Interrelationships among growth, endocrine, immune, and temperament variables in neonatal Brahman calves

N. C. Burdick,*† J. P. Banta,‡ D. A. Neuendorff,‡ J. C. White,‡ R. C. Vann,§ J. C. Laurenz,* T. H. Welsh Jr.,† and R. D. Randelt‡

*Department of Animal and Wildlife Sciences, Texas A & M University, Kingsville 78363; †Texas AgriLife Research and Department of Animal Science, College Station 77843; ‡Texas AgriLife Research and Extension Center, Overton 75684; and §Brown Loam Branch Experiment Station, Mississippi State University, Raymond 34154

ABSTRACT: Interrelationships among growth, endocrine, immune, and temperament variables were assessed in neonatal Brahman calves. The velocity upon exiting a working chute (exit velocity) of an animal was measured and used as an objective indicator of temperament to classify calves as calm, intermediate, or temperamental. Calves (n = 116) were weighed weekly between d 0 and 21 to 24, and blood samples were collected for plasma and serum on d 0, 1, 2, 7, 14, and 21 to 24 after birth to measure concentrations of immunoglobulins, cortisol, and epinephrine (EPI). Body weight increased from d 0 through d 21 to 24 (P < 0.001) with bulls (n = 60) having greater BW than heifers (n = 56; P = 0.02). Serum concentrations of cortisol were greatest on d 0 before declining (P < 0.001) over the ensuing 21 to 24 d and were not related to temperament (P = 0.89) or sex (P = 0.97). Concentrations of EPI were affected by time, with an increase in EPI concentrations in temperamental bulls between 2 and 14 d of age (P < 0.008). Concentrations of EPI were not affected by temperament (P = 0.44) or sex (P = 0.68). Serum immunoglobulin concentrations peaked on d 1 before declining (P < 0.01) but were not related to temperament (P = 0.40 to 0.68). Of the stress hormones measured (cortisol and EPI), only cortisol was associated with the early performance of the calf. Calf BW at d 21 to 24 and BW gain were positively associated with serum immunoglobulin concentrations, yet negatively associated with concentrations of cortisol. Serum immunoglobulin concentrations were negatively correlated with cortisol concentrations (r = -0.28; P = 0.003), yet positively associated with EPI concentrations (r = 0.51; P = 0.003). During the neonatal period in this study, there was no relationship of temperament with passive immunity or stress hormone concentrations; however, growth was positively associated with passive immunity and negatively associated with stress hormones. Measuring exit velocity as early in life as d 21 to 24 fails to accurately predict temperament at weaning in over 40% of Brahman calves. Our conclusion is that measurement of exit velocity should be done nearer to the time of weaning than to birth. These data can be beneficial in developing best management practices for young calves.

Key words: growth, immunity, immunoglobulin, neonatal calf, stress, temperament

©2009 American Society of Animal Science. All rights reserved.

INTRODUCTION

Neonatal morbidity and mortality are important factors affecting survival in all species. Passive immunity acquired via transfer of maternal immunoglobulins in colostrum provides newborn mammals with early protection against pathogens. This is particularly important in cattle because calves are born hypogammoglobulinemic and depend solely on transfer from colostrum for antibody-mediated immunoprotection (Salmon, 1999; Van de Perre, 2003). Limited or complete failure of transfer of immunoglobulin can result in increased incidence of morbidity, which can contribute to failure to thrive as evidenced by suboptimal or diminished growth (Donovan et al., 1998; Parreño et al., 2001).

Excitable or temperamental calves have greater peripheral blood concentrations of cortisol and catecholamines after weaning than do calm calves (Curley...
et al., 2006a,b, 2008; King et al., 2006). Elevated physiological concentrations of cortisol for a short period of time (acute stress) are not usually detrimental to the long-term health of an individual and may even enhance immune function (Galvean et al., 1999; Dhabhar, 2002; Sorrells and Sapolsky, 2007). However, prolonged or repetitive exposure to elevated cortisol concentrations (chronic stress) can negatively affect performance and the immune response to pathogens of an animal (Fell et al., 1999; Shi et al., 2003; Silberman et al., 2003; Compas et al., 2004; Zhao et al., 2008). In addition to cortisol, epinephrine (EPI) produced by the sympathomedullary system (SMS) can influence innate and adaptive immunity (Benschop et al., 1996; Kizaki et al., 2008; Marketon and Glaser, 2008).

