MATERNAL TEMPERAMENT AND OFFSPRING DISPOSITION AFFECT GROWTH PERFORMANCE

By

MICHAEL SIMS

Bachelor of Science in Biology

Texas A&M Texarkana

Texarkana, Texas

2013

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May 2022

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DISPOSITION AFFECT GROWTH PERFORMANCE

Thesis Approved:

Paul Beck

Thesis Adviser

Janeen Salak-Johnson

Andrew Foote

Name: MICHAEL SIMS

Date of Degree: MAY, 2022

Title of Study: Maternal Temperament and Offspring Disposition Affect Growth Performance

Major Field: Animal Science

Abstract: Cattle temperament has been described as the level of fearfulness toward humans or a novel environment. Cattle with an undesirable temperament may have increased aggression toward handlers, poor reproductive success, and reduced carcass quality. Our objectives were to observe maternal temperament during calving and subsequent influence on offspring disposition at weaning and effects on growth performance and carcass value. Maternal behaviors at calving were observed from cow herds kept at four locations within the University of Arkansas system. Cows were assigned a maternal disposition score (**MDS**) at calving. Calves were then observed at weaning and assigned a chute score (**CS**). Both scoring techniques were based on previously established scoring systems. Data were analyzed using GLIMMIX procedures of SAS ($\alpha = 0.05$). The animal was the experimental unit but blocked by location for all dependent variables. Location, sex, diet, dam age, and MDS were included in the class as covariables for all finishing growth performance and carcass data related to CS**.** A Pearson correlation was generated to evaluate the relationship between the two scoring systems. No correlation was observed between MDS and CS ($P = 0.22$). Cows that were more aggressive at calving birthed heavier calves ($P < 0.01$) than indifferent cows. Maternal disposition score had an effect on feedlot receiving weight. Calves born to cows with MDS of 2 or 3 (very aggressive or very attentive, respectively) were heavier ($P = 0.03$) upon arrival at the feedlot than those from cows with MDS of 4 or 5 (indifferent or apathetic, respectively). Calves with CS of 3 (nervous) were heavier ($P < 0.01$) at weaning than those with CS of 1 (docile). Restless calves were heavier than nervous calves at the end of the finishing phase. Also, calves that were docile at weaning had greater marbling than calves that were restless, but calves that were restless at weaning had greater lean muscle area than those that were nervous. Our findings suggest that calves with a midrange temperament may have greater growth potential throughout their lives.

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CHAPTER I

INTRODUCTION

Animal temperament is used to describe cattle's many reactions, such as nervousness, flightiness, calmness, excitability, or emotionality of animals (Stricklin and Kautzscanavy, 1984). It is also used to describe fearfulness to humans and reactivity to novel environments (Grandin, 1993). There have been disparities among researchers to describe a common definition of temperament; however, in beef production settings, it typically is defined as the characteristics of an animal's reaction to standard animal handling practices. Temperament is a measure of many behavioral characteristics displayed by animals, which can be quantified by observing behaviors deviating from a normal environment (Oliphint, 2006). Stressors have been described as factors or situations that prompt a behavioral or physiological stress response in animals. Stressors, like standard handling procedures for cattle, may produce these responses making it important to understand their effects.

Behavioral responses to stressful circumstances, such as human handling, have also been described as temperament in cattle (Café et al., 2011; Grandin, 1993; Burrow, 1997). Additionally, it can determine how an animal demonstrates maternal behaviors while exposed to routine management (Buddenberg et al., 1986). An animal's behavior can be the product of its environment, past experiences, genetics, physiological status, or novelty of the stressor (Murphy et al., 1994; Grandin, 1997; Lewis et al., 1998). Increased aggressive behavior, especially toward handlers, is associated with an undesirable temperament, resulting in poor maternal care, impaired reproduction, and reduced growth performance (Sandelin et al., 2005; Hoppe et al., 2010; Voisinet et al., 1997). Animal temperament is typically assessed by scoring an animal's behavior while in proximity to human handlers using methods like pen score (PS) (Hammond et al., 1996; Murphey et al., 1981; Le Neindre et al., 1995), chute score (CS) (Grandin, 1993; Fordyce et al., 1982), or chute exit velocity (EV) score (Curley et al., 2006; Burrow et al., 1988; Burrow et al., 1997). It is important to understand the roles that animal temperament plays in beef production situations to comprehend better its effects on economically important traits to cattle producers and overall cattle well-being.

Behaviors such as escape, freezing, aggression, avoidance, and docility are all thought to be characteristics of animal temperament (Lyons, 1989; Burrow, 1997). Petherick et al. 2002 suggest that the different tests used to assess temperament measure different facets of animals' fear responses. The degree of difficulty, or lack thereof, that producers or cattle workers have during the routine handling of animals is typically considered a predictor of temperament (Morris et al. 1994). Temperament has also been described as not only the response to handling or restraint but a lasting trait of an individual's general behavioral style, emotional tone, or responsiveness which is a ''dynamic attribute of an individual that modulates environmental influences on behavioral and physiological systems'' (Lyons, 1989). Cattle differences in emotional response depend not only on their reactivity to humans but also on the novelty of the stressor and social and environmental situations (Grignard et al. 2000). Others have described temperament as a constant individual trait, which includes an animals' excitatory or inhibitory reactions (Grandin, 1997), degree of motor activity (Hurnik et al. 1995), persistent habits, emotionality (Voisinet, 1997), and alertness (Lyons, 1989).

Cattle producers must understand and identify herd temperament since it is a valuable welfare assessment trait. Excitable cattle display a heightened fear response to avoid human handling. Research has shown that excitable cattle have higher concentrations of stress hormones and increased glucose levels (Probst et al., 2012). Unfortunately, many temperament assessment tests involve technical equipment mostly unavailable to cattle producers; however, chute scores can be a useful tool, as cattle producers often use body condition scores. By incorporating chute scores on the farm, producers may better understand the state of animal welfare within the herd.

CHAPTER II

REVIEW OF LITERATURE

Methods of Cattle Temperament Assessment

It has been suggested that improvement of temperament in domestic livestock will reduce the amount of stress experienced during handling (Burrow, 1997). Therefore, research with the intention of improving animal temperament should likewise advance animal welfare as well as improve a product from an economical perspective. In beef production, poor temperament has negatively impacted cattle productivity and overall well-being (Fordyce et al., 1988). Cattle that exhibit wilder temperaments have lower weight gains (Burrow, 1997), increased injuries during transportation (Fordyce et al., 1988), and reduced meat quality (Voisinet et al., 1997). The temperament and disposition of cattle relate to how the animal reacts in a particular situation. However, an individual's behavior most likely reveals important personality characteristics of that animal. It is vital to understand better beef cattle temperament, including animal and handler safety (Grandin, 1997) and the economic factors that contributed to reduced growth performance in beef cattle (Voisinet et al., 1997). Equally important to determining how heritable these behaviors are (Schmutz et al. 2001). Tools for determining cattle temperament must be indicative of the animal's stress responsiveness and be consistent and repeatable. While techniques have been developed to gauge animal temperament, many are subjective and allow human error to affect the assessment.

