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**Animal Behavior and Cognition**

# Association of maternal temperament and offspring disposition on growth performance

**Michael Sims,[†,‡] Reagan N. Cauble,[†] Jeremy Powell,[||] Beth Kegley,[||] Andrew P. Foote,[‡] Janeen L. Salak-Johnson,[‡] and Paul Beck[‡,1]**

[†]Ten Triple X Ranch, Glen Rose, TX 76652, USA
[‡]Department of Animal and Food Sciences, Oklahoma State University, Stillwater, OK 74074, USA
[||]Division of Agriculture, Department of Animal Science, University of Arkansas, Fayetteville, AR 72701, USA
[1]Corresponding author: paul.beck@okstate.edu

## ABSTRACT

Animal behavior is complex and varies in definition, depending upon specific traits under observation. Temperament is one component of behavior, that in cattle, is described as the level of fearfulness to a novel or threatening environment. Temperament is a heritable trait which is important since aggressiveness and docility contribute to reproductive success, growth, and carcass quality. We observed maternal temperament at calving and the subsequent influence, if any, on offspring disposition at weaning and their effects collectively on growth performance and carcass traits. Maternal behaviors at calving were observed at four locations within the University of Arkansas system. Cows were assigned a maternal disposition score (**MDS**) at calving; a scale from 1 to 5 in which aggression decreases. At weaning, calves were assigned a chute score (**CS**); a scale from 1 to 6 in which aggression increases. Both scoring systems have been previously established. Blood was collected during the 56-d backgrounding period postweaning for blood glucose analysis. Data were analyzed using GLIMMIX procedures of SAS ($\alpha = 0.05$). The relationship between the two scoring systems was determined with a Pearson correlation ($P = 0.22$). Animal was the experimental unit and blocked by location for all dependent variables. Location, sex, diet, and MDS were included in the class as covariables for all growth performance and carcass data related to CS. Cows that were more aggressive birthed heavier calves ($P < 0.01$) compared to indifferent cows. Calves born to cows with either very aggressive or very attentive (MDS of 2 or 3, respectively) scores were heavier upon feedlot entry ($P = 0.03$) compared to those from indifferent or apathetic cows (MDS of 4 or 5, respectively). Calves defined as nervous and restless (CS of 3 and 2, respectively) were heavier at weaning compared to docile calves ($P < 0.01$). Restless calves were heavier compared to nervous calves upon arrival and exiting the feedlot ($P \leq 0.01$). Calves that were docile at weaning had greater marbling compared to calves that were restless ($P \leq 0.01$). Calves that were restless at weaning had greater lean muscle area compared to calves that were nervous ($P = 0.05$). No definitive relationship was determined between dam and calf temperament. However, the results suggest temperament does impact growth performance and carcass traits but whether the influence comes from the dam or calf temperament, specifically, remains unanswered.

**Key words:** chute score, disposition, growth performance, temperament

## INTRODUCTION

Cattle behavioral responses to stressful circumstances, such as human handling, have been generally described as temperament (Grandin, 1993; Burrow, 1997; Cafe et al., 2011) and are further defined as the level of fearfulness to humans or their reactivity to a novel or threatening environment (Grandin, 1993). Specific observations, such as nervousness, flightiness, calmness, excitability, or the emotionality of animals are used in association to temperament (Stricklin and Kautz-Scanavy, 1984). In beef production settings, temperament typically refers to an animal's reaction to standard handling practices such as calf processing or common stressors such as weaning and can also describe maternal behaviors (Buddenburg et al., 1986). Standard handling procedures may result in an undesirable behavioral or physiological stress response, making it important to understand the impact that temperament has on herd productivity.

Cattle behavior can be influenced by environment, experiences, genetics, physiological status, or novelty of the stressor (Murphy et al., 1994; Grandin, 1997; Lewis and Hurnik, 1998). For example, novel conditions may cause cattle to display behaviors of self-defense and fear, while a more distinct response may indicate increased excitability or fear response (Grandin, 1997; Oliphint, 2006) which may have negative outcomes, including increased aggression toward handlers, poor reproductive success and maternal care, and reduced growth performance (Sandelin et al., 2005; Hoppe et al., 2010; Voisinet et al., 1997). Understanding beef cattle temperament is vital for several reasons, including animal and handler safety (Grandin, 1997), the heritability of temperament to better select for docile traits, and the economic factors that positively impact growth performance (Voisinet et al., 1997).