The secretion of EPI and the combined effects of EPI, cortisol, and the spectrum of physiological differences that accompany temperament have yet to be assessed in neonatal Brahman calves. Therefore, this study was designed to determine the interrelationships among growth, endocrine, immune, and temperament variables in neonatal Brahman calves.

MATERIALS AND METHODS

All experimental procedures were in compliance with the Guide for the Care and Use of Agricultural Animals in Research and Teaching and were approved by the Texas A & M University Animal Care and Use Committee.

Animals and Experimental Design

Brahman calves (Bos indicus; born spring 2006; 60 males and 56 females) were used. Calves were pastured with dams at the Texas A & M AgriLife Research Center in Overton until they were weaned (173 ± 2 d). Blood samples (2 x 10 mL) were collected via jugular venipuncture in an evacuated tube with no additive and a tube coated with EDTA (Becton-Dickinson, Franklin Lakes, N.J.) from calves as soon as possible after birth (d 0); on d 1, 2, 7, and 14; and between d 21 to 24 after calving. Blood samples were placed on ice after collection and processed within 30 min using a refrigerated centrifuge at 5°C. Serum and plasma were harvested from whole blood by centrifugation at 1,500 x g for 15 min at 5°C and stored at −80°C. Calf blood samples were analyzed for serum IgA, IgG, IgG1, IgG2, IgM, and cortisol, and plasma concentrations of EPI. Samples were thawed on ice until assayed. Calves were weighed on d 0, 7, 14, and 21 to 24 for calculation of ADG. Exit velocity, measured between 21 to 24 d after birth and at weaning, was used as an indicator of temperament (Burrow et al., 1988; Curley et al., 2006a). All exit velocity measurements were carried out using the same facility in which the calves were isolated temporarily from the sight of but were within hearing range of their dams. The weaning measurements were made and then the calves were removed permanently from their dams.

Temperament

Exit velocity at 21 to 24 d after birth and at weaning was measured as an indicator of temperament as described previously (Curley et al., 2006a, 2008). Briefly, the time for a calf to traverse 1.83 m after its exit from a working chute was determined using 2 infrared sensors (FarmTek Inc., North Wylie, TX) and was used to calculate velocity (velocity = distance/time in m/s). Calves were ranked based on their exit velocity (temperament) at weaning, with calm calves being those 1 SD slower than the mean (n = 25; 1.0 ± 0.12 and 0.98 ± 0.12 m/s at d 21 to 24 and weaning, respectively). Temperamental calves were those 1 SD faster than the mean (n = 20; 2.23 ± 0.14 and 3.64 ± 0.14 m/s at d 21 to 24 and weaning, respectively). Intermediate calves were all remaining calves (n = 71; 1.36 ± 0.07 and 2.32 ± 0.07 m/s at d 21 to 24 and weaning, respectively). For comparison purposes, calves were ranked also on d 21 to 24 to determine the number of calves that switched temperament group.

Serum Concentrations of Cortisol

Serum concentrations of cortisol were measured by routine methods employing a solid phase RIA as per manufacturer’s instructions (DSL-2100, Diagnostic Systems Labs, Webster, TX). The minimum detectable cortisol concentration was 1.2 ng/mL, and the intraassay CV was 5.8%.

Plasma Concentrations of Epinephrine

Plasma concentrations of EPI for 5 calm, 17 intermediate, and 9 temperamental randomly selected calves (15 heifers and 16 bulls) were determined by enzyme immunoassay as per manufacturer’s instructions (17-BCTHU-E02, Alpco Diagnostics, Boston, MA). The minimum detectable EPI concentration was 11 pg/mL, and inter- and intraassay CV were 17.7 and 10.4%, respectively.

Serum Concentrations of Immunoglobulins

Serum concentrations of IgA, IgM, IgG, IgG1, and IgG2 were determined using double-antibody sandwich ELISA specific for bovine immunoglobulin (E10-121, E10-118, E10-116, E10-117, and E10-101 for IgA, IgM, IgG1, IgG2, and IgG, respectively; Bethyl Laboratories, Montgomery, TX). Serum concentrations of specific immunoglobulin were determined by comparison with a standard curve generated with known concentrations of bovine IgA, IgM, IgG1, IgG2, or IgG, and are presented as milligrams per milliliter.
Calves were placed into temperament groups based on exit velocity at weaning as stated above (calm: 0.98 ± 0.12 m/s; intermediate: 2.32 ± 0.07 m/s; temperamental: 3.64 ± 0.14 m/s; P < 0.001). Exit velocity increased in intermediate and temperamental calves (P < 0.001), but not calm calves from d 21 to 24 to weaning (P = 0.89; Figure 1). Sex did not affect exit velocity at d 21 to 24 or at weaning (P = 0.18). Specifically, mean exit velocity was 1.60 ± 0.17 and 1.40 ± 0.15 m/s for heifers and bulls at d 21 to 24, respectively (P = 0.27), and 2.23 ± 0.17 and 2.31 ± 0.15 m/s for heifers and bulls at weaning, respectively (P = 0.14).

