ASSESSMENT OF FOOT SCORE TRAITS ON BULL PRODUCTIVITY

A Thesis

Presented to the

Faculty of the College of Graduate Studies and Research

Angelo State University

In Partial Fulfillment of the

Requirements for the Degree

MASTER OF SCIENCE

by

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May 2021

Major: Animal Science

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ACKNOWLEDGEMENTS

First and foremost, I would like to thank my committee members: Dr. Chase Runyan, Mr. Corey Owens, Ms. Audrey Zoeller, and Dr. Laurence Musgrove for their support and time throughout the process. Thank you to my advisor Dr. Chase Runyan for taking me on as a graduate student, it has been an incredible honor to learn from you. You have mentored me through graduate school and constantly encouraged me through the process. Thank you to Mr. Corey Owens and Ms. Audrey Zoeller for being a mentor through undergraduate and graduate school, encouraging me to be the best version of myself. Additionally, thank you to Dr. Will Dickison for being an additional advisor throughout my time at ASU; I will treasure the time we spent working together on competitive contests for high school and middle school students.

Secondly, I would like to thank Angelo State University and Angelo State University Department of Agriculture for their generosity and investment in my education. With the support of these entities, I was able to focus on my education, research, and student success.

Additionally, I would like to take a moment to thank God for the opportunities that I had throughout my time at Angelo State University. I would not be where I am without the love and support of my family. My mom Michelle Felger, brother, Shane Lockhoof, and grandparents, Tom and Ruth Felger, for always believing in me, supporting me, and reminding me I can do anything. Thank you to Clay Heger and family for their patience, love and support throughout the process. To the friends that have helped and supported me along the way Kalynn Hardegree, Ashley McGinnis, Courtney Shields and Brooklyn Dendle.

ABSTRACT

The objective of this study was to evaluate foot score guidelines developed by the American Angus Association in correlation to bull fertility. Angus bulls were utilized (n=167) over the course of six years (bulls born in 2014 through 2020) from Angelo State University's Registered Angus cattle program. Confirmation of the claw set and foot angle were evaluated, receiving a numerical score utilizing the American Angus Association Guidelines. Bull productivity was evaluated as weight measures along with scrotal circumference (measurement of the testes at the largest portion in centimeters) and a numerical scoring method for motility. Pearson Correlation Coefficient analysis was used to compare yearling-age foot scores with productivity traits. Detection of significantly correlated variables ($P \leq 0.05$) was observed for recorded weaning weight and yearling weight measures with recorded scrotal circumferences (0.47 and 0.52 respectively). The objective of the study is to evaluate the relationship of foot scores in Angus bulls with scrotal circumference and sperm cell motility. Scrotal circumference and sperm cell motility were lowly correlated with ankle scores of 0.14. The standard error values for scrotal measures with regard to the ankle scores of 3 and 7 was 0.63 whereas the standard error values for scores 4 through 6 range from 0.25 to 0.28. With regard to "marginally unsound" cattle with foot scores of 3 or lower, it is not unreasonable to speculate that these bulls were limited, to some degree, in their movement or skeletal organization and therefore physiologically unable to develop, grow, and perform.

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INTRODUCTION

In beef cattle, there are a number of factors that can affect performance and disrupt economic income for ranchers. A trait that can be seen in live cattle is structural (skeletal) soundness. The skeleton of cattle is centered around the movement of the joints, while the legs and hooves are correlated with their ease of movement (Herring 2014). The ability for the animal to move can have a direct impact on an animal's function and the longevity of their production (Herring 2014). Beef cattle travel throughout acres looking for a source of food, water, and shelter. The ease or difficulty of movement contributes to their ability to travel the distance needed to survive the terrain that they encounter.

For beef and dairy producers, economic loss is to be avoided as it can negatively impact bottom-line revenue. Producers pay for the development and routine health of an animal; additional treatments in maintaining hoof and leg health are a cause for economic loss. An animal's longevity can impact a producer's overall income from an animal; the longer an animal lives, the greater number of offspring can then be sold. Producers who are frequently having to cull excessive numbers of breeding-age animals and replace with current year's offspring see an additional cost in waiting for replacements to reach reproductive maturity while still developing them through feed and medical needs.