A scoring classification system was developed in the 1960s to determine differences in cattle temperament (Tulloh, 1961). The scheme was used to describe temperamental behaviors related to determining the degrees of temperament. Initially, behaviors of British breed cattle were recorded as individuals upon entering the scale, squeeze chute, and the bail, or exiting the pen and behaviors while alone in the exiting pen. Based on these behaviors, Tulloh classified temperament scores on a scale of 1 to 6, that as aggravation or irritation increased, the number increased. The resulting scores were defined as follows: a score of 1 described a docile animal that stood in the bail, rarely moved except to raise or lower head, and may lean forward or backward or against the side crush—this animal is unperturbed by the procedures; a score of 2 described a docile animal that was slightly restless, moved frequently, occasional tail flicks, and blows quietly; a score of 3 described a restless animal the continuously moves while pushing or pulling on the bail and pushing the sides of the crush, frequent tail flicks, snorts, and resistant to ear-tagging procedures; a score of 4 described a nervous animal, very restless and quivers when a hand is placed on its back and defecates while in bail; a score of 5 describes a wild animal that is extremely restless and violently struggles, and loudly bellows and froths at the mouth; and a score of 6 describes a very wild aggressive animal that attacks observer by kicking, or butting them by lunging forward in bail during head measurements. A problem with Tulloh's system was that all animals that received scores of 2 or higher were considered potentially "stubborn" animals; thus, this characteristic is a poor indicator of temperament. Other behaviors that can be used to assess cattle temperament include exit velocity and chute scores. Exit velocity is assessed by observing and calculating the speed at which the animal exits and the distance it travels post-handling. Early studies have shown that the restrained chute test and chute exit velocity scores are practical methods for determining animal temperament (Burrow et al., 1988; Grandin, 1993).

Human-cattle interactions frequently occur in beef, mainly through animal handling during different standard management practices. Both exit velocity and chute scores are frequently used to assess temperament (Burrow et al., 1988; Grandin, 1993; Curley et al., 2006). Chute scores are subjective measurements and should be used with other objective measures since objectives measures attempt to assess behaviors similar to chute scores but related to production traits (Manteca and Deag, 1993; Curley et al., 2006; Sebastian et al., 2011). Moreover, many assessments for determining animal temperament require equipment that may be a financial burden to cattle producers. It may be plausible to use other assessment measures such as body condition scores in conjunction with chute scores. It may be a feasible tool for producers if it can be determined that chutes scores can be effectively used to determine herd temperament.

Heritability of Cattle Temperament

Temperament is an important heritable trait in cattle for reasons such as animal welfare (Burrow, 1997), economic benefit (Petherick et al., 2002), and handler safety (Grandin, 1993). Temperament is influenced by genotype and past experiences (Fordyce et al. 1982). Research shows that cows have a strong influence on the temperament of their calves through both genetic transference (Kadel et al., 2006) and early life calf experience gained from their mother (Grandin, 1993). Therefore, selection pressure can be put on a breeding program to adjust herd temperament to something more manageable.

Previous studies conducted to determine estimates for heritability of behavior have included factors known to affect behavior, including genetics (Morris et al., 1994; Hoppe et al., 2010), sex (Hoppe et al., 2010; Wyatt et al., 2013), age (Sato, 1981), maternal influence (Fordyce and Goddard, 1982), animal experience (Fordyce et al., 1988; Grandin, 1997), and chute scores (King et al., 2006). More specifically, Burrow (1997) found heritability estimates for temperament to be between 0.23 and 0.36, including chute scores, exit velocity, exit distance, disposition, and temperament scores. These estimates indicate temperament is a moderately heritable trait in cattle.

Cattle with undesirable temperaments are not only difficult and potentially dangerous to handle, but the relationship with other traits makes it necessary to determine temperament to attempt to increase production efficiency. Due to variability in animal behaviors, assessing temperament should be made over multiple observations to give a better idea of an individual's true temperament. Human contact occurs more frequently in feedlot situations than in pasture conditions, and production differences from temperament are possible due to increased exposure to handling. Research shows that animals can habituate to chute exposure after repeated use (Stookey et al., 1994). That movement on a scale may decrease over 5 to 10 days (Piller et al., 1999). Another study by Sebastian et al. (2011) found that cattle did not habituate to the chute; thus, their stress response increased over time, mainly due to infrequent handling. Differences among researchers are likely more likely due to habituation or observer bias, which may reflect the subjectivity of temperament tests. Other causes for differences in results may also be credited to cattle growth that requires more movement in the chute, which becomes mistakenly associated with increased agitation. Lyons (1989) suggests that measurement subjectivity or observer bias is unavoidable in behavior studies and that instruments used in behavior research cannot give holistic information on animal temperament. Sebastian et al. (2011) also determined inter-individual behavioral variability and within individual consistency/repeatability in the manifestation of temperament occurred regardless of the type of temperament assessment used. It is possible to relate differences in behavior if temperament is consistent with other production traits that have direct economic importance to producers.

Growth Performance and Temperament

The adverse effects caused by stressors such as human handling affect cattle's well-being and can result in economic issues for producers and consumers. Since cattle temperament affects growth and performance, feeding efficiency, carcass characteristics, and meat quality, this ultimately affects the beef industry (Voisinet et al., 1997; Petherick et al., 2009). Cattle with calm temperaments, as defined by Cooke et al. (2011), have significantly greater average daily gain (ADG) than those with higher temperament scores (Voisinet et al., 1997; Francisco et al., 2015). Voisinet (1997) found that cattle with calm temperament (no movement during restraint) gained 0.15 kg/d than those who were more agitated or wild. Francisco (2015) found that cattle with "adequate" (chute score ≤ 3) temperament were 29 kg heavier over 109 days compared to "excitable" (chute score >3) cattle. In a 2010 study, Hoppe (2010) and others found that as chute scores increased, average daily gain decreased, suggesting that less docile animals are less productive. Cattle that exit a restraint chute more slowly have more rapid weight gain and have greater live weights than cattle that exit quickly (Burrow and Dillon, 1997; Voisinet et al., 1997; Müller et al., 2006; Café, 2014). Francisco (2015) showed that both weaning BW and hot carcass weight decreased in excitable (chute score > 3) calves. Café et al. (2014) demonstrated that cattle with higher temperament scores tended to spend less time eating and had reduced dry matter intake than calmer cattle.

Researchers have determined that cattle with lower chute scores had greater performance across beef production traits (Café et al., 2014). Café and others found that increasing chute score prior to feedlot entry was associated with reduced mid-feedlot body weight ($P = 0.027$), reduced background average daily gain ($P = 0.016$), and a tendency toward reduced body weight ($P = 0.09$) at the end of the feedlot period. Increased feedlot chute score was related to reduced body weight at the beginning of backgrounding ($P = 0.034$), mid feedlot ($P < 0.001$), and at the end of the feedlot period ($P < 0.001$), and to reduced feedlot ADG ($P = 0.003$) and DMI ($P = 0.001$). Feed intake per session also decreased ($P = 0.020$) with increasing background chute score and tended to decrease ($P = 0.05$) with increasing feedlot chute score.

Adverse effects of hostile temperament on growth in beef cattle (Voisinet et al., 1997; Cooke et al., 2018) and reproductive development in beef heifers and cows (Fordyce et al., 1988; Cooke et al., 2011) have been reported. Cattle with poor temperament have been shown to have reduced growth (Burrow and Dillon 1997), lower feed-to-gain conversion (Voisinet et al. 1997), and lower dressing percentages (Petherick et al. 2002) than those with a calm temperament. Petherick et al. (2002) suggested that causes for reduced performance in cattle are increased arousal state and fearfulness. Research has shown that poor temperament can have lifelong effects on animal growth performance. The effect of poor temperament on growth development would be vital to determine as early in the animal's life as practical.

