) event in Albuquerque, NM March 31 & April 1, 2006

Professional Bull Riders (PBR) event in Dallas, TX June 25, 2006

Professional Bull Riders World Final (PBRWF) event in Las Vegas, NV October 28-November 4, 2006

Aggression

Temperament was assessed based on whether or not bulls ‘hooked’ or attempted to ‘hook’ the rider after the ride. The term hook refers to a bull trying to attack the rider or other men in the arena with their horns. This is a visible indication of temperament that can be recorded and used for analysis. Due to the large numbers of events and the number of bulls used in this study, it was not feasible to evaluate flight speed or other individual temperament assessments. There was a score of zero (0) for bulls that did not show aggression and a score of one (1) for bulls that did show aggression by hooking or attempting to hook the men in the arena.

Coat Color

The same group of bulls that had been video recorded at the rodeo events was assigned to color categories. There are many color pattern combinations of bulls that were not given individual color assignments due to the wide variety of colors presented and the difficulty in analyzing so many variables. The color groups were assigned based on the primary color of the animals as follows: red, black, brown, white, yellow, spotted, brindle and gray.

Buckoff

A rider gets off the bull at some point in each ride. It is considered a "buckoff" if the rider gets off the bull before the 8-second buzzer is sounded. This variable was available for all of the events, or outs, for the 2006 rodeo season and the range of outs per bull was 1 to 38 for 2006.

Career Buckoff

This is the buckoff percentage of the bull from 2003 to 2008 recorded across all events and reported by the officiating sponsor of the event. This allowed a larger sample size of animals to be evaluated and a more comprehensive evaluation of the animals from all events where there were data recorded.

Outs

An out is each time the bull comes out of the chute at a bull riding event. The number of times a bull competed and came out of the chute in 2006 ranged from 1-33 outs for the animals in this study.

Career Outs

This represents the total outs a bull has had in his career from 2003-2008. The range of career outs per bull was 1 to 133.

Laterality

Each bull was placed into the chute facing left or facing right. This was considered the "delivery" of the bull. Laterality was determined by the direction of the delivery and was categorized as left or right. The laterality of the bull was based on the bulls and was used during the analysis of individual events, 2006 events, and the career records of the bulls in the study to investigate brain-sidedness, evaluate the relationship of laterality to aggression, score, color and buckoff percentage.

Animal Pedigree

Each animal's pedigree was obtained from breeders when possible. However, additional pedigree information was obtained through computer software from the American Bucking Bull Inc. (A.B.B.I.), the official registry of bucking bulls in the United States. This information is based only on the DNA registration information, and, therefore known parents were not included in the database if they were not registered with the A.B.B.I. (2008) The bulls containing the missing pedigree information were excluded from the datasets DS and DS1 and the sire contribution was not part of the statistical analysis for DBG and DAB.

Animal Year of Birth

The year of birth was obtained by a variety of methods. The first choice was to obtain the year of birth from the database from the A.B.B.I. (2008) The registry does not require year of birth on all animals if it is not reported. The year of birth was then searched for on the Professional Bull Riders website www.pbrnow.com. The year of birth was also researched through the websites of individual bull owners.

Score

This is the standard performance evaluation across events for this project. A bull is scored by four judges at each event with the highest and lowest scores dropped. The scores of the remaining judges are added together to obtain the final bull score. The bull is scored by each judge on a scale of 1 - 25 with 25 being the top score per judge, and the final score is out of a total of 50 points. The judges evaluated the performance of the bull based on the following criteria: "speed, power, drop in the front end, kick in the back end, direction change and body rolls. A body roll occurs when a bull is in the air and kicks either his hind feet or all four feet to the side" (PBR, 2008).

The more of these criteria the bull exhibits, the higher the bulls score will be. Although scores were recorded at the events by the researcher, they were not used directly for this study. This was due to the inconsistency of reporting the bull scores as they contributed to the final score the rider received. The scores that were used were from a database online located at www.probullstats.com. The purpose of this website is to provide riders with bull statistics in order to help them prepare for events when they know the bull they have drawn. The judges submit official scores to the officiating organization which then submit the official scores to ProBullStats. This gives consistency to the scores and because they are the judges’ scores it gives a more accurate representation of the bulls’ performance.

Average Score

This is the average bull score for the year 2006. The average mark reported on www.probullstats.com lists the average mark as the mark one judge gives which has a maximum value of 25 points. For standardization purposes that score was doubled to keep all of the scores out of 50 possible points.

Career Average Score

This is the average score for the bull over his career from 2003 to 2008. The career average of the scores was used in order to get a larger sample size of outs for the bulls to determine the bulls' consistency.

Datasets

There were 525 total observations for this project consisting of 339 bulls, some with multiple observations. The 525 observations were listed as the dataset DAB. This dataset was further divided into two subgroups DS1, DS and DBG. DS1 consisted of 106 observations of 69 bulls and was utilized to examine sire influence among full and half-brothers. The dataset DBG was designed for bulls that competed at multiple events that were video tapped and contained 128 bulls. DS only contained bulls (n = 149) that had pedigree information available. This subgroup differed from DBG by not including animals that were only represented at one event which DS did.