As an inherited trait, hoof structure and leg conformation can be passed to offspring. The practice of keeping or culling cattle can be utilized within the industry to help eliminate those traits that are undesirable or utilize traits that are preferred in offspring. Culling, or

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removing of characteristics, can also help reduce negative economic impacts that producers could potentially have due to additional medical requirements of inferior performing animals. Keeping animals that have positive characteristics could potentially lead to a larger gain for producers as these characteristics could be seen as more valuable to buyers. Producer's cull those that are not structurally sound; though culling gets rid of the animal, there could be economic impacts on the producer.

The American Angus Association has a scoring guideline which can be utilized by seedstock producers to evaluate their herd's ankle angle and claw set. Evaluation of the guidelines to justify the demographic of age when evaluating hoof health will assist producers in making selections in correlation with their herd health goals. The American Angus Association guidelines utilize a scoring method to evaluate both the foot angle and the claw set on a numerical score from 1-9. In both foot angle and claw set, the ideal number observed is that of a 5. Scoring should take place for yearling bulls and heifers prior to hoof trimming.

OBJECTIVES

1. Evaluate the correlation of foot and ankle scores with traditional measures of growth in developing, yearling Angus bulls.
2. Assessment of the relationship of Angus cattle foot and ankles scores with bull fertility traits.

LITERATURE REVIEW

Foot and leg structure are essential for beef cattle as they can contribute to their longevity including effective mating and their overall performance (McGuire 2019, Jeyaruban et al. 2012; Van Marle-Koster et al. 2019; Giess 2017). Livestock with joint and or foot issues tend to spend less time grazing and remain in poorer conditions than those with ideal feet. Greer et. al. (1980) and Dekkers et. al. (1994) express that a cow's ability to be successful within a herd is correlated to the structure of the animal's feet and legs, as they play an important role in the ability of movement. Throughout the skeleton, there are multiple connections that allow for the body to move with ease; when moving becomes difficult, the animal will have to compensate elsewhere thus impacting an animal's welfare (Vollmar 2016). Herring (2014) states that the skeleton of cattle is structured with alignment towards the legs, their relative appearance and movement which can have direct impacts on animal's functionality and longevity. Locomotion has been described as the ease of movement an animal can exhibit (Boelling and Pollott 1998). Lameness can be contributed to numerous factors including that of undesirable foot and leg structure which, as a result, effects their "locomotion". Lameness is caused by a variety of diseases that affect the hoof causing problems associated with walking (Tomlinson et. al 2004). Other lameness issues can develop from injury during mating, nutritional deficiencies, toxicities, weather and terrain.

In a cattle operation, there is a direct correlation between number of offspring produced and profit. Beef cattle need to have survivability, fertility, and longevity in order to be effective producers in a herd, and to separate the three would be difficult as they are all intertwined with one another (Herring 2014). The practice of keeping and culling can be utilized by producers to offset undesirable traits for those that can be more profitable, even at a young age, to decrease the input cost for development. Producers conduct bull soundness exams to ensure their fertility; the inability for a bull to successfully reproduce requires producers to input costs that will not receive a return due to the inability to reproduce (Thundathil et. al 2016). Bull Breeding Soundness Evaluations (BBSE) are done at yearling age, evaluating reproductive traits and their ability to successfully reproduce. The BBSE has multiple components; an important evaluation is of semen which is evaluated under a microscope assessing gross motility (or the mass movement) and individual motility (or progressive motility) (Chenoweth and McPherson 2010). Motility of a fresh semen sample gives you a good idea of his ability to breed cows as well as the chance for preservation of those genetics through semen freezing. Motility is absolutely critical to a bull's ability to produce offspring. Another component is the measurement of the scrotal circumference and the evaluation of the testes; testes should be even in size while the scrotal circumference should be measured around the widest part of the testes in centimeters (Chenoweth and McPherson 2010). Scrotal circumference is a trait that has been used extensively when estimating fertility in the progeny of that sire. The combination of scrotal circumference and motility can help create fertility estimates for bulls to ensure reproductive success (Chenoweth and McPherson 2016).