Measurement of temperament can be evaluated by scoring an animal's behavior in a standard test situation, such as a chute score (**CS**) (Fordyce et al., 1982; Grandin, 1993), pen score (**PS**) (Le Neindre et al., 1995; Hammond et al., 1996; Murphey et al., 1981), or chute exit velocity (**EV**) (Burrow et al., 1988; Burrow, 1997; Curley et al., 2006). These subjective analyses allow a group of animals to be subcategorized by their temperament. It is important to understand how

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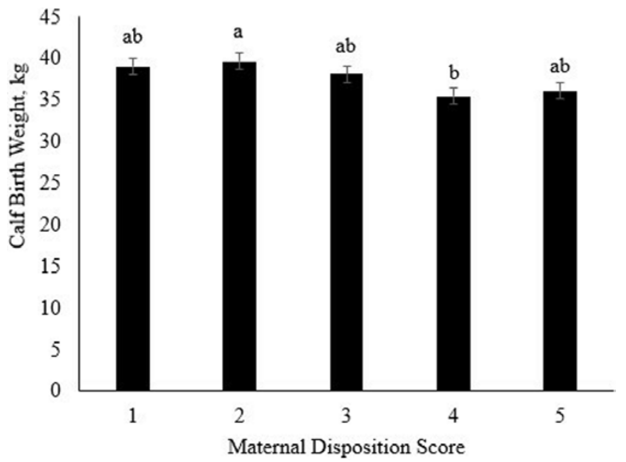


**Figure 1.** MDSs and their association with calf birth weight ($P < 0.01$). MDSs were recorded at calving and increased on a 1 to 5 scale as aggressive behavior decreased. Preweaning: score 1, $N = 4$; score 2, $N = 40$; score 3, $N = 178$; score 4, $N = 187$; score 5, $N = 26$. Means without common superscript differ ($P \leq 0.05$).

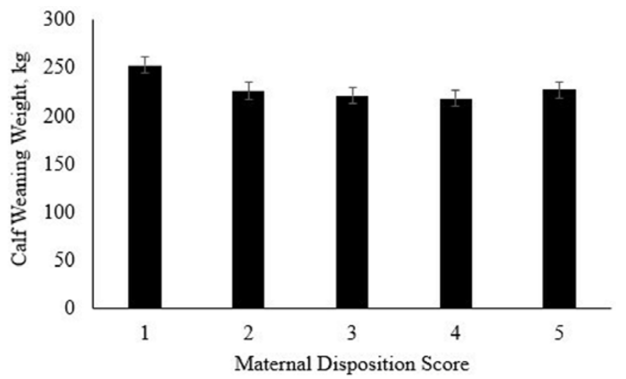


**Figure 2.** MDSs and their association with calf weaning weight ($P = 0.37$). MDSs were recorded at calving and increased on a 1 to 5 scale as aggressive behavior decreased. Preweaning: score 1, $N = 4$; score 2, $N = 40$; score 3, $N= 178$; score 4, $N = 187$; score 5, $N = 26$.

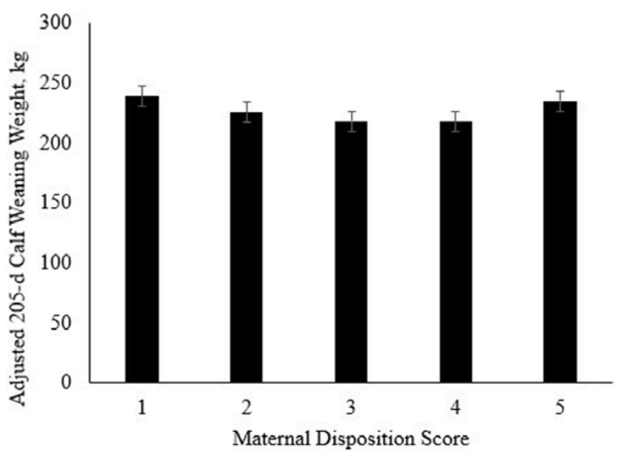


**Figure 3.** MDSs and their association with calf weaning weight adjusted for a 205-d period ($P = 0.23$). MDSs were recorded at calving and increased on a 1 to 5 scale as aggressive behavior decreased. Preweaning: score 1, $N = 4$; score 2, $N = 40$; score 3, $N = 178$; score 4, $N = 187$; score 5, $N = 26$.

animal temperament affects beef production and if these subjective tests can accurately reveal components of unwanted temperament to determine the effects on economically important traits to cattle producers. The standard tests are cost-effective tactics to evaluate behavioral issues or selection progress within the herd. However, they do not definitely reveal the hormonal stress response and status for each animal accurately.