**Growth Performance**

The calves gained (P < 0.001) BW from birth (mean BW = 34.87 ± 0.99 kg) through d 21 to 24 of age (mean BW = 57.04 ± 0.99 kg) as anticipated. Bull calves weighed more at birth than heifer calves (P = 0.02). With these differences maintained throughout the measurement period, ADG of bull calves differed from those calculated for heifer calves (P < 0.001). The rate of BW gain increased weekly (mean ADG = 1.71, 2.30, and 2.62 kg/d for wk 1, 2, and 3, respectively; P = 0.003) and was unaffected by temperament. Calf BW at d 21 to 24 was strongly associated with both birth weight and ADG of the calf from birth through d 21 to 24 (r = 0.74 and r = 0.72, respectively; P < 0.001). However, birth weight was not associated with ADG during the first 3 wk of life (r = 0.09; P = 0.29).

**Stress Hormones**

Serum cortisol concentrations were not affected by temperament (P = 0.89) or sex (P = 0.97). There was a tendency for a sex × temperament interaction (P = 0.06), with calm heifers having lesser concentrations of cortisol than temperamental heifers and temperamental bulls having lesser concentrations of cortisol than calm bulls. Concentrations of cortisol were greatest at birth (d 0) and decreased through d 14 of age (P < 0.001; Figure 2A). Serum cortisol concentrations in blood samples taken just before release of calves from the working chute were positively correlated with the exit velocity measurement on d 21 to 24 (r = 0.27; P = 0.005) and with exit velocity measured at weaning (r = 0.21; P = 0.03).

Concentrations of EPI were determined to further evaluate the potential relationships of a SMIS stress hormone on growth and passive immunity. Plasma concentrations of EPI changed over time (P < 0.008; Figure 2B) but were not affected by sex (P = 0.68) or temperament (P = 0.44). There was a time × temperament interaction, in that EPI increased between d 2 and 14 of age in temperamental calves only (P = 0.02). There was a tendency for a positive correlation between EPI concentrations of d 1 and exit velocity measured at weaning (r = 0.33; P = 0.07).

---

**Statistical Analysis**

Data for BW, ADG, exit velocity, cortisol, EPI, and immunoglobulin were analyzed using the PROC MIXED procedure specific for repeated measures (SAS Inst. Inc., Cary, NC.). Sources of variation included sex, temperament group (based on weaning exit velocity), time, and their interactions. Specific comparisons were determined using Fisher's protected LSD with comparisons of P < 0.05 considered significant. Pearson correlation coefficients were also determined (Statview, SAS).

**RESULTS**

**Temperament**

Sixty-four out of 116 calves (55.2%) were classified the same (calm, intermediate, or temperamental) on d 21 to 24 and at weaning. Eight out of 19 (42.1%) were classified as temperamental on d 21 to 24 and at weaning, whereas 10 out of 19 (52.6%) were classified as intermediate at d 21 to 24 and at weaning. Five out of 25 calves (20%) were classified as calm on d 21 to 24 and at weaning, and 19 out of 25 (76%) were classified as intermediate on d 21 to 24 and calm at weaning. Only 1 out of 116 was classified as calm at d 21 to 24 and temperamental at weaning, and only 1 out of 116 was classified as temperamental at d 21 to 24 and calm at weaning. Because exit velocity increased from d 21 to 24 to weaning in intermediate and temperamental calves (as discussed below), and because measuring exit velocity at weaning is more practical from an industry perspective, the weaning temperament grouping was utilized to test all growth, endocrine, and immune data (Figure 1).
Immunoglobulins