Voisinet (1997) determined that feedlot cattle with excitable temperaments had an increased tendency to have tougher and dark cutters. Temperament can affect meat quality by creating a product with significantly higher proportions of dark cutters in nervous or wild cattle, leading to quality grade discounts (Voisinet, 1997). Fordyce (1988) reported that nervous cattle had greater carcass bruising and bruise scores than calm cattle and showed bruise trim per carcass increased by about 0.3 kg per unit increase in temperament score. Cattle with excitable temperaments have inferior meat quality traits than calmer cohorts (Voisinet et al., 1997; Vann, 2011). Llonch et al. (2017) determined that feed intake was lower in more temperamental steers. Feed efficiency increases with cattle feeding longer feeding and with more frequent meals. As dominant steers eat more frequently and for longer, reducing competition at the feeder would improve feed efficiency. Feed efficiency can also be improved through a reduction in inactivity. Selection for calmer cattle would reduce activity and increase feed intake, improving feed efficiency and promoting growth.

Effects of Stress on Cattle Health and Welfare

The cow's poor temperament can negatively affect the progeny's genetic potential. Vann et al. (2017) demonstrated that calf temperament, body weight, and ADG were associated with dam temperament, partly due to the effect during fetal development. An unfavorable intrauterine environment may result in long-term consequences on metabolic growth and the stress axis of the offspring via epigenetic programming or fetal reprogramming. Fetal programming is a change in the fetus's response to a specific insult during a critical period of prenatal development (Zambrano et al., 2014). The placental environment is of vital importance in fetal development and can significantly influence the overall productivity of livestock. Understanding how the maternal environment influences placental growth and development is imperative because it directly impacts fetal development. Despite production animals spending only 25% of their life in utero from conception to slaughter, any negative effects that alter the environment can have long-lasting effects on the offspring. The potential for prenatal growth is sensitive to both direct and indirect effects of the maternal environment, especially during the early stages of embryonic life (Vonnahme et al., 2007). Maternal stress may affect fetal development directly through hormonal regulation of fetal genes through the maternal-fetal interface or indirectly through modification of the placental environment and its function (Merlot et al., 2008).

Prenatal Exposure to Maternal Stress

Although cortisol increases during pregnancy and reaches its peak in the third trimester, too much cortisol can impact fetal development. Glucocorticoids, being able to cross the placental barrier, help mediate prenatal stress to the fetus if regulated correctly. In pigs, glucocorticoids have been shown to cross the placental barrier (Klemcke, 1995) and affect prenatal tissue growth (Muglia et al., 1995). Maternal cortisol is regulated by the enzyme 11β-hydroxysteroid dehydrogenase type 2 (11β-HSD2) found in the placenta, which maintains low maternal cortisol levels (Benediktsson et al., 1997). Despite this regulatory mechanism, 25% of maternal cortisol still reaches the fetus, and if the 11β-HSD2 activity is suppressed or inactivated, this can result in too much exposure (Otten et al., 2004). High glucocorticoid concentrations in pregnant females have been shown to cause reduced growth, dysregulation of the HPA axis, behavioral alterations, and glucose intolerance in the offspring (Kapoor et al., 2006).

The role of hormones in regulating fetal growth and the development of fetal tissues have been identified using a range of techniques, including removal of fetal endocrine glands, hormone supplementation to the fetus and mother, and gene knockout and disruption experiments (Fowden, 1995). Hormones can affect tissue growth and variation in utero, and specific hormone deficiencies have been associated with intrauterine growth restriction. They also show that hormones act on fetal growth directly, via genes, and indirectly, through changes in placental growth, fetal metabolism, and/or the production of growth factors and other hormones by the placental tissues (Fowden, 2003). Hormones present in fetal circulation are sourced from several pathways and may be secreted by the endocrine glands of the fetus. The fetal pancreas, thyroid, pituitary, and adrenal glands are functional from early in gestation and become increasingly more reactive to stimuli during late gestation (Fowden et al., 2001). Hormones may also be derived from the placental tissues. These tissues produce many hormones, including steroids, peptides, and glycoproteins, released into the fetal bloodstream (Challis et al. 2001). The amount of hormone transmitted in this way, which may vary between species, depends on the maternal-fetal interface and the penetrability of the placental barrier (Sibley et al. 1997).

Glucocorticoids can program tissues in utero and may also mediate the programming effects of nutritional and other environmental challenges during pregnancy. Overexposure of glucocorticoids to glucocorticoids through the maternal bloodstream or limiting placental 11βHSD2 can lead to hypertension, glucose intolerance, and HPA dysfunction in the fetus. However, postnatal effects are dependent on fetal age and the duration of exposure to stress. For example, in sheep, maternal glucocorticoid exposure in early gestation leads to hypertension. However, it does not affect glucose intolerance in the adult offspring. In contrast, glucocorticoid treatment late in gestation has the opposite effects (Gatford et al. 2000), but glucose tolerance is exacerbated by repeated prenatal glucocorticoid administration (Moss et al. 2001). In rats, maternal glucocorticoid concentrations increased by stress or ACTH administration result in permanent changes in HPA function, behavior, and neuroendocrine responsiveness in the adult offspring (Welberg and Seckl, 2001).

Glucocorticoid stimulated changes in hormone production, especially in the placenta, maybe due to maternal effects. Placental hormones like progesterone influence maternal metabolism, increasing glucose delivery to the fetus (Joachim et al., 2003). Alterations in progesterone levels may then modify the allocation of nutrients between the maternal and fetal tissues and possibly alter the fetus's availability of resources for tissue growth. Ward et al. (2002) determined that in fetal sheep, the reduction in the number of cells producing placental somatotropin hormones due to increased cortisol may also hinder mammary development and cause a limitation on nutrition after birth from reduced lactation. Therefore, modifications during lactation caused by prenatal glucocorticoid exposure may provide a mechanism linking pre- and immediate postnatal growth and lead to postnatal programming of tissues. Prenatal risk factors, including suboptimal parental nutrition, gestational stress, exposure to environmental chemicals, and advanced breeding technologies, can determine postnatal growth, feed efficiency, milk yield, carcass composition, and reproductive potential (Sinclair et al., 2016). When the maternal environment becomes influenced by these external stressors, the placental environment can be altered, which can program nutrient partitioning, growth, development, and fetal organ systems (Vonnahme et al., 2007).

Prenatal Stress Effects on Growth and Development

Maternal stress during gestation can result in premature delivery and fetal growth restriction, linked to a greater risk of neonatal mortality in livestock. In domestic livestock species, offspring born at above-average body weight have a greater chance of survival than those born with below-average weight. Problems associated with low birth weight reported in livestock include increased neonatal mortalities (Hammer et al., 2011) and slow postnatal growth (Wu et al., 2006). Fetal growth restriction is correlated with placental characteristics such as abnormal uterine blood flow (Holland et al., 1992), reduced placental size (Wu et al., 2006), insufficient nutrient transferability at the maternal-fetal interface (Fowden et al., 2006), and altered hormone production and metabolism (Sinclair et al., 2016). Factors that may impact bovine fetal growth and development include parity, age, and size of the dam, genotypes of the sire and dam, and maternal nutrition.