Seedstock producers have begun to evaluate and select for traits that attribute to foot and leg structure as it can attribute to the longevity of cattle in their herd (Giess 2017). Red Angus beef cattle producers predominately utilize Stayability EPD (STAY) to determine the longevity (Giess 2017). Longevity of both dairy and beef cattle is pertinent to the economic benefit of producers so that development costs do not occur more than once. The productive life of a cow impacts development costs, average herd age, weaning weights, total revenue and many other important aspects of cattle production systems. Poor structure can affect the lifespan of cattle causing an increased cost for replacements and development (Herring 2014).

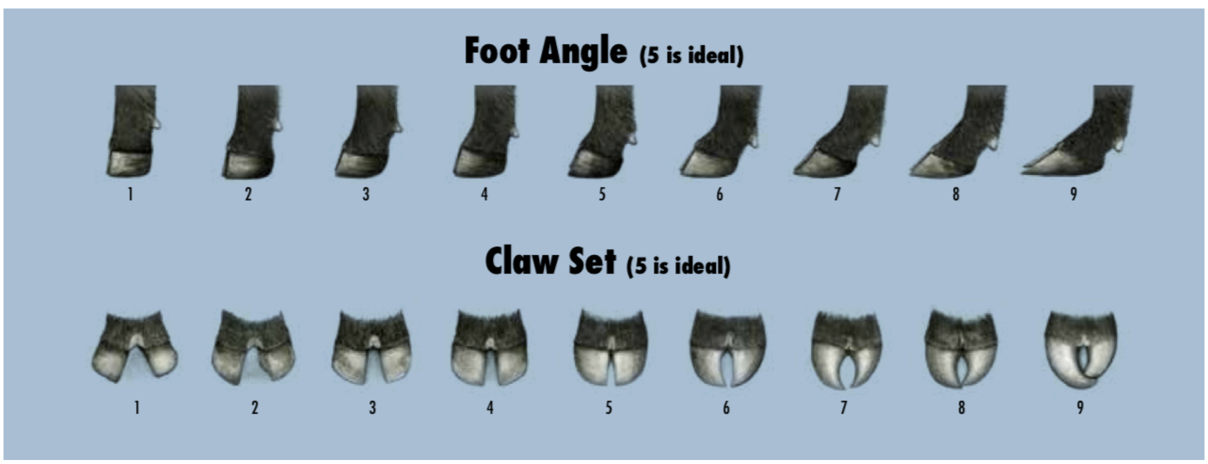
Lack of physical soundness can directly result in culling of a cow or bull, thus effecting a producer's profit margin. Cattle with hoof abnormalities will become unprofitable. Farmers believe hoof abnormalities are associated with genetics; therefore, they have reached out to dairy breed associations to emphasize the evaluation of hooves (Hanh et al. 1984). Poor foot and leg structure have resulted in economic losses in dairy cattle due to additional cost of treatment, medicine, and increased labor for treatment (Jeyaruben et al. 2012). Poor foot structure can be due to genetics, breed, age, body weight, environment, ground or floor type, changes in management, or diet (Vollmar 2016). Morphology of the claw can be described as the angle of the toe, heel height, heel angle, dorsal border length, and ground circumference (Van Marle-Koster et al. 2019). The American Angus Association has begun evaluation of two specific traits related to foot structure including foot angle and claw set. Evaluation of the two traits should be done separately as there is a low genetic correlation (0.22) between foot angle and claw set (Wang et al. 2017). Understanding the genetic correlation behind traits is critical to making decisions that can improve the herd characteristics. Evaluation according to the American Angus Association guidelines is based on a numerical scale of 1-9; scores of 1-3 and 7-9 are seen as undesirable, whereas 4-6 are desirable. Claw set is seen to be uniform; the space between the lateral and medial claw should be consistent from the tip where the hoof touches the ground to where the hoof meets the leg (Giess 2017). The shape of the claw should be seen as the curvature and size of the lateral and medial claw on the hoof, in addition the space between the claws serves to evaluate the amount of divergence (Beef Improvement Federation). Scoring of hoof claw shape is based on a numerical score of 1-9; scores of 1-3 are seen as claws with a large amount of divergence and undesirable, 4-6 is desirable, and 7-9 is seen as scissor claw shape and undesirable (Figure 1). Foot angle measures the angle that is seen from the tip touching the ground to where the hoof meets the leg (Giess 2017). The ideal angle of the hoof should be 54°, which would relate to an angle of 144° for the metacarpus and foot (Herring 2014). If the angle of the foot is greater than 144° then the pastern joint will be seen as too straight or too steep, thus resulting in a score of 1-3 when scoring the angle of the foot (Herring 2014). If the angle of the foot is less than 144°, then the pastern joint will be seen as too weak, thus resulting in a score of 7-9 (Herring 2014). As seen in previous studies, cows that have more acceptable foot scores have a body condition score that is more desirable (McGuire et. al 2019). Claw abnormalities including front claw, front feet angle, rear claw, and rear feet angle are seen more prevalent in heavier weight cattle at time of slaughter. Vollmar et al. (2016) found that heavier cattle had a higher prevalence of scissor claw abnormalities as well as mobility impairment and that Northern region exhibited a higher prevalence of scissor claw defects and Bos Indicus displayed a higher number of cattle with mobility impairment.