Statistical Analysis

Analysis of variance procedures were used (GLM and MIXED of SAS) to determine the contributions of the variables to the performance of the bulls. The GLM and MIXED procedures were used to analyze temperament, delivery, coat color, buckoff percentage and contributions of the sire and dam. GLM procedures were used to obtain R-Square values for each model and to calculate simple means to be compared to the least squares means from the MIXED procedure. Pearson's correlation coefficients were used to determine the association between variables including the relationship between temperament and delivery, temperament and coat color, temperament and buckoff percent and coat color and buckoff percent. The chi-square test was utilized to determine relationships between pairs of categorical variables in the datasets.

There were different statistical models used for each variable to allow for the adequate representation of the data to be reflected in the results. For instance, all models contained color and year of birth because those effects were constant across datasets; conversely the aggression score was only in statistical models that tested for the effects of score for events attended. For DAB and DBG the sire was excluded from the model because a large number of bulls did not have a sire listed. Conversely, for DS1 and DS the sire was put into the model to examine the sire effects.

The models were also adjusted for the different variables being analyzed and these adjustments were applicable across all datasets. When "score" was being analyzed, the model contained the variables temperament, delivery, event, color and year of birth. The analysis of "Average Score" involved all of the data for the bulls in the 2006 rodeo season and included the regression on buckoff percentage for 2006 and the regression on the number of outs for 2006. Similarly, "Career Average Score" used the bulls' career buckoff percentage and their career outs. Both of these models required the removal of the variables temperament, delivery and event because without having attended those events, temperament and delivery was not known. While delivery is considered fairly consistent for a bull, this is not guaranteed for each event. The data show at least two bulls that have a different delivery over the course of the events that were witnessed. It would be inappropriate to include delivery except when it was verified. As previously mentioned, the delivery is typically based on the preference of the bull. The same principal applies to temperament. The bull may end up having a consistent temperament score or he may end up showing different behaviors at different events. Without being able to verify a consistent temperament it could not be included in some of the models.

All of the datasets analyzed buckoff percent and career buckoff percent as well. When running the levels of significance for all of the datasets, the only variables used in these models were year of birth, color and outs, or career outs, respectively. This fits with the above justification for excluding certain variables from the models. Buckoff percent and career buckoff percent were also used in correlation analyses.

RESULTS AND DISCUSSION

The levels of significance (*P*-values) from analyses of variance for all of the datasets as presented. The first dataset, DAB is shown in Table 1. When analyzing score, the only significant factor was event ($P = 0.02$). However, this may be explained by different bulls end up competing at different events and therefore the quality of bulls may be influencing the results. This could be analyzed by tracking a group of contemporary bulls competing in the same events and comparing the performance variation between events. The average score was influenced by buckoff percent ($P = 0.01$) with a regression coefficient of 0.1 ± 0.006 (Table 2), outs ($P <.0001$) with a regression coefficient of 0.07 ± 0.012 (Table 2) and year of birth ($P = 0.01$). The R-Square value for the model was 0.34, indicating that 68% of the variation was not accounted for.

The career average score showed comparable findings to the average score as it was influenced by career buckoff percentage ($P = 0.01$) with a regression coefficient of 0.03 ± 0.0006 (Table 2), career outs ($P <.0001$) with a regression of 0.07 ± 0.012 (Table 2), and year of birth ($P = 0.001$) respectively. The R-square value for career average score was 0.48 which indicates more variation is accounted for in this trial.

The 2006 buckoff percentage was influenced by the year of birth ($P = 0.02$) and outs ($P = 0.0003$), however, the R-square value was only 0.11 which indicated that this model did not adequately identify factors that influence the trait.

The career buckoff percentage analysis provided an interesting contrast to the 2006 buckoff percentage. Similar to the buckoff percentage model, the career buckoff percent was impacted (*P* <.0001) by career outs; conversely, in the buckoff percentage analysis, the year of birth did not impact the buckoff percent (*P* = 0.22) whereas coat color did (*P* = 0.02). The year of birth significance may be due to the ability of bulls to perform as they age. The significance of coat color may not be identifiable at a single event or even after a year of competing. It may be significant long term either due to the sire contributions, it may be indicative of family line differences or due to longevity of the different bulls competing that was not tracked in this project. The R-square value was 0.14 and did not explain variation in the trait to much extent.

The next dataset, DS1 has its analyses represented in Table 3. When score was analyzed, there were no significant variables; however, the R-square value was 0.68 indicating that the model accounted for 68% of the differences in the score when sire was included. The average score showed that the only significant effect was outs (*P* <.0001) with a regression coefficient of 0.03 ± 0.003 (Table 2).