The effects of gestational diet on offspring phenotype are more associated with maternal nutrition during the first rather than the second trimester and were sex-specific. Male offspring exposed to low protein maternal diets during the first trimester were heavier during the post-weaning period than high protein treatments (Micke et al., 2014). Calves change from a diet primarily of glucose and amino acids to a much higher fat content at parturition. The major nutritional factors affecting preweaning calf growth and body condition at weaning are the performance of the dam through lactation (Bartle et al., 1984) and the quality and availability of nutrients from pasture or supplementation before (Richardson et al., 1977) and after birth (Hennessy et al., 2001).

Transportation stress has also been attributed to unwanted alterations in fetal development (Littlejohn et al., 2016). Elevated cortisol levels in pregnant cows due to transportation stress may alter the placental environment in subsequent calves. Littlejohn et al., (2016) found that basal cortisol concentrations were greater in prenatally stressed calves ($P < 0.01$) than in controls and that cortisol concentration was positively correlated to PS, EV, and Temperament Score. Based on parity, age, and temperament, cows were assigned to prenatal stress (PNS) treatment. Maternal temperament was determined using a balance between weaning and mature temperament scores, which used pen score and exit velocity for each determination. The PNS treatment cows were transported for two hours at gestational days 60, 80, 100, 120, and 140Based on the behavior metrics recorded in the study, prenatally stressed calves were more temperamental than controls throughout the weaning period. The calf serum concentration of cortisol was taken at days -168, -140, -28, and 0 relative to weaning. Serum concentration of cortisol, PS, EV, and, TS were all greater in prenatally stressed calves compared to controls (Littlejohn et al., 2016). The data from this study indicate that prenatal transportation stress may have a transgenerational influence on calves and have adverse effects on the mechanisms associated with stress hormones and their feedback systems, as shown by the presence of increased stress hormones in calves throughout the weaning period.

Littlejohn et al. (2018) compared differential DNA methylation sites of PNS calves to non-transported controls to investigate the effects of prenatal stress on fetal development. Increases in DNA methylation in the promoter region typically cause reduced transcription activity in that region and may affect gene expression by activating or deactivating cellular processes (Levine et al., 1991). Calves exposed to transportation stress during gestation had either hyper- or hypomethylated sites compared to control calves (Littlejohn et al., 2018). Hypermethylated calves were at least 10% more methylated than controls. Hypomethylated calves were at least 10% less methylated than controls. These DNA modifications sites located in promoter regions were used to predict alterations in key pathways in PNS calves compared to control bull calves (Littlejohn et al., 2018). Littlejohn and others (2018) reported that in PNS bull calves, 113 canonical pathways associated with behavior, stress response, metabolism, immune function, and cell signaling were altered compared to non-transported controls. Specifically, genes CRYBB3, CDX2, DRD1, DIO3, GNAS, POMC, COMT, and PRKCA were all significantly altered compared to controls (Littlejohn et al., 2018).

The modification to gene expression through DNA methylation caused by prenatal stress can significantly impact the productivity of domestic livestock. Calves exposed to transportation stress in utero showed significant alterations of the CRYBB3, PRKCA, and DRD1 genes (Littlejohn et al., 2018), which are associated with behavioral and neurological disorders in humans such as schizophrenia (Harada et al., 2003), psychosis (Andreou et al., 2016), and Alzheimer's disease (Middleton et al., 2002). Prenatal stress calves also had significant alterations of GNAS, DIO3, and CDX2 genes, which have shown to affect growth and development in mammals. Yu et al. (2000) reported that disruption of the GNAS gene leads to distinct phenotypes in mice and has also been reported to play a major role in cattle growth and metabolism (Plagge et al., 2004). Mice with maternal allele disruption of GNAS exhibited obesity, while mice with paternal allele disruption of the gene weighed 80% less than littermates by day 60 (Yu et al., 2000). Prenatally stressed calves showed modifications to DIO3 and CDX2 genes (Littlejohn et al., 2018), linked to embryonic cell growth and thyroid hormone regulation (Xie et al., 2013; Yang et al., 2017).

Additionally, PNS calves showed differences in dopamine feedback systems compared to control calves (Littlejohn et al., 2018). Previous research suggests that prenatal stress can influence dopamine receptors that affect adulthood (Berger et al., 2002). Berger et al. (2002) found that rats exposed to prenatal restraint stress in the last week of pregnancy exhibited differences in the expression of dopamine receptors compared to control rats which is indicative of permanent altered corticolimbic pathways due to prenatal stress (Berger et al., 2002). Prenatally stressed calves also had altered POMC and COMT levels, associated with cattle temperament (Garza-Brenner et al., 2017).

Intrauterine reprogramming of the HPA and other endocrine axes may occur from central or peripheral changes in enzymes or receptors (Fowden et al., 2004). In adult rats, guinea pigs, and sheep, prenatal glucocorticoid exposure also alters glucocorticoid receptor gene expression in the liver, kidney, hippocampus, hypothalamus, and amygdala (Welberg et al., 2001; Sinclair et al., 2016). These changes are organ-specific and are conditional on gestational age at glucocorticoid exposure (Welberg et al., 2001). Tissue-specific alterations in glucocorticoid receptor gene expression have been observed in malnourished adult rats before birth (Langley-

Evans et al. 1996). In addition, prenatal glucocorticoids permanently alter transmitter systems involved in regulating glucocorticoid receptor expression in the brain (Muneoka et al. 1997). The central changes in glucocorticoid receptor expression will alter the functioning of the HPA axis. In contrast, the peripheral changes in glucocorticoid receptor mRNA abundance might explain the tissue-specific nature of glucocorticoid programming (Fowden et al., 2004).

Prenatal overexposure to maternal glucocorticoids from stress can permanently alter fetal growth potential and cause dysfunction of the HPA axis throughout the offspring's lifetime. The maternal-fetal interface allows the transport of nutrients between mother and fetus by way of the placenta. It allows for the transportation of hormones and peptides that can influence metabolism and other endocrine functions. Alterations to the fetal brain and growth tissue from maternal stress can profoundly negatively impact animal performance, and further research is needed to identify and understand this.

CHAPTER III

METHODOLOGY

This experiment was conducted according to the Institutional Animal Care and Use Committee guidelines at the University of Arkansas (Protocol number 14062).

Experimental Animals

This study was conducted over a single calving season (2017 and 2018). Crossbred calves born in both spring and fall seasons were reared at four different University of Arkansas research locations resulting in 473 total animals. Beef Research units included: 1) Southwest Research and Extension Center (SWREC) in Hope, Arkansas, U.S.A. (33°42'27.4"N 93°33'25.7"W); 2) Livestock and Forestry Research Center (LFRS) in Batesville, Arkansas, U.S.A. (35°49'35.8" N 91°46'29.1" W); 3) Southeast Research and Extension Center (SEREC) in Monticello, Arkansas, U.S.A. (33°35'29.3"N 91°48'48.5"W); and 4) Savoy Research Unit (SRU) in Fayetteville, Arkansas, U.S.A (36°07'42.5"N 94°18'47.8"W).