Glucocorticoid-stimulated changes in hormone production, especially in the placenta, may have their programming effects from the mother. Placental hormones like progesterone influence maternal metabolism that increase 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 availability of resources for tissue growth by the fetus. Additionally, modifications in lactation caused by prenatal glucocorticoid exposure may, therefore, provide a mechanism linking pre- and immediate postnatal growth, and lead to postnatal programming of tissues that were unaffected by glucocorticoids in utero. When the maternal environment becomes influenced by these external stressors the placental environment can be altered, which can program nutrient partitioning, growth and development, as well as fetal organ systems (Vonnahme et al., 2007). Conversely, overexposure to maternal glucocorticoids from stress has the ability to permanently alter fetal growth potential and cause dysfunction of the HPA axis throughout the offspring's lifetime. Alterations to the fetal brain and growth tissue from maternal stress can have a profoundly negative impact on animal performance. The physiological stress from the mother can be passed to the offspring.

The physiological and observable stress responses not only impact calf growth performance, but can also hinder carcass quality. Temperament can affect meat quality by creating a product with significantly higher proportions of dark cutters in nervous or wild cattle, which can lead to quality grade discounts (Voisinet et al., 1997). Fordyce et al. (1988) reported nervous cattle had greater carcass bruising and bruise scores compared to 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 compared with those of calmer cohorts (Voisinet et al., 1997; Vann et al., 2008). Little research has been done using subjective scoring and the associated impact on carcass quality.

Therefore, the objective of our experiment was to determine if there was a correlation between dam temperament and calf temperament via maternal disposition scores (**MDSs**) assigned at calving and calf CSs at weaning. Additionally, we aimed to determine if dam and calf temperament influenced postweaning growth performance, blood glucose concentrations, and carcass quality. The results from this investigation might provide insight and tools for producers to utilize and better understand the impact that behavior has on production success.

## MATERIALS AND METHODS

This experiment was conducted according to the Institutional Animal Care and Use Committee guidelines at the University of Arkansas (Protocol number 14062) and at Oklahoma State University (AG 19-8).

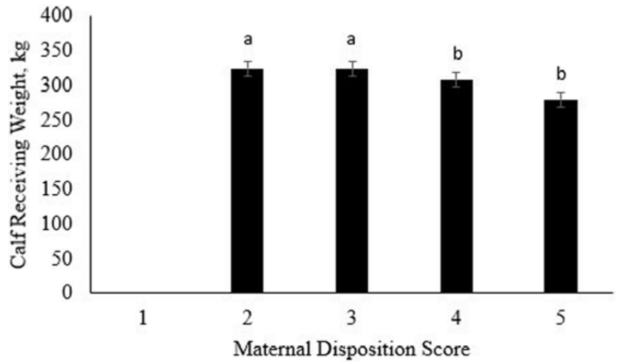


**Figure 4.** MDSs and their association with calf feed yard receiving weight ($P < 0.03$). MDSs were recorded at calving and increased on a 1 to 5 scale as aggressive behavior decreased. Finishing: score 1, $N$ = 0 and was therefore removed from the analysis for subset data in the finishing phase; score 2, $N$ = 11; score 3, $N$ = 58; score 4, $N$ = 57; score 5, $N$ = 2. Means without common superscript differ ($P \leq 0.05$).

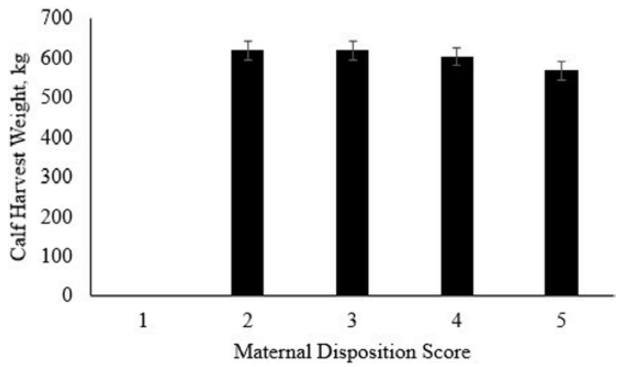


**Figure 5.** MDSs and their association with calf harvest weight ($P$ = 0.24). MDSs were recorded at calving and increased on a 1 to 5 scale as aggressive behavior decreased. Finishing: score 1, $N$ = 0 and was therefore removed from the analysis for subset data in the finishing phase; score 2, $N$ = 11; score 3, $N$ = 58; score 4, $N$ = 57; score 5, $N$ = 2.