Table 1 Levels of significance (*P*- values) from analyses of variance for DAB (n = 525)

Variables evaluated	Score	2006 Average score	Career average score	2006 Buckoff percent	Career buckoff percent
Buckoff percent	--	0.01	--	--	--
Career buckoff percent	--	--	0.01	--	--
Outs	--	<.0001	--	0.0003	--
Career outs	--	--	<.0001	--	<.0001
Coat color	0.39	0.48	0.13	0.29	0.02
Aggression	0.52	--	--	--	--
Delivery	0.93	--	--	--	--
Event	0.02	--	--	--	--
Year of birth	0.13	0.01	0.001	0.02	0.22
Residual variance	7.304	1.316	0.983	241.71	157.78
R-Square[a]	0.14	0.34	0.48	0.11	0.14

[a]R-Square value from GLM, other values from MIXED analyses

Table 2 Regression coefficients (and standard errors) across datasets to evaluate average score and career average score

Independent variables	DAB	DS	DBG	DS1
Outs	0.01	0.07	0.04	0.03
±	0.005	0.01	0.011	0.006
Buckoff percentage	0.07	0.010	0.02	0.01
±	0.005	0.006	0.005	0.010
Career outs	0.03	0.03	0.02	0.03
±	0.003	0.006	0.003	0.006
Career buckoff	0.01	0.07	0.02	0.01
±	0.005	0.006	0.005	0.011

This could prove useful information for performance management of the bulls. The bull owner could use this information when planning the event schedules and maximize performance by managing the number of outs a bull has each year. The career average score showed that career outs (*P* <.0001), with a regression coefficient of 0.03 ± 0.006 (Table 2), and coat color (*P* = 0.05) were important factors. The R-square value was 0.64. The coat color may be significant because this dataset is examining full- and half-brothers which reinforces the theory that coat color may be influenced by the family lines over and above what is attributable to sires.   None of the variables for buckoff percentage were significant; however, the R-square value was 0.74. The only significant variable in the career buckoff was color (*P* = 0.03). Again, this may be due to the relationship between coat color and family lines. The R-square value for career buckoff was 0.69. It is unclear why there is a discrepancy between average buckoff percentage and career buckoff percentage. All three analyses produced much larger R-square values when sire was included in the statistical models.

The analyses for DBG (Table 4) produced statistics more similar to the results from DAB than it was to DS1. When analyzing score, the only influential effect was event (*P* = 0.004). For average score, outs (*P* = .0002), which had a regression coefficient of 0.04 ± 0.011 (Table 2), year of birth (*P* = 0.0009) and 2006 buckoff percentage (*P* = 0.0003) all impacted the average score. However, the R-square value was 0.35 so even though all of the traits were important factors in the average score, the model does not account for 65% of the variance. The R-square value increased when career average score was analyzed to 0.54 and represents a larger amount of variation that is explained in this model. All of the variables in career average score were significant with career buckoff percentage (*P* = 0.005), career outs (*P* <.0001), coat color (*P* = 0.03) and year of birth (*P* <.0001) respectively. This dataset included bulls that had competed in at least two events, so repeatability across bulls may be influential more so here than the dataset DAB. When examining the buckoff percentages nearly all variables were significant for both buckoff percentage and career buckoff percentage.

Table 3 Levels of significance (*P*- values) from analyses of variance for DS1 (n = 105)

Variables evaluated	Score	2006 Average score	Career avg. score	2006 Buckoff percent	Career buckoff percent
2006 Buckoff percent	--	0.84	--	--	--
Career buckoff percent	--	--	0.64	--	--
2006 Outs	--	<.0001	--	0.83	--
Career outs	--	--	<.0001	--	0.93
Coat color	0.24	0.20	0.05	0.26	0.03
Aggression	0.10	--	--	--	--
Delivery	0.54	--	--	--	--
Event	0.22	--	--	--	--
Year of birth	0.37	0.08	0.75	0.11	0.13
Residual variance	4.89	1.05	1.54	115.97	113.67
Sire variance	0.39	0.99	0.07	145.17	82.36
R-Square[a]	0.679	0.739	0.642	0.737	0.690

[a]R-Square value from GLM, other values from MIXED analyses

Table 4 Levels of significance (*P*- values) from analyses of variance for DBG (n = 313)

Variables evaluated	Score	2006 Average score	Career average score	2006 Buckoff percentage	Career buckoff percentage
2006 Buckoff percent	--	0.0003	--	--	--
Career buckoff percent	--	--	0.005	--	--
2006 Outs	--	0.0002	--	0.93	--
Career outs	--	--	<.0001	--	<.0001
Coat color	0.15	0.04	0.03	0.04	0.003
Aggression	0.91	--	--	--	--
Delivery	0.81	--	--	--	--
Event	0.004	--	--	--	--
Year of birth	0.27	0.0009	<.0001	0.0005	0.006
Residual variance	6.49	0.82	0.55	170.40	115.31
R-Square[a]	0.228	0.347	0.536	0.216	0.269

[a]R-Square value from GLM, other values from MIXED analyses

The dataset DS was analyzed (Table5) and the results closely resembled the results for the dataset DAB (Table 1). The variables tested in the score analysis were not significant; however, there was a trend (*P* = .07) toward event effect. This is probably explained, as mentioned above, by the differences of bulls or judges at different events. The average score was influenced by year of birth (*P* = 0.02) and outs (*P* <.0001), and had an R-square value of 0.34. The effect of the year of birth on the average score could be an age effect but it could also be due to popular bloodlines at that point in time. The career average score reinforced the results of the average score model described above as the effects of outs (*P* <.0001), year of birth (*P* = 0.0009) and coat color (*P*= 0.04) were influential. The buckoff percentage, when analyzed, followed the trend of the previous datasets and was impacted by outs (*P* = 0.03) and year of birth (*P* = 0.00); however the R-square value (0.17) raises questions as to the validity of the model. Career buckoff percentage was influenced by career outs (*P* <.0001) and coat color (P = 0.05), and a year of birth trend (*P* = 0.07).