Environmental impacts effecting hoof growth can include diet changes including vitamin and mineral concentrations needed for keratin growth of hooves. Keratinization is the process in which the epidermal cells form the structural basis of the hoof through synthesis, then the process of cornification which makes the cells dead (Tomlinson et. al 2004). Consequently, vitamins, minerals, and trace elements are essential for the process of hoof and horn formation to occur, thus producers must ensure environments provide the needed nutrients (Tomlinson et. al 2004). While the environment can aid in hoof growth, if animals with improper toe structure are in an environment with branches or saplings, the toe can get caught and cause problems; this could be seen in cattle that have a toe score of 1-3 depicting the toes are divergent (Herring 2014). In addition, the percentage of moisture in the soil and ground can affect the moisture in the hoof leading to deformities and hoof health disorders. When hooves remain moist, they serve as a potential habitat for certain bacterial species. In an environment that the ground is hard, cattle's hooves typically do not have issues growing too long, but in soft soil it can become a problem in which claws grow too long (Herring 2014). Cattle in colder weather can experience blood vessels being constricted and therefore less oxygen and needed nutrients for the cells that contribute to the growth of the hoof (Van Marle-Koster et al. 2019).

MATERIALS AND METHODS

Data was collected from Angus cattle at the Angelo State University Management, Instruction and Research (MIR) Center located six miles north of San Angelo, Texas on the north shore of O.C. Fisher reservoir from 2014 to 2020. The center consists of 6,000 acres of native rangeland and farmland. Measurements were assessed by considering Front Hoof Angle (FA), Front Hoof Depth (FHD), Front Claw Shape (FC), Rear Hoof Angle (RA), Rear Hoof Depth (RHD), and Rear Claw Shape (RC). A visual rubric utilized from the American Angus Association provided a resource in identifying proper scoring (Figure 1). Scores were based upon a scoring method of 1-9 with 5 being the ideal score (Figure 2).

Figure 1 American Angus Association Scoring Guidelines Visual



Conformation of the claw set was evaluated from the front profile in regard to the shape (curl of the claw set) and evenness of the claw set (Smith 2011). Ideal scores were seen as even, normal claws and scored as 4-6; a score of a 1-3 meant that the claws were open whereas a score of 7-9 indicated an extreme scissor. Conformation of the claw angle was evaluated from side profile in regard to the angle of the foot (Smith 2011). Ideal scores were seen as normal and received a 4-6; a score of 1-3 meant that the foot angle was steep, whereas 7-9 indicated a shallow heel. Evaluation of both claw set and foot angle were conducted on a flat, level surface with the animal in a standing position.

Figure 2 Description of Traits used by the American Angus Association Foot Score Guidelines

Foot Angle		Claw Set
Extremely straight pasterns. Very short tow. Unsound.	-1-	Extremely weak, open, divergent claw set. Unsound.
Straight front and rear pasterns. Marginally unsound.	-2-	Open, divergent claw set. Marginally unsound.
Moderately straight front and rear pasterns	-3-	Moderately open/divergent claw set.
Slightly straight front and rear pasterns	-4-	Slightly open/ divergent claw set
Ideal. Approximately 45-degree angle at pastern joint. Appropriate length of toe and depth of heel.	-5-	Ideal. Symmetrical claws, with appropriate space between claws.
Slightly shallow heel and long toe	-6-	Slight tendency for claws to curl. One claw may be slightly larger than the other.
Moderately shallow heel and long tow. Somewhat weak pasterns	-7-	Tendency for claws to curl, with one claw longer than the other.
Shallow heel and long toe. Marginally unsound	-8-	Moderate scissor claw and/or screw claw. Curling of one or both claws. Near crossing claws. Marginally unsound.
Extremely shallow heel and long toe. Extremely weak pasterns. Unsound	-9-	Extreme scissor claw and/or screw claw. Pronounced curling of one or both claws. Crossing claws. Unsound.