## Experimental Animals

This study took place over two consecutive years (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 animals used in this study. Beef unit research locations 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 ranged from 3 to 11 yr and calved between January 29, 2018, and May 1, 2018. Cows at the LFRS ($N$ = 153) were of English and Continental breeding (Angus and Hereford parentage). Cow age ranged from 2 to 7 yr and calved between September 3, 2017, and November 17, 2017. Cows at the SEREC ($N$ = 89) were predominantly Beefmaster parentage with some Angus crosses. Cows ranged from 2 to 15 yr and calved between September 7, 2017, and December

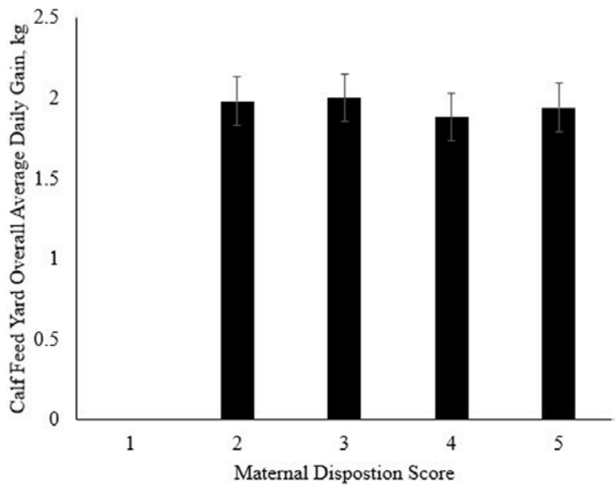


**Figure 6.** MDSs and their association with calf overall (receiving and harvest weights) ADG during the finishing phase ($P$ = 0.10). MDSs were recorded at calving and increased on a 1 to 5 scale as aggressive behavior decreased. Finishing: score 1, $N$ = 0 and was therefore removed from the analysis for subset data in the finishing phase; score 2, $N$ = 11; score 3, $N$ = 58; score 4, $N$ = 57; score 5, $N$ = 2.

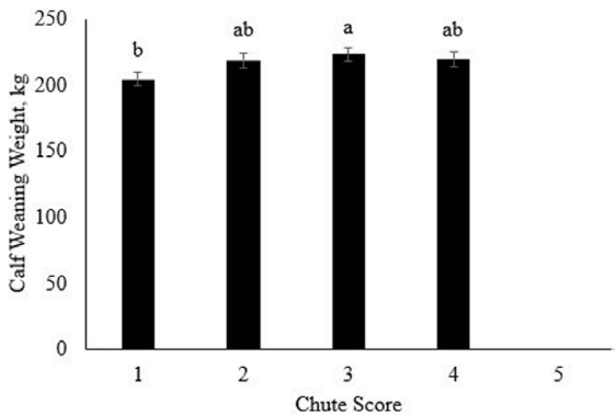


**Figure 7.** Calf CS at weaning and their association with calf weaning weight ($P$ = 0.05). Weaning: score 1, $N$ = 50; score 2, $N$ = 247; score 3, $N$ = 157; score 4, $N$ = 14; score 5, $N$ = 1 and was therefore removed from the analysis. Means without common superscript differ ($P \leq 0.05$).

1, 2017. Cows at the SRU ($N$ = 88) were predominantly Angus parentage with some Angus and Hereford crosses. Cows ranged from 3 to 15 yr and calved between August 10, 2017, and October 4, 2017.

## Animal Handling

Multiple observers were present for both MDS and CSat all locations. Observers were trained personnel selected for their previous experience with both scoring systems and animal handling training. Personnel were blinded to study objectives to keep scoring as objective as possible.

During each calving season, observers assigned MDSs (Sandelin, et al., 2005) to dams while calves were being process ($N$= 473). Calves were processed by two handlers at each location in the pasture in which they were born, with the dam near. Pairs were approached in either a four-wheeler or a farm truck depending upon the location. Calves were caught by hand and restrained by one handler while the other followed standard processing procedures for all locations. Processing of calves included placing an identification tag within the middle third portion of the left ear, weighing, and, if applicable, castrating male calves, all within 24 h after parturition. Calf gender, birth weight, castration status, and MDS were also recorded at the time of processing. After processing, calves were returned to dams and reared on cool or warm-season forages respective of calving season. Calves were weaned at 6 to 8 mo of age at all locations, and body weight was recorded and adjusted for a 205-d weaning weight following the Beef Improvement Federation guidelines. Body weights and blood was collected from weaning (day 0), 1 wk postweaning, and on days 28 and 56 (the duration of the backgrounding period). Prior to weaning, calves were managed in working facilities roughly four times during the breeding procedures for AI techniques. Working facilities were used at this time to simply sort dams from calves.