Table 5 Level of significance (*P*- values) from analyses of variance for DS (n = 243)

Variables evaluated	Score	2006 average Score	Career avg. Score	2006 Buckoff percent	Career buckoff percent
2006 Buckoff percent	--	0.11	--	--	--
Career buckoff percent	--	--	0.22	--	--
2006 Outs	--	<.0001	--	0.03	--
Career outs	--	--	<.0001	--	<.0001
Coat color	0.30	0.47	0.04	0.21	0.05
Aggression	0.99	--	--	--	--
Delivery	0.90	--	--	--	--
Event	0.07	--	--	--	--
Year of birth	0.14	0.02	0.02	0.04	0.07
Residual variance	6.78	0.645	0.817	84.890	85.507
Sire variance	1.15	0.927	0.246	173.45	86.888
R-Square[a]	0.16	0.34	0.49	0.17	0.18

Table 6 Least squares means and standard errors for color across datasets

Color	DAB	DBG	DS	DS1
Black	43.90 ± 0.46	43.96 ± 0.52	43.68 ± 0.22	43.28 ± 0.41
Brindle	42.70 ± 0.76	44.32 ± 0.97	43.92 ± 0.38	44.10 ± 0.86
Brown	44.15 ± 0.54	43.93 ± 0.72	43.94 ± 0.34	44.28 ± 0.53
Gray	43.42 ± 0.90	43.47 ± 1.14	43.56 ± 0.48	42.86 ± 0.72
Red	44.15 ± 0.54	44.60 ± 0.62	44.14 ± 0.26	44.15 ± 0.44
Spotted	43.18 ± 0.51	42.56 ± 0.58	43.69 ± 0.26	43.36 ± 0.43
White	43.95 ± 0.85	44.04 ± 1.04	44.11 ± 0.47	44.65 ± 0.90
Yellow	43.33 ± 0.85	44.06 ± 1.17	43.27 ± 0.43	43.42 ± 0.69

[a]R-square value from GLM analyses, other values from MIXED.

The least squares means are presented for color (Table 6), year of birth (Table 7), temperament (Table 8) and delivery (Table 9) for information purposes. Mean separations were not performed. It is important to consider the importance of even the slightest increase or decrease in score. One tenth of a point could mean the difference between winning a $100,000 purse and taking second place for $20,000. The same stakes are on the line for the bull riders because the bulls' score is half of the overall ride score which determines how the rider places at the event.

Table 7 Least squares means and standard errors for year of birth across datasets

Year of birth	DAB	DBG	DS	DS1
1996	44.31 ± 1.47	43.90 ± 1.47	43.73 ± 2.07	44.51 ± 2.09
1997	46.23 ± 1.76	45.16 ± 1.80	46.54 ± 1.84	46.34 ± 1.85
1998	43.48 ± 1.11	44.03 ± 1.28	43.09 ± 1.51	43.79 ± 1.58
1999	43.74 ± 0.55	44.63 ± 0.64	43.84 ± 0.61	43.46 ± 0.62
2000	42.80 ± 0.42	43.59 ± 0.51	43.09 ± 0.48	42.84 ± 0.50
2001	42.42 ± 0.35	42.96 ± 0.42	42.25 ± 0.41	42.11 ± 0.42
2002	42.59 ± 0.45	42.82 ± 0.62	42.52 ± 0.51	42.88 ± 0.59
2003	43.60 ± 0.83	43.85 ± 1.15	43.20 ± 0.83	43.68 ± 0.87

Table 8 Least squares means and standard errors for temperament across datasets

Temperament	DAB	DBG	DS	DS1
0	43.77 ± 0.40	43.84 ± 0.45	43.54 ± 0.47	43.25 ± 1.20
1	43.53 ± 0.43	43.89 ± 0.53	43.52 ± 0.51	42.16 ± 1.06

Table 9 Least squares means and standard errors for delivery across datasets

Delivery	DAB	DS	DS1	DBG
L	43.63 ± 0.38	43.92 ± 0.43	43.59 ± 0.46	42.36 ± 0.64
R	43.66 ± 0.44	43.81 ± 0.53	43.47 ± 0.51	43.02 ± 0.77

Table 10 provides the *P*-values from the chi-square tests for two-way factor distributions across all of the datasets in this project. In the dataset DAB relationships were between color and delivery ($P = 0.03$), year of birth and delivery ($P = 0.03$) and between year of birth and temperament ($P = 0.06$). The relationship between color and delivery may be due to the influence of sire and family lines and a possible heritable relationship between sire and delivery. The relationship between year of birth and delivery may indicate a different relationship in older bulls relative to younger bulls. The same rationale can be applied to the year of birth and temperament. Possibly, the older a bull gets the less aggressive he may become due to his acclimation to performing.