Evaluation of bull productivity included scrotal circumference and motility. Motility was evaluated by trained professionals on a score of 1 - 5 based on motility parameters listed in Table 1. Scrotal circumference was measured using a measuring tape around the widest part of the testes in centimeters.

Table 1. Semen grading scores for semen motility parameters

Scale	Grade	Characteristics
5	(+++++) Excellent	More than 80% of the sperm show vigorous motion. Swirls are formed due to the movements of the sperm. The movements are rapid and changing and hard to observe individual sperm samples in undiluted semen.
4	(++++) Very good	About 70-80% of the sperm show vigorous motion which causes waves and eddies but not as vigorous as the excellent grade.
3	(+++)	About 45-70% of the sperm are in motion. Motion is vigorous. Waves and eddies are formed slow across the sample.
2	(++) Fair	30-40% of the spermatozoa are in motion. Movements are vigorous. No waves or eddies present.
1	(+) poor	Little to no mobility found. < 20% of the spermatozoa are in motion. Not progressive and little oscillation.

Adapted from Hossain et al. (2012)

Trained personnel visually assessed scores on yearling-age males at the MIR Center each year from 2015 - 2020. This project assessed the effects of yearling-age foot scores on bull productivity.

Pearson Correlation Coefficient analysis was used to compare the yearling-age foot scores with several standard production traits. Proc Mixed models in SAS were used to analyze the weight data with a model that included day, claw score, ankle score, and 2-way interactions. The Pdiff option will be used to detect differences in Least Squares Means which is considered as different when $P \leq 0.05$.

RESULTS AND DISCUSSION

Angus bulls (n = 167) were evaluated for several production traits as part of the Angelo State University Registered Angus cattle program. Bulls are developed prior to breeding seasons with production characteristics including birth weight, weaning weight, yearling weight, scrotal circumference, semen motility, claw scores, and ankle scores being recorded variables across a continuous 6-year period. Pearson Correlation Coefficient analysis detected significantly correlated variables in this data that resulted in a $P \leq 0.05$ and are presented in Table 2.

Table 2. Characteristic Correlation

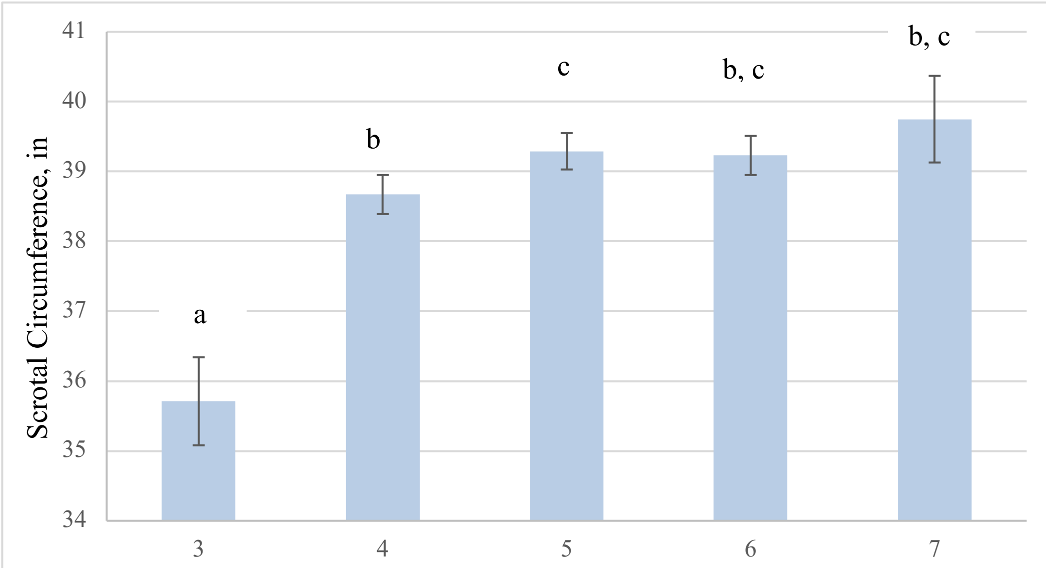
	Birth Weight	Weaning Weight	Yearling Weight	Scrotal Circumference	Motility	Claw Score	Ankle Score
Birth Weight	1.00	0.21	0.07	0.15	0.00	0.05	0.12
		0.009	*0.35*	*0.07*	*0.96*	*0.51*	*0.14*
Weaning Weight		1.00	0.73	0.47	0.09	0.00	0.06
			0.001	***0.001***	*0.31*	*0.97*	*0.43*
Yearling Weight			1.00	0.52	0.10	0.02	0.03
				0.001	*0.23*	*0.75*	*0.67*
Scrotal Circumference				1.00	0.21	0.05	0.14
					0.01	*0.55*	*0.06*
Motility					1.00	0.00	0.14
						0.98	*0.09*
Claw Score						1.00	0.07
							0.38
Ankle Score							1.00