Serum concentrations of IgA increased from birth to d 1 ($P < 0.001$: Figure 3A). Concentrations of IgA subsequently decreased and by d 14 were near the detectable limit of the assay. Peak concentrations of IgA were not related to sex ($P = 0.80$) or temperament ($P = 0.52$). Serum IgM concentrations exhibited a temporal pattern similar to that observed for IgA, with peak concentrations occurring on d 1 of age before declining through d 14 of age ($P < 0.001$: Figure 3B). Serum IgM concentrations were not related to sex ($P = 0.45$) or temperament ($P = 0.68$). However, there was a sex × temperament interaction ($P = 0.03$) in which...
temperamental bulls had the greatest concentration of IgM compared with calm bulls, and calm heifers had the greatest concentration of IgM compared with temperamental heifers. Also, IgM concentrations increased in calm calves on d 21 to 24 \((P = 0.06)\), but not in intermediate \((P = 0.66)\) or temperamental calves \((P = 0.60)\). Serum IgG concentrations also increased from birth to d 1 \((P < 0.001; \text{Figure 4A})\). Serum IgG concentrations were not related to sex \((P = 0.88)\) or temperament \((P = 0.40)\). Similar to IgG, serum concentrations of IgG\(_1\) increased from birth to d 1 after birth before decreasing through d 14 \((P < 0.001; \text{Figure 4B})\). Serum concentrations of IgG\(_1\) were not related to sex \((P = 0.69)\) but were affected by temperament with tempera-
mental calves having greater IgG1 concentrations than intermediate calves ($P = 0.04$). There was a tendency for serum concentrations of IgG2 to be affected by time ($P = 0.07$; data not shown). Serum IgG2 concentrations were not related to sex ($P = 0.48$) or temperament ($P = 0.53$).

**Figure 4.** Relationship between temperament and serum concentrations of IgG (A) and IgG2 (B) from birth through d 24 of age in calm, intermediate, and temperamental calves ($n = 25$ calm, 71 intermediate, and 20 temperamental calves; least squares means ± SEM). Bars with different letters differ ($P < 0.05$).

**Relationships Among Temperament, Stress Hormones, Passive Immunity, and Growth**

Exit velocity measured at 21 to 24 d of age was correlated with exit velocity measured at weaning ($r = 0.62$; $P < 0.001$). Of the stress hormones measured, cortisol,
Table 1. Correlations between early performance, cortisol, and calf temperament

<table>
<thead>
<tr>
<th>Variable</th>
<th>Peak cortisol</th>
<th>Exit velocity d 21 to 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
<td>&lt;0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>BW d 21 to 24</td>
<td>0.12</td>
<td>-0.02</td>
</tr>
<tr>
<td>ADG d 0 to 24</td>
<td>-0.20*</td>
<td>-0.06</td>
</tr>
<tr>
<td>Exit velocity weaning</td>
<td>0.11</td>
<td>0.62**</td>
</tr>
</tbody>
</table>

Calves were weighed weekly from birth through 21 to 24 d of age for calculation of ADG. Whole blood was collected and serum isolated from calves at birth (d 0), d 1, d 2, d 7, d 14, and between 21 to 24 d of age for determination of serum concentrations of cortisol. On d 21 to 24 and at weaning, exit velocity was determined as a measurement of temperament.

*P < 0.05; **P < 0.001.

but not EPI, was associated with the early performance of the calves (Table 1). Cortisol measured on d 0 was negatively associated with ADG of the calf from birth (d 0) through d 21 to 24 (r = -0.20; P = 0.04). Growth variables (birth weight, BW at d 21 to 24, and ADG of the calf through d 21 to 24) were not correlated with concentrations of EPI (P = 0.42 to 0.89) or exit velocity (P = 0.18 to 0.66).

Birth weight was not associated with peak concentrations of immunoglobulin (P = 0.25 to 0.98; Table 2). However, BW at d 21 to 24 was positively associated with peak IgM (r = 0.18; P = 0.04) and IgG2 (r = 0.19; P = 0.05) concentrations. Calf ADG was associated (r = 0.19; P = 0.04) with peak IgM concentrations.

Concentrations of EPI were positively associated with peak concentrations of IgM (r = 0.51, P < 0.003; Table 3). Peak concentration of cortisol was negatively associated with peak IgM (r = -0.19; P = 0.04) and IgG2 concentrations (r = -0.28; P = 0.003; Table 3). Exit velocity measured at 21 to 24 d of age was positively associated with peak IgM concentrations (r = 0.37; P = 0.04), whereas exit velocity measured at weaning was negatively associated with peak IgA concentrations (r = -0.35; P = 0.05).

**DISCUSSION**

This study evaluated interrelationships among growth, endocrine, immune, and temperament variables in neonatal Brahman calves. Specifically, the data described herein characterize the temporal patterns in concentrations of stress hormones and immunoglobulins and their relationship to growth performance in the neonatal calf from d 0 through d 21 to 24 after parturition.