A subset of calves (all males) from the SWREC location ($N$ = 74) and LFRS location ($N$ = 62) were used for the finishing portion of the study. The subset was selected only from these locations due to research trials conducted on the calves from the other two. Calves were backgrounded at original locations before shipping to the Willard Sparks Beef Research Center at Oklahoma State University in Stillwater, Oklahoma. Upon arrival, calves were separated into pens resulting in 5 calves per pen and stepped up every 7 d for a 28-d period to a high concentrate diet. All diets contained rolled corn, sweet bran, and prairie hay mixed with mineral supplement. Diets contained tylosin (60 to 90 mg/d; Tylan-40), monensin (50 to 480 mg/d; Rumensin-90, Elanco), and ractopamine hydrochloride during the last 37 d of the trail (70 to 430 mg/d; Optaflexx, Elanco). Body weights were recorded twice: once upon arrival and once again when exiting the feed yard for harvest.

Calves were shipped to a commercial slaughter plant. Harvest data were collected after a 24-h period by trained personnel. The USDA quality, yield grade, LM area and 12th rib fat thickness were determined by video image analysis (VBG 2000; E+V Technology GmbH, Oranienberg, Germany).

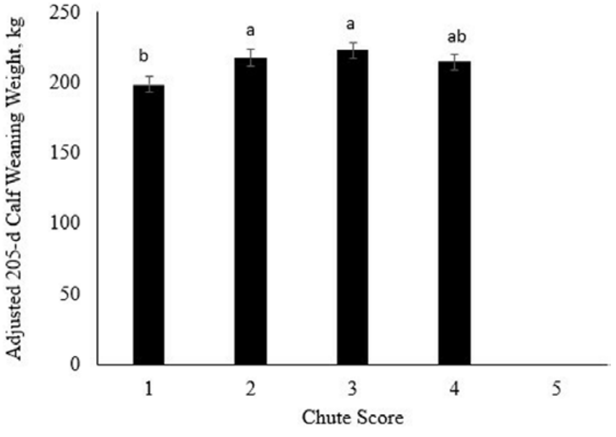


**Figure 8.** Calf CS at weaning and their association with calf weaning weight ($P < 0.05$) adjusted for a 205-d period. Weaning: score 1, $N$ = 50; score 2, $N$ = 247; score 3, $N$ = 157; score 4, $N$ = 14; score 5, $N$ = 1 and was therefore removed from the analysis. Means without common superscript differ ($P \leq 0.05$).

## Maternal Disposition Scoring at Calving

MDSs (Table 1) used were from a case study that examined maternal behavior over a 25-yr period (Sandelin et al., 2005), with minor modifications. The original scale encompassed descriptions from 1 to 4, but for this analysis, an additional score took the place of 1 and was referred to as highly aggressive. Sandelin and others originally described the preceding scores (2 to 5) (2005). Scores increased on a 1 to 5 scale as aggressive behavior decreased. Cows that received a disposition score of 1 at calving were designated as highly aggressive and were described as extremely flighty and ran away from the handler. Cows that received a disposition score of 2 at calving were designated as very aggressive and were described as those who fought the handler to protect her calf. Cows that received a disposition score of 3 at calving were designated as very attentive and were described as those cows that remained in close proximity with mild aggression but did not fight the handler to protect her calf. Cows that received a disposition score of 4 were designated as indifferent and were described as those that remained in proximity but showed no aggression toward the handler but remained in sight of the calf. Cows that received a disposition score of 5 at calving were designated apathetic and were those that showed no emotion toward their calf in the presence of the handler, grazed away, or moved out of proximity entirely. Calves were then reared with dams on pasture until weaning, where a CS (Table 2, BIF, 2002) was assigned. The MDSs reported in this study do not encompass the entire range of known maternal behavior and are limited to the dam's reaction to handler involvement for calf identification and data collection at birth.

## Chute Scoring at Weaning

CS were assigned to calves at weaning and based on the Beef Improvement Federation guidelines (2002). Scores increased on a 1 to 6 scale as aggressive behavior increased. Calves who received a chute score of 1 at weaning were designated docile.

**Table 1.** MDS 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 et al. (2005).

**Table 2.** Calf CS 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. |

Adapted from Beef Improvement Federation (2016).