Cows at the SWREC (n = 143) were predominantly Angus parentage with a small percentage of Bos indicus influence (12%). Cows were 3 to 11 years old and calves were born between January 29, and May 1, 2018. Cows at the LFRS (n = 153) were of English and Continental breeding. Cows were 2 to 7 years old and calves were between

September 3, and November 17, 2017. Cows at the SEREC (n = 89) were predominantly Beefmaster parentage with some Angus crosses. Cows were 2 to 15 years old and calves were born between September 7, and December 1, 2017. Cows at the SRU (n = 88) were predominantly Angus parentage with some Angus and Hereford crosses. Cows were 3 to 15 years old and calves were born between August 10, and October 4, 2017.

Animal Handling

During each calving season, observers assigned cows maternal disposition scores (**MDS**, Sandelin, et al., 2005) during the processing of newborn calves (n = 473). Processing of calves included an ear identification tag, and if applicable, males were castrated, all within 24 h after parturition. Also, calf sex and birth weight were also recorded at processing time. After processing, calves were returned to dams. Animals were reared on cool or warm-season forages reflective of the calving season. All calves were weaned at 6 to 8 months of age, and body weight was recorded and adjusted for 205-day weaning weight. A subset of calves from the SWREC location (n = 74) and LFRS location (n = 62) were used for the finishing portion of the study. Calves were backgrounded at original locations before shipping to the Willard Sparks Beef Research Center at Oklahoma State University in Stillwater, Oklahoma. Calves received a standard receiving diet and were stepped up to a finishing diet upon arrival. Body weights were recorded upon arrival and when exiting the feedyard for harvest.

Maternal Disposition Scoring at Calving

Maternal behaviors were used to assign a maternal disposition score (MDS; Table 1) as described by Sandelin et al., 2005, with minor modifications. The original scores system was 1 to 5, where the higher the score, the less aggressive the animal. Cows assigned a 1 score at calving were highly aggressive, extremely flighty, and ran away from the handler; a 2 score was assigned to those that were very aggressive, and fought the handler to protect her calf; a 3 score was assigned to those that were very attentive and remained in close proximity to calf, and showed mild aggression toward the handler; a 4 score was assigned to those that were indifferent and remained in proximity to calf, but showed no aggression toward the handler; and cows assigned a 5 score were observed to be apathetic and shows no emotion toward their calf in the presence of the handler, grazed away, or moved out of proximity entirely. Moreover, those calves reared on pasture with dams until weaning were assigned a chute score (CS; Table 2, BIF 2002). The MDS reported in this study are limited to the dam's reaction to handler involvement with the calf during processing at birth.

Chute Scoring at Weaning

Chute scores (CS) were on a 1 to 6 scale and were assigned to calves at weaning and based on the Beef Improvement Federation guidelines (2002). Scores increased as aggressive behavior increased. At weaning, calves which received a CS of 1 were docile, gentle, and easy to handle. These calves moved slowly during processing and were undisturbed, settled, and somewhat dull, and did not pull on the headgate when inside the chute and exited the chute calmly. Calves that received a CS score of 2 were restless; they were quieter than average but appeared stubborn during processing. They tried to back out of the chute or pull on the headgate and promptly exited the chute. Calves that received CS of 3 were nervous and impatient but with a manageable temperament. These nervous calves showed a moderate struggle, movement, tail flicking, repeatedly pushed and pulled on the headgate, and exited the chute briskly. Calves that received a CS of 4 at weaning were flighty, jumpy, out of control, quivered, and struggled violently. These calves also bellowed and frothed with continuous tail flicking. Calves that received a CS of 5 were designated as aggressive similar those assigned a CS 4, but with added aggressive behavior, fearfulness, extreme agitation, and continuous movement. Finally, calves that received a CS of 6 were designated as very aggressive and had extremely aggressive temperaments often trashing or attacking handlers.

Sample Collection and Analysis

A subset of bull (n = 17) and steer (n = 17) calves from the SWREC herd were bled via jugular venipuncture at weaning (October 1, 2018; D0) and then again at D1, D2, D3, D7, D28, and D56 postweaning. Samples were centrifuged (Sorvall RC-6, Thermo-fisher Scientific, Waltham MA) at 2500 rpm for 20 minutes at room temperature, and serum was collected and stored at 4°C until further analysis. Glucose concentrations were determined using a YSI 2900D Biochemistry Analyzer (YSI Incorporated, Yellow Springs, OH).

Statistical Analysis

Data were analyzed using the GLIMMIX procedures of SAS (SAS Inst. Inc., Cary, NC, 2016). Only data from calves that received CS of 1, 2, 3, or 4 were used since no calves received CS of 5 or 6. The experimental unit was the individual animal and was blocked by location. The RANDOM statement was used and included the location for all dependent variables. Finishing data included location, calf sex, finishing diet, and MDS score in the class statement as covariables for all CS finishing performance and carcass data. A Pearson correlation was generated to evaluate the relationship between both scoring systems. Significance was declared at $P \leq 0.05$.

CHAPTER IV

FINDINGS

Maternal Disposition

Maternal disposition score at the time of calving impacted calf birth weight (P < 0.01). The calves from cows with MDS of 2 were 4.2 kg heavier at birth than those cows that received MDS 4 (Table 3), which may affect calf survivability. Research by Sandelin et al. (2005) reported that cows with very aggressive maternal scores (MDS of 2) had 16% greater calf survival than indifferent cows (MDS of 4). Sandelin et al. (2005) found that as maternal behavior scores increased in aggression, calf survival rate also increased, indicating that more attentive cows at birth improved the survivability of the offspring.

The impact of all other scores on birth weight was intermediate. Although cow temperament influenced calf birth weight, there were no differences (P = 0.37) in weaning weight, or when weaning weight was adjusted on a 205-d scale (P = 0.23). Maternal disposition at the time of calving significantly affected feedlot receiving weight (P = 0.03). Cows that were either very aggressive or very attentive (MDS of 2 or 3, respectively) had calves with greater feedlot arrival weight than cows described as indifferent or apathetic (MDS of 4 or 5, respectively). Maternal disposition at calving did not significantly affect final body weight during the finishing phase or ADG through the finishing phase. Using restraint tests during rectal pregnancy diagnosis, Fordyce and

Goddard (1984) also observed a significant dam-daughter relationship for movement and temperament scores suggesting that cows have a non-genetic influence on the behavior of their offspring that persists into maturity. Using a restraint test, Burrow (1997) determined heritability estimates for temperament behaviors to be between 0.23 and 0.37, suggesting moderate heritability of temperament to offspring. Conversely, we did not find an association between dam MDS and calf CS, which may partly explain by the calves in this study habituating to human handling prior to weaning. Previous research shows that habituation to human handling increases tameness, reduces stress reactions and fearfulness towards people, and results in more manageable animals (Uetake et al., 2003; Petherick et al., 2009).

Animals can acclimatize to chute exposure after repeated use (Stookey et al., 1994). It has been shown that movement on the scale decreases over 5 to 10 days (Piller et al., 1999), but Sebastian et al. (2011) found that cattle did not habituate to the chute; thus, their stress response increased over time. However, this was most likely due to infrequent handling. In our study, calves were handled frequently throughout the preweaning period during routine management at calving, branding, and breeding, most likely resulting in a lack of correlation between calf CS and dam temperament.