Table 10 *P*-values from chi-square test for 2-factor distributions across datasets

Variables Tested	Datasets			
	AB	DS	BG	SI
Aggression x Color	0.96	0.79	0.44	0.50
Aggression x Delivery	0.77	0.68	0.53	0.36
Color x Delivery	0.03	0.10	0.07	0.002
YOB[a] x Delivery	0.03	0.19	0.04	0.10
YOB[a] x Aggression	0.06	0.05	0.07	0.48

[a]YOB = year of birth

The DS dataset did not show as much significance in the relationships among traits as DAB. This may be due simply to the sample sizes between the two datasets or a relationship between year of birth and temperament (*P* = 0.05) existed, as well as a tendency for a relationship between color and delivery (*P* = 0.10). The same tendencies existed in the dataset DBG with a color and delivery relationship and a year of birth and temperament relationship that are both *P* = 0.07. In the dataset DS1, color and delivery relationship (*P* = 0.002) was significant while there was a tendency for there to be a relationship between year of birth and delivery (*P* = 0.10).

Across all datasets there was a relationship between color and delivery.

Three of the datasets showed a tendency for significance for year of birth and temperament while three other datasets showed a tendency for significance for year of birth and delivery.

Table 11 represents the distribution across temperament and delivery combinations and was designed to identify whether brain-sidedness could contribute to bucking performance which could be useful in developing training methods for the bulls. Sire influence was also analyzed to determine whether there could be adequate genetic variation that could be exploited in breeding programs. In the dataset DAB, the relationship between temperament and delivery was not significant. The frequency of delivery preference was 62.2% of bulls with a left delivery and 37.8% right delivery. There was a distinct manual laterality trait that follows the findings of Arave and Walters (1980) in their lying preference study conducted with dairy cattle. This may show that a manual laterality preference in cattle spans across multiple behaviors. The chi-square test showed no difference in distribution of delivery across temperament (P = 0.77). None of the other datasets (Table 12, Table 13, Table 14) showed different distributions between temperament and delivery.

Table 11 Frequency table: aggression x delivery for DAB (n = 463)

	Delivery		
Aggression[a]	Left	Right	Total
0	182	113	295
Percent (%)	63.19	64.57	
1	106	62	168
	36.81	35.43	
Total	288	175	463
	62.20	37.80	100.00
chi-square *P*-value			0.77

a

[a]Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 12 Frequency table: aggression x delivery for DBG (n = 272)

	Delivery		
Aggression[a]	Left	Right	Total
0	107	63	170
Percent (%)	61.14	64.95	62.50
1	68	34	102
	38.86	35.05	37.50
Total	175	97	272
	64.34	35.66	100.00
chi-square *P*-value			0.53

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 13 Frequency table: aggression x delivery for DS (n = 213)

Aggression[a]	Delivery		
	Left	Right	Total
0	90	51	141
Percent (%)	65.22	68.00	66.20
1	48	24	72
	34.78	32.00	33.80
Total	138	75	213
	64.79	35.21	100.00
chi-square *P*-value			0.68

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 14 Frequency table: delivery x aggression for DS1 (n = 87)

Aggression[a]	Delivery		
	Left	Right	Total
0	40	19	59
Percent (%)	67.80	67.86	67.82
1	19	9	29
	32.20	32.14	32.18
Total	59	28	87
	67.05	31.82	100
chi-square *P*-value			0.36

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

The chi-square analysis for color and delivery was also conducted on all datasets. There was a tendency across all datasets for a relationship to exist. For the DAB (Table 15) the *P*-value was 0.03 (Table 9). This represents the largest dataset in the project. Table 16 is from the dataset DS and had a *P*- value of 0.10 (Table 9). Although it is not statistically significant there is a very interesting trend. The dataset DBG (Table 17) also trended to significance (P = 0.07) Table 9. However, the dataset DS1 (Table 18) had a *P*-value of 0.00 (Table 10). This could be due to the family lines and the genetic influence of both color and possibly of delivery preference.

Tables 19, 20, 21 and 22 represent the frequency tables for year of birth and delivery for all of the datasets. Three of the models, DAB, DBG and DS1 all showed either impact for a relationship or a trend towards influence with chi-square test *P*-values of 0.03, 0.04 and 0.10 respectively (Table 9). Alternatively, in the dataset DS the chi-square test had a *P*-value of 0.19.