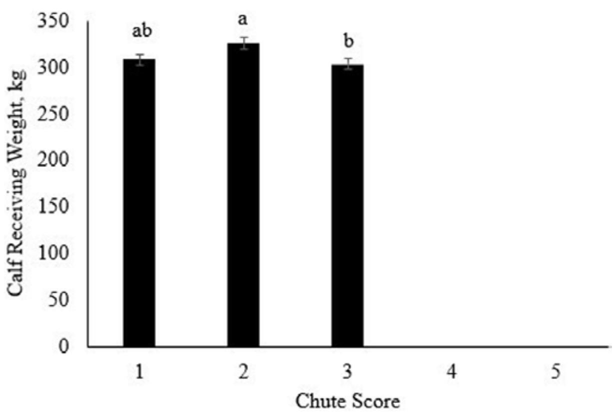


**Figure 9.** Calf CS at weaning and their association with calf feed yard receiving weight ($P < 0.01$). Finishing: score 1, $N = 4$; score 2, $N = 45$; score 3, $N = 45$; scores 4 and 5, $N = 0$ and was therefore removed from the analysis. Means without common superscript differ ($P \leq 0.05$).

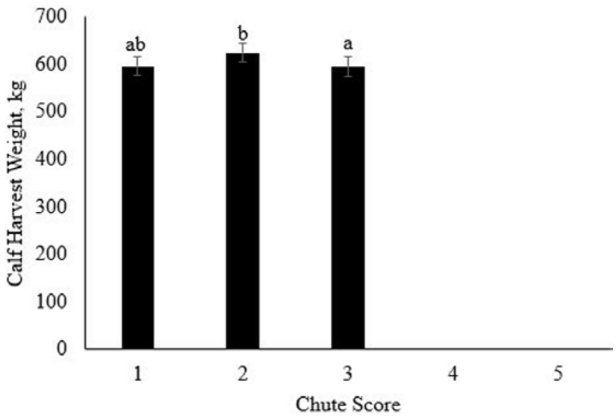


**Figure 10.** Calf CS at weaning and their association with calf harvest weight ($P = 0.01$). Finishing: score 1, $N = 4$; score 2, $N = 45$; score 3, $N = 45$; scores 4 and 5, $N = 0$ and was therefore removed from the analysis. Means without common superscript differ ($P \leq 0.05$).

Docile calves were described as having a mild disposition that were gentle and easily handled. It stands and moves slowly during processing. Undisturbed, settled, and somewhat dull, does not pull on the headgate when inside the chute and exits the chute calmly. Calves that received a disposition score of 2 at weaning were designated as restless. Restless calves were described as those quieter than average but may be stubborn during processing. May try to back out of the chute or pull on the headgate and promptly exit the chute. Calves that received a disposition score of 3 at weaning were designated as nervous. Nervous calves were described as those with a typical, manageable temperament but nervous and impatient. Nervous calves showed a moderate amount of struggling, movement, tail flicking, repeatedly pushed and pulled on the head gate, and exited the chute briskly. Calves that received a disposition score of 4 at weaning were designated as flighty. Flighty calves were described as jumpy and out of control, quivers, and struggles violently. May bellow and froth at the mouth. Continuous tail flicking. Calves that received a disposition score of 5 at weaning were designated as aggressive. Aggressive calves were those that may be similar to score 4, but with added aggressive behavior, fearfulness, extreme agitation, and continuous movement. Calves that received a disposition score of 6 at weaning were designated as very aggressive. Very aggressive calves were those with extremely aggressive temperament and may thrash about or attack handlers.

## Sample Collection and Analysis

Blood from a subset of bull ($N = 17$) and steer ($N = 17$) calves from the SWREC group were bled via jugular venipuncture at weaning (October 1, 2018; day 0). Calves were selected based on pen and weaning BW. Additional blood samples were obtained on days 1, 2, 3, 7, 28, and 56 postweaning. Samples were centrifuged (Sorvall RC-6, Thermo-Fisher Scientific, Waltham MA) at 2,500 rpm for 20 min at room temperature, and serum was collected and stored at 4 °C until further analysis. Blood glucose concentrations were determined using a YSI 2900D Biochemistry Analyzer (YSI Incorporated, Yellow Springs, OH). Serum samples were transferred into a 96 well plate for each time point and inserted into an analyzer for glucose concentrations.