As expected, measures of growth were positively correlated with the correlation coefficient ranges from 0.21 to 0.73 of the significantly correlated growth measures.

Additionally, weaning weight and yearling weight measures were correlated with recorded scrotal circumferences (0.47 and 0.52 respectively). Finally, the last significant correlation observed in these data was the positively low-moderate association between scrotal circumference and semen motility scores. While correlation does not necessarily imply causation in this analysis, it is widely accepted that these traits and their positive correlation coefficients are not surprising (Setiaji et al. 2019).

Because the objective of this research is to assess the relationships of foot scores in Angus bulls with various other production traits, the remainder of this report will focus on the interesting tendencies of correlation found in the Claw Score and Ankle Score variables. It was valuable to discover that there are low correlations between the claw score and ankle score and all variables that were analyzed. This would suggest that efforts in breeding systems to improve foot score and ankle score can be accomplished with little impact or unintended consequences of negatively impacting other developing bull traits. Because the foot score and ankle score Expected Progeny Differences (EPDs) have become available as selection tools in EPD rankings and Angus population evaluations in 2018, Angus bull breeders can increase therefore increase selection pressure for ideal foot scores and ankle scores without altering currently established breeding decisions. In Table 2. Scrotal Circumference and Motility were lowly correlated with ankle scores, 0.14 for each relationship, as well as the lowest *P* – values for all ankle score correlations. These tendencies were then analyzed in Mixed models of SAS and the Least Squares Means are reported in Figure 3.

Figure 3: Least Squares Means of Scrotal Circumference estimates by Ankle Score

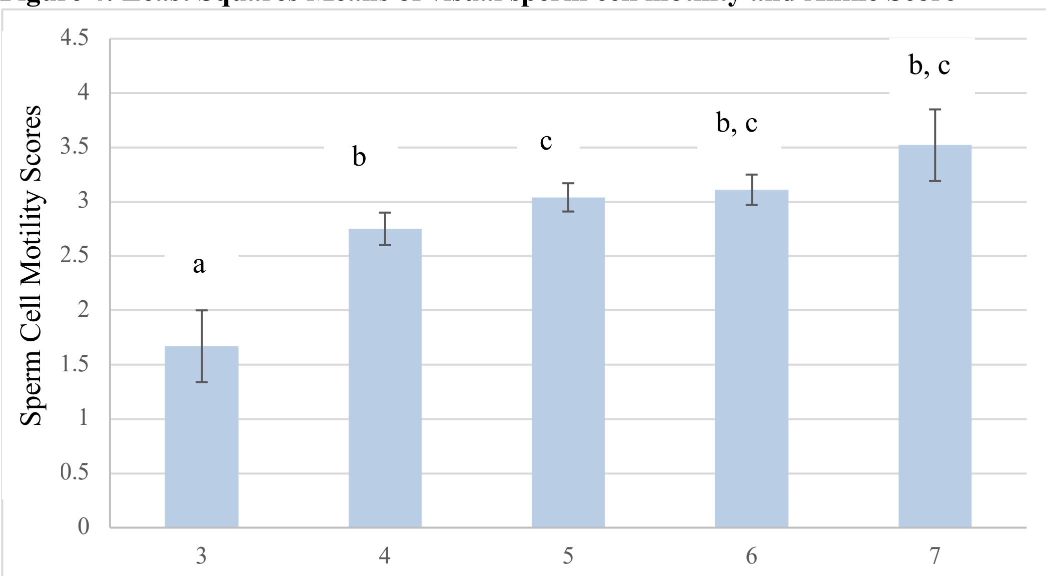


a,b,c Differing superscripts designate differences ($P \leq 0.05$)