Table 15 Frequency table: color x delivery for DAB (n = 524)

Color	Delivery		Total
	Left	Right	
Black	129	59	189
Percent (%)	68.62	31.38	35.88
Brindle	11	19	30
	36.67	63.33	5.73
Brown	27	18	45
	60.00	40.00	8.59
Gray	8	9	17
	47.06	52.94	3.25
Red	53	34	87
	60.92	39.08	16.60
Spotted	77	37	114
	67.54	32.46	21.78
White	12	8	20
	60.00	40.00	3.82
Yellow	16	6	22
	72.73	27.27	4.20
Total	333	191	524
	63.55	36.45	100.00
chi-square *P*-value			0.03

Table 16 Frequency table: color x delivery for DS (n = 244)

Color	Delivery Left	Delivery Right	Total
Black	61	23	84
Percent (%)	72.62	27.38	34.43
Brindle	7	8	15
	46.67	53.33	6.15
Brown	13	6	19
	68.42	31.58	7.79
Gray	5	5	10
	50.00	50.00	4.10
Red	33	14	47
	70.21	29.79	19.26
Spotted	25	25	50
	50.00	50.00	20.50
White	6	3	9
	66.67	33.33	3.69
Yellow	8	2	10
	80.00	20.00	4.10
Total	158	86	244
	64.75	35.25	100.00
chi-square *P*-value			0.10

Table 17 Frequency table: color x delivery for DBG (n = 314)

	Delivery		
Color	Left	Right	Total
Black	88	30	118
Percent (%)	74.58	25.42	37.58
Brindle	7	8	15
	46.67	53.33	4.78
Brown	19	14	33
	57.58	42.42	10.51
Gray	3	5	8
	37.50	62.50	2.51
Red	29	19	48
	60.42	39.58	15.29
Spotted	47	26	73
	64.38	35.62	23.25
White	7	3	10
	70.00	30.00	3.19
Yellow	8	1	9
	88.89	11.11	2.87
Total	208	106	314
	66.24	33.76	100.00
chi-square *P*-value			0.07

Table 18 Frequency table: color x delivery for DS1 (n = 104)

	Delivery		
Color	Left	Right	Total
Black	24	4	28
Percent (%)	85.71	14.29	26.67
Brindle	3	0	3
	100.00	0	2.86
Brown	9	3	12
	75.00	25.00	11.43
Gray	4	2	6
	66.67	33.33	5.71
Red	13	8	21
	61.90	38.10	20.00
Spotted	10	15	25
	40.00	60.00	23.81
White	3	1	4
	75.00	25.00	3.81
Yellow	5	0	5
	100.00	0	4.76
Total	71	33	104
	67.62	31.43	100.00
chi-square *P*-value			0.002

Table 19 Frequency table: year of birth x delivery for DAB (n = 298)

	Delivery		
Year of Birth	Left	Right	Total
1996	4	0	4
Percent (%)	100.00	0.00	1.34
1997	1	2	3
	33.33	66.67	1.01
1998	11	1	12
	91.67	8.33	4.03
1999	31	7	38
	81.58	18.42	12.75
2000	53	31	84
	63.10	36.90	28.19
2001	50	35	85
	58.82	41.18	28.52
2002	38	19	57
	66.67	33.33	19.13
2003	7	8	15
	46.67	53.33	5.03
Total	195	103	298
	65.44	34.56	100
chi-square *P*-value			0.03

Table 20 Frequency table: year of birth x delivery for DBG (n = 202)

	Delivery		
Year of Birth	Left	Right	Total
1996	4	0	4
Percent (%)	100.00	0	1.98
1997	1	2	3
	33.33	66.67	1.49
1998	8	0	8
	100.00	0	3.96
1999	25	6	31
	80.65	19.35	15.35
2000	44	23	67
	65.67	34.33	33.17
2001	32	25	57
	56.14	43.86	28.22
2002	19	7	26
	73.08	26.92	12.87
2003	3	3	6
	50.00	50.00	2.97
Total	59	29	88
	67.05	32.95	100
chi-square *P*-value			0.47

Table 21 Frequency table: year of birth x delivery for DS1 (n = 88)

	Delivery		
Year of Birth	Left	Right	Total
1998	3 100.00	0 0	3 2.86
1999	15 83.33	3 16.67	18 17.14
2000	13 61.90	8 38.10	21 20.00
2001	33 70.21	14 29.79	47 44.76
2002	7 53.85	6 46.15	13 12.50
2003	0 0	2 100.00	2 1.90
Total	71 68.27	33 31.73	104 100.00
chi-square *P*-value			0.10

Table 22 Frequency table: year of birth x delivery for DS (n = 104)

	Delivery		
Year of Birth	Left	Right	Total
1996	2	0	2
	100.00	0	0.82
1997	1	2	3
	33.33	66.67	1.23
1998	6	1	7
	85.71	14.29	2.88
1999	26	7	33
	78.79	21.21	13.58
2000	47	24	71
	66.20	33.80	29.22
2001	45	27	72
	62.50	37.50	29.63
2002	26	17	43
	60.47	39.53	17.70
2003	5	7	12
	41.67	58.33	4.94
Total	158	85	243
	65.02	34.98	100.00
chi-square *P*-value			0.19

The relationship between color and temperament did not contribute to the evidence provided by Hemmer (1990) and Tozer et al. (2003) in establishing a relationship between coat color and aggression. In all datasets (Table 23, Table 24, Table 25 and Table 26) the chi-square test was not significant. It is possible that with a larger sample size or more structured data set, a relationship, if it exists, could be established.