## Statistical Analysis

The GLIMMIX procedures of SAS (SAS Inst. Inc., Cary, NC) was utilized to analyze the categorical data set that was not

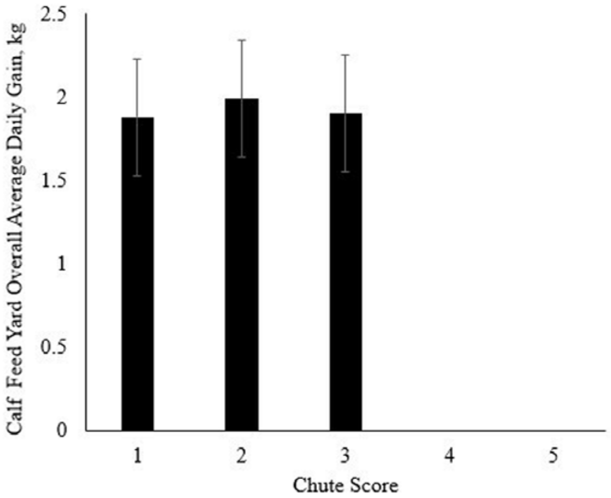


**Figure 11.** Calf CS at weaning and their association with calf overall ADG during the finishing phase ($P = 0.14$). Finishing: score 1, $N = 4$; score 2, $N = 45$; score 3, $N = 45$; scores 4 and 5, $N = 0$ and was therefore removed from the analysis.

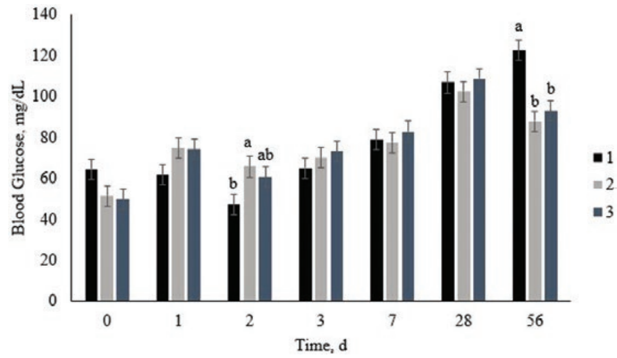


**Figure 12.** Calf CS and their association with calf blood glucose levels during the backgrounding period. Weaning CSs increased on a 1 to 5 scale as aggressive behavior increased. Score 1, $N = 3$; score 2, $N = 24$; score 3, $N = 7$; score 4, $N = 0$; score 5, $N = 0$. Due to low sample size CS 4 and 5 were removed from the analysis. Means within day without common superscript differ ($P \leq 0.05$).

distributed normally. No calves received a CS of 5 or 6 at weaning. Thus, data reported only included scores 1 through 4. The animal served as the experimental unit and was blocked by location. The RANDOM statement was used and included 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 $P \leq 0.05$.

## RESULTS AND DISCUSSION

### Maternal Disposition

Maternal disposition scores and their association with calf birth weight, calf weaning weight, adjusted 205-day weaning weight, feedyard receiving weight, calf bodyweight at harvest, and finishing ADG are presented in Figures 1–6; respectively. MDS at the time of calving impacted calf birth weight ($P < 0.01$, Figure 1). The calves from cows with MDS of 2 were 4.2 kg heavier at birth than those cows that received MDS 4, which may have implications on 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 did not differ compared to scores of 2 and 4. Although cow temperament influenced calf birth weight, there were no differences ($P = 0.37$) in actual weaning weight, or 205-d adjusted weaning weight ($P = 0.23$). As previously stated, more aggressive cattle gave birth to lighter calves compared to more attentive cows. The similarity in weaning weight might (Figures 2 and 3) be explained by compensatory gain throughout calfhood until weaning. Maternal disposition at the time of calving significantly affected feedlot receiving weight ($P = 0.03$, Figure 4). 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). This might be explained by food-aggressive behavior. It can be surmised that the aggressive nature of the dam might have influenced weaning behavior in the calves, more specifically food dominating behavior where calves kick and throw their head at bunkmates to secure food. Maternal disposition at calving did not significantly affect feedlot exit body weight ($P = 0.24$, Figure 5) or average daily gain (**ADG**) through the finishing phase ($P = 0.10$, Figure 6), which like weaning weights, might be due to compensatory gain. More specifically, during the finishing phase, calves were housed in fewer head per pen which would negate the need for food-aggressive behavior.

Using CSs during rectal pregnancy diagnosis, Fordyce and Goddard (1984) found temperament scores of *Bos indicus* cross cows were lowly heritable but moderately repeatable. Fordyce and Goddard (1984) also observed a significant dam–daughter relationship for movement and temperament scores suggesting that cows have a nongenetic influence on the behavior of their offspring that persists into maturity. In restrained tests, Burrow (1997) determined average estimates for heritability of temperament behaviors to be 0.23, suggesting moderate heritability of temperament to offspring. Conversely, we did not find a correlation between MDS and CS that may be partly explained by the calves habituating to human handling prior to weaning during calving and during the breeding season. Previous research shows that habituation to human handling increases tameness, reduces stress reactions, fearfulness toward people, and results more manageable animals (Uetake et al., 2003; Petherick et al., 2009).