While all bulls in this data would have a scrotal measure that is acceptable for breeding purposes, significant differences were observed as ankle score 3 bulls were the lowest of all scores. Ankle scores of 4 were higher than 3 but still lower than bulls with ankle score of 5. No differences were detected between foot scores 5, 6 or 7, however. Physiological reasons for this observation is difficult to explain at this point of the analysis, computationally however, the significance of this analysis could be due to the normal distribution of these data. The standard error values for scrotal measures with regard to the ankle scores of 3 and 7 was 0.63 whereas the standard error values for scores 4 – 6 range from 0.25 – 0.28. Suggesting that a smaller number of bulls were considered "marginally unsound" as described in figure 1 of this report. With regard to "marginally unsound" cattle with foot scores of 3 or lower, it is not unreasonable to speculate that these bulls were limited, to some degree, in their movement or skeletal organization and therefore physiologically unable to develop, grow, and perform.

Because scrotal circumference is a predictor of semen quality and sperm cell motility, it is no surprise that the motility by ankle score analysis is similar to the SC results. The LSMEANS of sperm cell motility by ankle score are presented in Figure 4.

Figure 4: Least Squares Means of visual sperm cell motility and Ankle Score



[a,b,c] Differing superscripts designate differences ($P \leq 0.05$)

These sperm cell motility values were assessed using the same trained personnel in all years of this data to minimize variation due to evaluator. The visual scoring system (described in Table 1.), is similar to standard assessment values that are used in Breeding Soundness Exams (BSE) for breeding bulls prior to breeding seasons. A BSE includes an evaluation of a breeding bull's physical breeding ability, evaluation of reproductive anatomy, and evaluation of a semen sample to assess sperm cell concentration, sperm cell morphology, and sperm cell motility (Bruner et al. 1995.) In this scoring system, bulls with a motility score of "2" or lower will fail BSE and therefore not considered as acceptable breeders. Unfortunately in this data an ankle score of 3, also implies an LSMEANS estimate of 1.67 ±

0.33 for sperm cell motility. Extreme caution is warranted when considering bulls that are both “marginally unsound” due to ankle score in conjunction with sperm cell motility with less than 50% sperm cells being motile.

IMPLICATIONS

Continued efforts to implement new knowledge, and practices are essential to meet the demand for beef of a growing and food-conscience population. Animal selection parameters must continue to consider genetic correlations when making breeding decisions that could improve the skeletal soundness, and reproductive traits to ensure an animal's ability to stay in a breeding program. The objective of this effort was to evaluate the genetic correlation that is associated with foot and claw scores in relation to characteristics productive traits like birth weight, yearling weight, mature weight, scrotal circumference, and semen motility. This study suggests that positive correlation between ankle scores to reproductive traits of scrotal circumference and motility. Furthermore, evaluation of reproductive traits and keeping those that are preferred can in turn lead to cattle having skeletal soundness associated with their ankle angles and a better chance of being considered as sound breeders in most production scenarios.

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BIOGRAPHY

Taylor Renee Lockhoof was born on December 1, 1997 in Austin Texas. Taylor was involved in the high school Texas FFA chapter where she found her love for agriculture. In May of 2016 she graded from High School and began her journey to Angelo State University in the fall of 2016. Taylor was involved in various organizations throughout the department and was a part of the 2018 meat judging team. She graduated with her Bachelor of Science with a degree in Agriculture Science and Leadership in December of 2019. Taylor decided to remain at Angelo State university to further her education and pursue a Master of Science degree in Animal Science with an emphasis in Beef Cattle. After graduation, Taylor plans on having a career in education and would like to eventually become an advocate for agriculture.