Table 23 Frequency table: aggression x color for DAB (n = 463)

	Color								
Aggression[a]	Black	Brindle	Brown	Gray	Red	Spotted	White	Yellow	Total
0	102	18	24	10	50	68	11	12	295
Percent (%)	22.03	3.89	5.18	2.16	10.80	14.69	2.38	2.59	63.71
1	59	9	17	4	28	34	8	9	168
	12.74	1.94	3.67	0.86	6.05	7.34	1.73	1.94	36.29
Total	161	27	41	14	78	102	19	21	463
	34.77	5.83	8.86	3.02	16.85	22.03	4.10	4.54	100
chi-square *P*-value								0.96	

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 24 Frequency table: aggression x color for DS (n = 213)

Aggression[a]	Color								Total
	Black	Brindle	Brown	Gray	Red	Spotted	White	Yellow	
0	52	9	12	5	26	27	3	7	141
Percent (%)	24.41	4.23	5.63	2.35	12.21	12.68	1.41	3.29	66.20
1	24	4	6	2	14	15	5	2	72
	11.27	1.88	2.82	0.94	6.57	7.04	2.35	0.94	33.80
Total	76	13	18	7	40	42	8	9	213
	35.68	6.10	8.45	3.29	18.78	19.72	3.76	4.23	100
chi-square *P*-values								0.44	

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 25 Frequency table: aggression x color for DBG (n = 272)

Aggression[a]	Color								Total
	Black	Brindle	Brown	Gray	Red	Spotted	White	Yellow	
0	60	8	16	3	31	41	4	7	170
Percent (%)	22.06	2.94	5.88	1.10	11.40	15.07	1.47	2.57	62.50
1	42	6	12	3	12	21	5	1	102
	15.44	2.21	4.41	1.10	4.41	7.72	1.84	0.37	37.50
Total	102	14	28	6	43	62	9	8	272
	37.50	5.15	10.29	2.21	15.81	22.79	3.31	2.94	100
chi-square *P*-value								0.44	

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 26 Frequency table: aggression x color for DS1 (n = 88)

	Color								
Aggression[a]	Black	Brindle	Brown	Gray	Red	Spotted	White	Yellow	Total
0	18	1	6	3	14	12	1	4	59
Percent (%)	20.45	1.14	6.82	3.41	15.91	13.64	1.14	4.55	67.05
1	8	2	5	1	3	7	2	1	29
	9.09	2.27	5.68	1.14	3.41	7.95	2.27	1.14	32.95
Total	26	3	11	4	17	19	3	5	88
	29.55	3.41	12.50	4.55	19.32	21.59	3.41	5.68	100
chi-square *P*-value								0.50	

[a]Non-aggressive is denoted as 0 and aggressive is denoted as 1

The next set of frequency tables represent year of birth and aggression (Table 27, Table 28, Table 29, Table 30) in these four respective datasets

Table 27 Frequency table: year of birth x aggression for DAB (n = 271)

Year of Birth	Aggression[a] 0	1	Total
1996	1	3	4
Percent (%)	0.37	1.11	1.48
1997	2	1	3
	0.74	0.37	1.11
1998	6	1	7
	2.21	0.37	2.58
1999	25	11	36
	9.23	4.06	13.28
2000	58	18	76
	21.40	6.64	28.04
2001	44	36	80
	16.24	13.28	29.52
2002	35	18	53
	12.92	6.64	28.04
2003	6	6	12
	2.21	2.21	4.43
Total	177	94	271
	65.31	34.69	100
chi-square *P*-value			0.06

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 28 Frequency table: year of birth x aggression for dataset DBG (n = 180)

Year of Birth	Aggression[a] 0	1	Total
1996	1	3	4
Percent (%)	25.00	75.00	2.22
1997	2	1	3
	66.67	33.33	1.67
1998	4	1	5
	80.00	20.00	2.78
1999	20	8	28
	71.43	28.57	15.56
2000	46	15	61
	75.41	24.59	33.89
2001	24	26	50
	48.00	52.00	27.78
2002	15	8	23
	65.22	34.78	12.78
2003	4	2	6
	66.67	33.33	3.33
Total	116	64	180
	64.44	35.56	100.00
chi-square *P*-value			0.07

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 29 Frequency table: year of birth x aggression for dataset DS (n = 212)

	Aggression[a]		
Year of Birth	0	1	Total
1996	0	2	2
Percent (%)	0	100.00	0.94
1997	2	2	3
	66.67	33.33	1.42
1998	4	0	4
	100.00	0.00	1.89
1999	20	10	30
	66.67	33.33	14.15
2000	48	14	62
	77.42	22.58	29.25
2001	34	27	61
	55.74	44.26	28.77
2002	27	11	38
	71.05	28.95	17.92
2003	6	6	12
	50.00	50.00	5.66
Total	141	71	212
	66.51	33.49	100.00
chi-square *P*-value			0.044

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 30 Frequency table: year of birth x aggression for DSI (n = 88)

Year of Birth	Aggression[a] 0	1	Total
1998	1	0	1
	100.00	0	1.14
1999	11	7	18
	61.11	38.89	20.45
2000	17	3	20
	85.00	15.00	22.73
2001	22	14	36
	61.11	38.89	40.91
2002	7	4	11
	63.64	36.36	12.50
2003	1	1	2
	50.00	50.00	2.27
Total	59	29	88
	67.05	32.95	100.00
chi-square *P*-value			047