Calf Disposition at Weaning Effects on Growth Performance

At weaning, the cows' MDS and calves' CS were not correlated ($R^2 = -0.10$; $P = 0.22$). Past research indicated a moderate relationship between maternal and offspring temperament (Fordyce and Goddard, 1984; Burrow, 1997). However, CS (Table 4) was associated with weaning weight ($P = 0.05$) and adjusted weaning weight ($P < 0.01$);

calves with a 3 CS (nervous) were 18.8 kg heavier than calves with a 1 CS (docile). Calves with 2 and 4 CS have intermediate weights but similar weights as calves with CS of 1 and 3. Conversely, once weaning weights were adjusted for a 205-d period, calves with CS of 2 and 3 did not differ (P = 0.21); however, both groups had heavier adjusted 205-d weaning weights than calves that received a CS of 1 (P < 0.01).

Our research is supported by Voisinet et al. (1997), who showed that when using the Grandin (1993) chute restraint test, Bos indicus cattle with a temperament score of 2 had 0.32 kg/d greater ADG than calm cattle with a score of 1. Furthermore, Voisinet et al. (1997) found that cattle with scores of 3 and 4 had numerically greater ADG than calm and excitable cattle. Voisinet et al. (1997) also determined that Bos taurus steers with the calmest temperament had 0.19 kg/d greater ADG than steers with the most excitable temperaments. This may suggest that over-selection for docility may be occurring in Angus breed cattle in the U.S. and that midrange temperament cattle have greater growth potential. Research by Fordyce et al. (1988) demonstrated that heavier calves had more desirable temperament scores, suggesting that a high growth rate would improve temperament. However, other research has shown that the correlations between temperament score and weight changed from positive at weaning to negative at 24 months (O'Rourke, 1989).

Chute Score Effects on Carcass Quality

Chute scores were re-evaluated during the finishing phase for the LFRS steers, and the SWREC bull and steer subset was tracked through finishing. The average daily gain was not affected by CS (P = 0.14); however, calves that received a chute score of 2 at weaning were heavier than calves that received a score of 3 upon arrival ($P < 0.01$) and exiting ($P = 0.01$) the feed yard. Chute score at weaning effected marbling score ($P < 0.01$) and longissimus muscle area (**LMA**) ($P = 0.05$). Calves that received a CS of 1 had greater marbling (Table 5) than calves that received a CS of 2 ($P < 0.01$), whereas calves that received a CS of 2 had greater LMA than calves with a CS of 3 ($P < 0.05$). Vann et al. (2008) found that cattle temperament affects future growth performance and carcass value. Using CS, EV, and PS together as a behavior metric, they determined that as aggression increased, feedlot treatment costs, net returns, and decreased animal growth performance were observed compared to calmer animals. Café and others (2011) found that increased temperament was associated with reduced carcass traits in Angus cattle. An increased flight speed was associated with reduced marbling scores and reduced longissimus lumborum muscle area.

Our data suggest that selecting cattle based upon an optimum midrange temperament that is neither too aggressive nor too docile may improve calf growth performance. These results do not encompass the entirety of cattle behaviors during human handling. Some research shows that incorporating multiple behavior metrics such as exit velocity or pen scores accompanied by chute scores may depict a more accurate understanding of an individual animal's true temperament (Burrow et al., 1988; Curley et al., 2006; Kadel et al., 2006).

Cattle with highly excitable temperaments may experience changes in their physiology, such as hormonal variations and immunological responses (Welberg and Seckl, 2001; Merlot et al., 2008) that may be associated with the animal's response to the stressor and could result in performance losses (Petherick et al., 2009; Francisco et al., 2015). Overly excitable cattle would likely respond to handling stress with more difficulty and thus have greater concentrations of stress hormones over their lifetime than cattle with calm dispositions. Physiological differences between aggressive and calm cattle warrant more research on stress's effects on animal performance and welfare.

Chute Score Effects on Blood Serum Glucose

Glucose samples were analyzed for the initial week that bull and steer calves from the SWREC group were weaned every 28 d during the backgrounding period (Table 6.) On D0 weaning, serum glucose concentrations were similar ($P = 0.32$), but on day 2 ($P = 0.04$), calves with CS 2 had greater concentrations than those with CS 1, and those with CS 3 were intermediate. After that, glucose concentrations were similar ($P \geq 0.50$) until d 56 ($P < 0.01$), where calves with CS 1 had greater glucose concentrations than calves with either CS 2 or 3.

The glucose concentrations observed in our study may be attributed to the energy deficiency caused by weaning and metabolic changes associated with weaning as ruminal and hepatic functions for the metabolism of volatile fatty acids produced during ruminal fermentation development (Suzuki et al., 2016). Ungerfeld and others (2009) reported that weaning distress was greater in calves heavier at weaning. While our study did not determine concentrations of stress hormones such as cortisol, stressors are energetically costly to the individual depending upon the stressor's intensity, duration, and novelty (Weary et al., 1995; Takayanagi et al., 2021). Stressful situations like weaning induce large elevations in stress hormones and the release of energy reserves as indicated by elevated glucose levels in previous research (Probst et al., 2012). The novelty of weaning stress may have induced the reallocation of energy resources to aid in the return to a state of allostasis (Ganzel et al., 2010; Takayanagi et al., 2021). Our study may also reflect the increased serum glucose concentrations at weaning in restless calves (CS of 2) compared to docile calves (CS of 1).

CHAPTER V

CONCLUSION

Poor animal temperament has been shown to impact aspects of beef production negatively. Due to the higher concentrations of stress hormones found in excitable cattle and the negative effects associated with stress, producers need tools to assess animal welfare on the farm. Chute scores and MDS may allow producers to determine cattle herds' overall temperament, thereby advancing animal welfare through selection.

It is hypothesized that physiological changes, including hormonal and immunological responses altered (Welberg and Seckl, 2001; Merlot et al., 2008), and performances losses (Petherick et al., 2009; Francisco et al., 2015) among highly excitable cattle may be more responsive to handling stress than cattle with calm dispositions. Therefore, we must explore the potential long-term effects of stress on the performance and welfare of highly excitable and docile cattle.

Our objectives were to observe maternal behaviors during calving to find correlations between offspring disposition and their effects on growth performance. In our study, aggressive cows gave birth to heavier calves than indifferent cows, which could have aided calf survivability based on previously mentioned research. Our findings suggest that calves with a moderate temperament had greater growth performance than calves with either overly aggressive or overly docile temperaments. Our data did not correlate glucose levels at the time of weaning to calf temperament during human handling; however, research has established that physiological stress, like weaning, can cause alterations in metabolism and may affect growth performance. Our data suggest that calves with an optimum midrange temperament may have greater growth potential throughout their lives. Using behavior metrics such as exit velocity and chute scores may reduce some errors associated with subjective scoring. Recording scores at calving and weaning might be useful techniques to aid animal production decisions and possibly improve animal welfare.

REFERENCES

Buddenburg, B.J., Brown, C.J., Johnson, Z.B., and Honea, R.S. 1986. Maternal behavior of beef cows parturition. J Anim. Sci. 62:42-46.

Burrow, H.M., Seifert, G.W., Corbet, N.J., 1988. A new technique for measuring temperament in cattle. Proc. Aust. Soc. Anim. Prod. 17: 154–157.

Burrow, H.M. 1997. Measurements of temperament and their relationship with performance traits in beef cattle. Animal Breeding Abstracts. 65: 477–495.

Cafe, L. M., Robinson, D. L., Ferguson, D. M., B. L. McIntyre, G. H. Geesink, P. L. Greenwood. 2011. Cattle temperament: Persistence of assessments and associations with productivity, efficiency, carcass and meat quality traits, carcass composition and quality. Meat. Sci. 89:52-57. J Anim. Sci. 89.5, 1452–1465.