Research indicates that animals can acclimatize to chute exposure after repeated use (Stooky et al., 1994) and that movement on a scoring scale may decrease over 5 to 10 d (Piller et al., 1999). In another study, Sebastian et al. (2011) determined that cattle did not habituate to the chute; thus, their stress response increased over time. This was most likely due to infrequent handling. Calves in our study were handled directly at the time of calving as previously described, and indirectly at breeding, specifically for the purposes of sorting calves from dams. It is possible that calves used in this study may have adapted to handling during contact at birth and breeding periods, resulting in a lack of correlation to dam temperament. Keeping in mind that temperament is a moderately heritable trait, the purposes of obtaining MDS at calving was to investigate whether it was a low-cost method to predict temperament in calves and thus providing a tool for producers to make management decisions for their herds.

## Calf Disposition at Weaning Effects on Growth Performance

At weaning, the cows' MDS and calves CS were negatively correlated ($R^2 = -0.10$) but not significant ($P = 0.22$), which is atypical from earlier research that shows a moderately heritable relationship between maternal and offspring temperament (Fordyce and Goddard, 1984; Burrow, 1997). Contrary to cow disposition's impact on weaning weight, CS influenced ($P < 0.05$) both weaning weight (Figure 7) and adjusted 205-day weaning weight (Figure 8). At the time of weaning, nervous calves (CS of 3) were 18.8 kg heavier ($P < 0.01$) than docile calves (CS of 1), with scores 2 and 4 being intermediate but similar to 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) results, 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 ADGs 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 overselection for docility may be occurring in Angus breed cattle in the United States 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 subsequently improve temperament. However, other research has shown that the correlations between temperament score and weight changed from positive at weaning to negative at 24 mo (O'Rourke, 1989).

CSs were re-evaluated during the finishing phase for the LFRS steers, and the SWREC bull and steer subset tracked through finishing with feedlot receiving weight, bodyweight at harvest, and finishing ADG presented in Figures 9–11; respectively. The finishing ADG (Figure 11) was not affected by CS ($P = 0.14$); however, calves that received a CS of 2 at weaning were heavier than calves that received a score of 3 upon arrival ($P < 0.01$, Figure 9) and exiting ($P = 0.01$, Figure 10) the feed yard. Calf CSs at weaning and their association with calf carcass characteristics are presented in Table 3. CS at weaning affected marbling score ($P < 0.01$) and longissimus muscle (**LMA**) ($P = 0.05$). Calves that received a CS of 1 had greater marbling 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. Cafe et al. (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.

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 experience human 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 warrants more research on the effects of stress on animal performance and welfare.

The effect of CS at weaning on blood glucose levels during backgrounding are presented in Figure 12. On day 0 weaning, serum glucose concentrations were similar ($P = 0.32$), but at 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 day 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 metabolism of volatile fatty acids produced during ruminal fermentation development (Suzuki et al., 2016). Ungerfeld et al. (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 intensity, duration, and novelty

**Table 3.** Calf CSs at weaning and their association with calf carcass characteristics

| Item | Score[1] | | | | | SEM[2] | *P*-value |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Marbling score[3] | 578[a] | 486[b] | 518[a,b] | - | - | 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[a,b] | 91.68[a] | 86.97[b] | | | 1.1 | 0.05 |

[1]Weaning CSs 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).
[2]SEM, pooled standard error of the mean.
[3]400, Small[00]; 500, Modest[00].
[a,b]Means within a row without common superscript differ ($P \leq 0.05$).

of the stressor (Weary and Fraser, 1995; Takayanagi and Onaka, 2021). Stressful situations like weaning induce large elevations in stress hormones and the release of energy reserves as indicated by elevated levels of glucose 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 and Onaka, 2021). Increased serum glucose concentrations at weaning in restless calves (CS of 2) compared to docile calves (CS of 1) in our study may also reflect this.

## IMPLICATIONS

The behavioral response of beef cattle to human handling is vital to producers due to the undesirable effects on the performance, handling, and welfare of livestock and handlers. Poor animal temperament has been shown to impact aspects of beef production negatively. Our objectives were to observe maternal behaviors during calving to find correlations to 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. Although growth performance differences were detected, CSs alone may not be a sufficient metric to assess cattle temperament properly. Using behavior metrics such as EV in conjunction with CSs may reduce some of the subjectivity issues associated with numerical scales and categorical scoring systems. However, our data suggest that calves with an optimum midrange temperament may have greater growth potential throughout their lives.

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## Conflict of interest statement

The authors declare no conflict of interest.

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