[a] Non-aggressive is denoted as 0 and aggressive is denoted as 1

Table 31 Pearson's Correlation Coefficients involving buckoff and number of outs across all datasets

Variables Evaluated	DAB	DS	DBG	DS1
Buckoff x Outs	0.21	0.10	0.08	0.07
P =	<.0001	0.10	0.15	0.50
Career Buckoff x Career Outs	0.27	0.22	0.30	0.06
P =	<.0001	0.002	<.0001	0.55

The Pearson's Correlation Coefficients between buckoff (both for 2006 and career average) and outs (and career outs) were calculated for all of the datasets in order to explore whether there was any relationship between those variables. The dataset DAB (Table 31) showed that the relationship between buckoff and outs and career buckoff and career outs was strongly associated (*P*<.0001) but they were not highly related (correlation coefficients of 0.21 and 0.27, respectively). The dataset DS showed a relationship between buckoff percentage and outs (*P* = 0.10) but there was still not enough of a relationship to be considered an effect. There was a significant correlation between career buckoff percent and career outs but they do not influence each other. In DBG the buckoff percentage and outs were not related in this data; however, the career buckoff percent and the career outs was (*P* <.0001) and although there was a low relationship between the two variables, this correlation was the highest of all of the datasets with a value of 0.30. The dataset DS1 was not significant.

GENERAL CONCLUSIONS AND IMPLICATIONS

There are many other factors not listed above that may be contributing to the performance of the bulls including the flank strap, travel time to the events, nutrition, arena flooring, for example, that also contributes to the score and may also contribute to the buckoff percentage of a bull. This project did not address many of these other contribution due to the difficulty of getting measurements and obtaining the information. It would also require a series of trials in order to establish repeatability and to identify ideal pressures of the flank strap.

Aggression

When calculating temperament it became a question of how to accurately represent temperament given the constraints at rodeo events. To begin with, these bulls were videotaped after traveling, sometimes a few miles and sometimes across the country. Different bulls at the same event could have completely inconsistent travel experiences which could cause altered behavior. Alternatively, bulls with more experience appear to travel better, though further research on travel time and performance should be undertaken, and therefore are expected to have more consistent performances. Additionally, it was not feasible to conduct normal temperament tests, such as the Flight Speed Test, since the bulls were performing during the data collection. Had flight speed scores been collected prior to bucking it could have negatively affected the performance of the bull. Conversely, had the bulls been scored after their performance it could have been skewed by the event. Therefore, the decision was made to view temperament when they were performing to get a consistent reading across multiple events.

Laterality

The results were as expected based on previous studies conducted on laterality. Further research should be conducted in order to more accurately determine whether there is a stronger correlation between delivery and temperament. The sample size and the type of temperament scoring system used in this study may not have accurately represented the relationships between brain-sidedness and performance. The learning ability may correlate to bucking ability or consistency which could prove important in breeding selection and training methods. This may be established by understanding if the bull is left or right brained and therefore, training may be able to be adjusted to learning ability.

Pedigree Information

The information that was available limited the ability of this study to fully analyze the significance of the sires and dams. The registry provided by the A.B.B.I. (2008) was lacking in not only pedigree information, but also the accessibility of the information. This needs to be improved for future research to adequately represent the animals being studied.

There were observed characteristics such as year of birth and coat color that contributed to the performance, or score, of the bucking bulls in this study. The aggressiveness of a bull did not appear to affect the score one way or another. However, the aggression appeared to have a relationship with the year of birth (age) of the bulls according to the chi-square test. This information may be useful to producers who select sires and dams based on aggression believing the more aggressive bulls perform better than less aggressive bulls.

The number of outs a bull had, whether in a year or over a career, showed an influence on the score. This may be due to the fact that the better bulls end up competing at different events and therefore have higher scores. However, there may, in fact, be a point of diminishing returns on not bucking a bull enough or bucking a bull too much. That was not evaluated in this project but future studies may prove this possibility beneficial to producers and stock contractors in their overall bull management.

The buckoff percent was influential in the score but this may actually be a byproduct of the score to begin with. The judging criteria do not consider buckoff to be actual criteria for the score, but rather, it may be the culmination of the criteria: spin, direction change, speed, power and drop (PBR, 2008). If a bull were to show power, speed and direction change it would increase his score but also make it harder for the rider to stay on, which is likely to result in a buckoff. Therefore, bulls with higher scores may tend to have more buckoffs because they are meeting the judging criteria and making the ride more difficult for the bull rider.

Delivery played an important role in the project. There was no association between delivery and temperament so the role of brain-sidedness was not established.

However, there were interesting relationships between delivery and coat color and delivery and year of birth which should be further explored.

When sires were added to the analyses it appeared that sire influenced many of the traits associated with score as evidenced by the increased R-square values. These traits are likely heritable, which would prove useful in the establishment of breeding values or EPDs. The effect of pedigree may have been further established had the pedigree information been available for use in the study. Evidence appears to be adequate to justify documenting pedigrees for bucking stock breeding animals. However, further research should be conducted to identify the heritabilities of the traits associated with bucking performance.

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