Curley Jr., K. O., J. C. Paschal, T. H. Welsh, Jr., R. D. Randel. 2006. Technical note: Exit velocity as a measure of cattle temperament is repeatable and associated with serum concentration of cortisol in Brahman bulls, J Anim. Sci. 84.11, 3100–3103.

Fordyce, G., Goddard, M.E., Seifert, G.W., 1982. The measurement of temperament in cattle and the effect of experience and genotype. Proc. Aust. Soc. Animal. Pro. 14: 329-332.

Fordyce, G., Goddard, M.E. 1984. Maternal influence on the temperament of Bos indicus cross cows. Proceedings of the Austalian Society of Animal Production 15: 345-348.

Fordyce, G., R. M. Dodt, and J. R. Wythes. 1988. Cattle temperaments in extensive herds in northern Queensland. Aust. J. Exp. Agric. 28:683.

Francisco, C. L., Resende, F. D., Benatti, J. M. B., Castilhos, A. M., Cooke, R. F., Jorge, A. M. 2015. Impacts of temperament on Nellore cattle: physiological responses, feedlot performance, and carcass characteristics, J Anim. Sci. 93:11 5419–5429.

Ganzel, B. L., Morris, P. A., & Wethington, E. 2010. Allostasis and the human brain: Integrating models of stress from the social and life sciences. Psychol Rev. 117.1: 134-174.

Grandin, T. 1997. Assessment of Stress During Handling and Transport. J Anim. Sci. 75.1: 249–257.

Grandin, T. 1993. Behavioral Agitation During Handling of Cattle Is Persistent over Time. Appl. Anim. Behav. Sci. 36.1: 1–9.

Hammond, A. C., T. A. Olson, C. C. Chase, Jr., E. J. Bowers, R. D. Randel, C. N. Murphy, D. W. Vogt, and A. Tewolde, 1996. Heat tolerance in two tropically adapted Bos taurus breeds, Senepol and Romosinuano, compared with Brahman, Angus, and Hereford cattle in Florida, J Anim. Sci. 74.2: 295–303.

Hoppe, S., H.R. Brandt, S. Konig, G. Erhardt, and M. Gauly. 2010. Temperament traits of beef calves measured under field conditions and their relationship to performance. J. Anim. Sci. 88: 1982-1989.

Kadel, M., Johnston, D., Burrow, H., Graser, H., Ferguson, D. 2006. Genetics of flight time and other measures of temperament and their value as selection criteria for improving meat quality traits in tropically adapted breeds of beef cattle. Aust J Agric Res. 57: 1029–1035.

Le Neindre, P., G. Trillat, J. Sapa, F. Ménissier, J. N. Bonnet, J. M. Chupin. 1995. Individual differences in docility in Limousin cattle, J Anim. Sci. Volume 73.8: 249–2253.

Lewis, N.J and Hurnik, J.F. 1998. The effect of some common management practices on the ease of handling of dairy cows. Appl. Anim. Behav. Sci. 58.3: 213-220.

Merlot, E., Couret, D., Otten, W. 2008. Prenatal stress, fetal imprinting and immunity. Brain Behav and Immun. 22.1: 42-51.

Murphey, R.M., Duarte, F.A.M. and Torres Penedo, M.C. 1981. Responses of cattle to humans in open spaces: Breed comparisons and approach avoidance relationships. Behav. Genet 11: 37-48.

Murphy, P.M., I.W. Purvis, D.R. Lindsay, P. Le Neindre, P. Orgeur, and P. Poindron. 1994. Measures of temperament are highly repeatable in Merino sheep and some are related to maternal behavior. Anim. Prod. Aust. 20: 247-250.

Oliphint, R. A. 2006. Evaluation of the inter-relationships of temperament, stress responsiveness, and immune function in beef calves (Doctoral dissertation). Texas A and M University, College Station, TX, United States.

O'Rourke, P.K. 1989. Validation of genetic parameters for breeding in Bos indicus cross cattle in the dry tropics. Final report of AMLRDC Project DAQ.54. Queensland Department of Primary Industries, Brisbane, Australia.

Petherick, J.C., Doogan, V.J., Venus, B.K., Holroyd, R.G., Olsson, P., 2009. Quality of handling and holding yard environment, and beef cattle temperament: 2. Consequences for stress and productivity. Appl. Anim. Behav. Sci. 120: 28–38.

Piller, C.A.K., Stookey, J.M., Watts, J.M., 1999. Effects of mirror-image exposure on heart rate and movement of isolated heifers. Appl. Anim. Behav. Sci. 63: 93-102.

Probst J.K., Spengler Neff A., Leiber, F., Kreuzer, M., Hillmann, E. 2012. Gentle touching in early life reduces avoidance distance and slaughter stress in beef cattle. Appl. Anim. Behav. Sci. 139: 42-49.

Sandelin, B. A., Brown, A. H., J., Johnson, Z. B., Hornsby, J. A., 2005. CASE STUDY: Postpartum maternal behavior score in six breed groups of beef cattle over twenty-five years. Prof Anim Sci, 21.1, 13-16.

Sebastian T, Watts J, Stookey J, Buchanan, F, and Waldner, C. 2011. Temperament in beef cattle: Methods of measurement and their relationship to production. Canadian Journal of Animal Science. 91.4: 557-565.

Stooky, J. M., T. Nickel, J. Hanson, and S. Vandenbosch. 1994. A movement-measuring-device for objectively measuring temperament in beef cattle and for use in determining factors that influence handling. J. Anim. Sci. 72(Suppl. 1): 207 (Abstr.).

Stricklin, W.R, and C.C Kautz-Scanavy. "The Role of Behavior in Cattle Production: A Review of Research." Appl. Anim. Ethology 11.4: 359–390.

Suzuki, Y., S. Haga, M. Nakano, H. Ishizaki, M. Nakano, S. Song, K. Katoh, S. Roh, 2016. Postweaning changes in the expression of chemerin and its receptors in calves are associated with the modification of glucose metabolism, J Anim. Sci. 94.11: 4600–4610.

Takayanagi, Y., & Onaka, T. 2021. Roles of Oxytocin in Stress Responses, Allostasis and Resilience. Int J Mol Sci. 23.1: 150.

Ungerfeld R., Quintans G., Enríquez D. H., Hötzel M. J. 2009. Behavioral changes at weaning in 6-month-old beef calves reared by cows of high or low milk yield. Anim. Prod. Sci. 49:637-642.

Uetake, K., S. Morita, Y. Kobayashi, S. Hoshiba, T. Tanaka. 2003. Approachability and contact behavior of commercial dairy calves to humans. Anim. Sci. J., 74:73-78.

Vann, R.C., J.A. Parish, W.B. McKinley. 2008. Mississippi Cattle Producers Gain Insight into Temperament Effects on Feedlot Performance and Subsequent Meat Quality. Prof Anim Sci. 24.6: 628-633.

Voisinet, B. D., T. Grandin, J. D. Tatum, S. F. O'Connor, J. J. Struthers. 1997. Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments, J Anim Sci. 75.4: 892–896.

Weary DM, Fraser, D.1995. Signaling need: costly signals and animal welfare assessment. Appl Anim Behav Sci. 44: 159-169.