Elevated serum cortisol concentrations in calves at birth were expected in view of the greater concentrations of maternal and fetal cortisol associated with periparturient processes (Mastorakos and Illias, 2003). Cortisol is essential for the prenatal and neonatal development of the lungs, kidneys, gastrointestinal tract, and liver (Schmidt et al., 2004; Owen et al., 2005). Neonatal cortisol secretion by the adrenal cortex is also important for development of the brain and associated neuroendocrine connections (Owen et al., 2005). The potential for the temperament and subsequent behavior of a neonate to be influenced by exogenous cortisol (via ingestion of maternal milk) or endogenous cortisol (via adrenal cortical production) or both is an intriguing topic (Glynn et al., 2007). Furthermore, temperament traits in humans have been associated with greater concentrations of cortisol and a greater adrenocortical response to a dexamethasone-CRH test (Tyrka et al., 2008). The decline in serum cortisol from its peak at parturition is in agreement with published results for swine and cattle in which cortisol concentrations decreased during the first 7 d after birth (Brown-Borg et al., 1993; Blum and Hammon, 2000). The adrenal medullary component is also important for the normal developmental processes of the neonate. For example, elevated concentrations of catecholamines are required at birth for the neonate to become alert and begin nursing (i.e., survival behavior; Herlenius and Lagercrantz, 2004; Ronca et al., 2006).

In this study, concentrations of cortisol and EPI were not correlated with each other. One possibility for the lack of correlation was that increased concentrations of cortisol at birth affect the negative feedback mechanisms of the hypothalamic-pituitary-adrenal (HPA) axis (Challis et al., 1995). Studies indicate that shortly after birth the HPA axis and the SMS are less responsive to cortisol, and this insensitivity lasts for approximately 48 h after birth (Schmidt et al., 2004). Therefore, even though the SMS and the HPA axis communicate, their relationship may be imbalanced during the first few days of life until serum cortisol declines to physiological concentrations normally denoted for older cattle. Another possibility may be stressor-specific interactions as per Pacak's (2000) study of the effect of

Table 2. Correlations between early performance and peak immunoglobulin concentrations

<table>
<thead>
<tr>
<th>Item</th>
<th>Peak IgA</th>
<th>Peak IgM</th>
<th>Peak IgG</th>
<th>Peak IgG2</th>
<th>Peak IgG3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
<td>-0.01</td>
<td>0.06</td>
<td>0.10</td>
<td>0.01</td>
<td>0.12</td>
</tr>
<tr>
<td>BW d 21 to 24</td>
<td>0.07</td>
<td>0.18*</td>
<td>0.10</td>
<td>0.08</td>
<td>0.19*</td>
</tr>
<tr>
<td>ADG d 0 to 24</td>
<td>0.08</td>
<td>0.19*</td>
<td>0.05</td>
<td>0.10</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Calves were weighed weekly from birth through 21 to 24 d of age for calculation of ADG. Whole blood was collected and serum isolated from calves at birth (d 0), d 1, d 2, d 7, d 14, and between 21 to 24 d of age for determination of concentrations of IgA, IgM, IgG, IgG2, and IgG3.

*P < 0.05.
Table 3. Correlations between stress hormones, temperament, and peak immunoglobulin concentrations

<table>
<thead>
<tr>
<th>Item</th>
<th>Peak IgA</th>
<th>Peak IgM</th>
<th>Peak IgG</th>
<th>Peak IgG₁</th>
<th>Peak IgG₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak cortisol</td>
<td>-0.15</td>
<td>-0.19*</td>
<td>-0.05</td>
<td>-0.12</td>
<td>-0.28*</td>
</tr>
<tr>
<td>EPI d 1</td>
<td>-0.19</td>
<td>0.51*</td>
<td>0.02</td>
<td>-0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Exit velocity, d 21 to 24</td>
<td>-0.20</td>
<td>0.37*</td>
<td>0.12</td>
<td>0.17</td>
<td>0.44*</td>
</tr>
<tr>
<td>Exit velocity, weaning</td>
<td>-0.35*</td>
<td>0.20</td>
<td>0.12</td>
<td>0.06</td>
<td>0.12</td>
</tr>
</tbody>
</table>

*Whole blood was collected and serum and plasma isolated from calves at birth (d 0), d 1, d 2, d 7, d 14, and between d 21 to 24 of age for determination of concentrations of serum of IgA, IgM, IgG, IgG₁, IgG₂, and cortisol, and plasma epinephrine (EPI). On d 21 to 24 and at weaning, exit velocity was determined as a measurement of temperament.