Welberg LAM & Seckl JR. 2001. Prenatal stress, glucocorticoids and the programming of the brain. J Neuroendocrinol. 13: 113–128.

APPENDICES

Table 1. Maternal Disposition Score at Calving.

Score	Name	Description
1	Highly aggressive	Cow was extremely flighty and ran away from handler.
2	Very aggressive	Cow was willing and did fight the handler to protect calf.
3	Very attentive	Cow remained in close proximity with mild aggression, but did not fight the handler to protect calf.
4	Indifferent	Cow remained in close proximity, showed no aggression toward handler, but remained in sight of calf.
5	Apathetic	Cow showed no emotion toward calf in presence of handler, grazed away or moved out of proximity.

Modified from Sandelin and others (2005)

Table 2. Calf Chute Score at Weaning

Score	Name	Description
1	Docile	Mild disposition. Gentle and easily handled. Stands and moves slowly during processing. Undisturbed, settled, somewhat dull. It does not pull on headgate when in chute. Exits chute calmly.
2	Restless	Quieter than average, but maybe stubborn during processing. May try to back out of chute or pull back on headgate. Some flicking of tail. Exits chute promptly.
3	Nervous	Typical temperament is manageable but nervous and impatient. A moderate amount of struggling, movement and tail flicking. Repeated pushing and pulling on headgate. Exits chute briskly.
4	Flighty	Jumpy and out of control, quivers and struggles violently. May bellow and froth at the mouth. Continuous tail flicking. Defecates and urinates during processing. Frantically runs fence line and may jump when penned individually. Exhibits long flight distance and exits chute wildly
5	Aggressive	May be similar to Score 4, but with added aggressive behavior, fearfulness, extreme agitation, and continuous movement which may include jumping and bellowing while in chute. Exits chute frantically and may exhibit attack behavior when handled alone.
6	Very Aggressive	Extremely aggressive temperament. Thrashes about or attacks wildly when confined in small, tight places. Pronounced attack behavior

Table 3. Calf growth performance associated with Maternal Disposition Score.

[2]Item	Score 1	2	3	4	5	SEM[1]	P - Value
Preweaning performance							
Birth weight, kg	39.0[ab]	39.7[a]	38.1[ab]	35.5[b]	36.1[ab]	0.97	<0.01
Weaning BW, kg	252.8	226.0	220.8	218.0	226.9	8.43	0.37
Adjusted 205 d BW, kg	238.8	225.4	218.1	217.8	234.8	8.32	0.23
Finishing							
Receiving BW, kg	-	323.6[a]	324.0[a]	307.9[b]	279.3[b]	10.91	0.03
Harvest BW, kg	-	619.1	618.7	602.5	567.9	22.84	0.24
Average Daily Gain, kg	-	1.98	2.00	1.88	1.94	0.15	0.10

[1]SEM = pooled standard error of the mean.
[2]Maternal Disposition Scores increased on a 1 to 5 scale as aggressive behavior decreased. (Pre-weaning: Score 1, n = 4; score 2, n = 40; score 3, n = 178; score 4, n = 187; score 5, n = 26). (Finishing: Score 1, n = 0 and was therefore removed from the analysis for subset data in the finishing phase; score 2, n = 11; score 3, n = 58; score 4, n = 57; score 5, n = 2).
[a-b] Means within a row without common superscript differ ($P \leq 0.05$).

Table 4. Calf growth performance associated with chute score at weaning.

[2]Item	Score				SEM[1]	P - Value
	1	2	3	4		
Weaning						
Weaning BW	204.3[b]	218.5[ab]	223.1[a]	219.6[ab]	5.4	0.05
205 d adjusted BW	198.5[b]	217.7[a]	223.0[a]	214.8[ab]	5.6	<0.01
Finishing						
Receiving BW, kg	308.1[ab]	325.8[a]	303.6 [b]	-	6.21	< 0.01
Harvest BW, kg	595.3[ab]	624.0[a]	595.1 [b]	-	20.15	0.01
Average Daily Gain, kg	1.88	1.99	1.90	-	0.35	0.14

[1]SEM = pooled standard error of the mean.

[2] Weaning Chute Scores increased on a 1 to 5 scale as aggressive behavior increased. (Pre-weaning: Score 1, n = 50; score 2, n = 247; score 3, n = 157; score 4, n = 14; score 5, n = 1 and was therefore removed from the analysis). (Finishing: Score 1, n = 4; score 2, n = 45; score 3, n = 45; scores 4 and 5, n = 0 and was therefore removed from the analysis).

[a-b] Means within a row without common superscript differ ($P \leq 0.05$).

Table 5. Calf carcass characteristics as it relates to calf chute score at weaning.

Item	Score[2] 1	2	3	4	5	SEM[1]	P - Value
Marbling Score[3]	578[a]	486[b]	518[ab]	-	-	25.0	<0.01
Yield Grade	3.0	3.2	3.3	-	-	0.2	0.43
Fat Thickness, cm	1.47	1.52	1.52	-	-	0.1	0.93
LMA, cm^2	92.26[ab]	91.68[a]	13.48[b]			1.1	0.05

[1]SEM = pooled standard error of the mean.

[2] Weaning Chute Scores increased on a 1 to 5 scale as aggressive behavior increased. (Score 1, n = 4; score 2, n = 45; score 3, n = 45; score 4, n = 0; score 5, n = 0. Due to low sample size CS 4 and 5 were removed from the analysis).

[3]400 = Small^{00}, 500 = Modest^{00}

[a-b] Means within a row without common superscript differ ($P \leq 0.05$).

Table 6. Calf glucose concentrations as it relates to calf chute score at weaning.

Item	Score[2]					SEM[1]	P - Value
	1	2	3	4	5		
Day Post Weaning							
Day 0	64.38	51.34	49.77	-	-	5.63	0.32
Day 1	61.59	74.56	74.12	-	-	5.42	0.32
Day 2	47.04[b]	65.69[a]	60.62[ab]	-	-	5.63	0.04
Day 3	64.89	70.06	73.05	-	-	3.86	0.50
Day 7	78.82	77.36	82.77			6.13	0.73
Day 28	106.76	102.67	108.65	-	-	4.99	0.53
Day 56	122.39[a]	87.92[b]	92.81[b]	-	-	4.01	<0.01

[1]SEM = pooled standard error of the mean.

[2] Weaning Chute Scores increased on a 1 to 5 scale as aggressive behavior increased. (Score 1, n = 3; score 2, n = 24; score 3, n = 7; score 4, n = 0; score 5, n = 0. Due to low sample size CS 4 and 5 were removed from the analysis).

[a-b] Means within a row without common superscript differ ($P \leq 0.05$).

VITA

Michael Sims

Candidate for the Degree of

Master of Science

Thesis: MATERNAL TEMPERAMENT AND OFFSPRING DISPOSITION AFFECT GROWTH PERFORMANCE

Major Field: Animal Science

Biographical:

Education:

Completed the requirements for the Master of Science in Animal Science at Oklahoma State University, Stillwater, Oklahoma in May, 2022.

Completed the requirements for the Bachelor of Science in Biology at Texas A&M Texarkana, Texarkana, Texas/USA in 2013.

Experience: Oklahoma State Univsersity 2019-2020 Ruminant Nutrition Laboratory Supervisor, University of Arkansas Forage and Nutrition Laboratory Supervisor 2013-2019

Professional Memberships: American Society of Animal Science