†P < 0.10; *P < 0.05.

Various stressors on concentrations of EPI and plasma ACTH. Therefore, differences due to stressor-specific mechanisms, more than physiological changes due to parturition, may explain the relatively weak relationships observed between cortisol and EPI in the neonatal calf. Whereas EPI was measured in only a subset of the calves in this study, these new data suggest that further studies are needed addressing changes in EPI concentrations in neonatal calves and its influence on growth, immune, and other endocrine variables.

In regard to the serum immunoglobulin profiles, the temporal pattern of IgA decline is similar to what would be expected with gut closure between 24 to 36 h after birth (Suh et al., 2003). The temporal declines of IgA, IgM, and IgG are similar to previous studies in beef and dairy cattle (Suh et al., 2003). However, the IgG₂ data contrast with literature published by Vann et al. (1995), who reported that IgG₂ concentrations increased from 1 h through 48 h after birth in Brahman calves. Taken together, the immunoglobulin data are similar to published literature in which the predominant immunoglobulin was IgG (with IgG₁ > IgG₂), followed by IgM and IgA as assessed by serum concentrations (Vann et al., 1995).

Although limited relationships were observed between stress hormones and measures of passive immunity, the negative correlations between cortisol and IgM and growth are reflective of potential immunosuppressive and catabolic effects of this adrenal steroid in the neonatal calf. Specifically, cortisol was negatively associated with concentrations of IgM and IgG₂. In contrast, EPI was positively associated with concentrations of IgM. Furthermore, IgM and IgG₂ were positively associated with calf BW at d 21 to 24. This suggests limited communication between the SMS and the HPA axis during the first weeks of life or the possibility of stressor-specific mechanisms of action in regard to parturition, as stated earlier. Additionally, concentrations of IgM began to increase in calm calves at 21 to 24 d of age. This is similar to studies in pigs and cattle, which suggest this is due to an increase in de novo IgM production by the young animal (Porter and Hill, 1970; Porter, 1972). Therefore, greater concentrations of cortisol in more temperamentally neonates may be preventing de novo synthesis of IgM.

Recent reports of an increased plasticity of the stress system in the neonate support the concept of limited communication between the SMS and HPA axis during the neonatal period (Matthews, 2001; Charmandari et al., 2005). Exposure to glucocorticoids after birth can lead to premature maturation of the dopamine and norepinephrine systems in the brain (Matthews, 2001). Helenius and Lagercrantz (2004) described critical periods during fetal development required for the normal maturation of dopaminergic and noradrenergic systems. Stress can alter the expression of these neurotransmitters and their cognate receptors. Thus, the stress response in the neonate is altered due to elevated concentrations of stress hormones when compared with the response of a calf at 6 to 7 mo of age. This may be due to the plasticity of the neuroendocrine mechanisms of the stress and behavioral responses in the neonatal calf.

Measuring exit velocity as early as 21 to 24 d fails to accurately predict temperament at weaning in over 40% of Brahman calves. Our conclusion is that measurement of exit velocity should be done nearer to the time of weaning than to birth. Although temperament was not related to circulating stress hormone or immunoglobulin concentrations, neonatal cortisol and immunoglobulin concentrations were associated with growth of the calf from birth through 3 wk of age. These data can be beneficial in developing best management practices for young calves. Future studies should investigate the influence of neonatal passive immunity as well as adrenal cortical and medullary functions on subsequent endocrine, behavior, and growth traits throughout the first year of life (Cavigelli and McClintock, 2003; Cavigelli et al., 2008).

LITERATURE CITED


plasma cortisol concentration after stress induced by restraint. 
infant rats predicts adult corticosterone dynamics and an early 
ament predicts life span in female rats that develop spontaneous 
Challis, J. R. G., E. T. M. Berduseo, T. M. Jeffray, K. Yang, and G. 
L. Hammond. 1995. Corticosteroid-binding globulin (CBG) in 
stress reactivity, and coping: Implications for depression in 
Welsh Jr., and R. D. Randel. 2008. Functional characteristics of 
the bovine hypothalamic-pituitary-adrenal axis vary with tem- 
2006a. Exit velocity as a measurement of cattle temperament is 
repeatable and associated with serum concentration of cortisol 
Curley, K. O. Jr., C. E. Schuehle Pfeiffer, D. A. King, J. W. Savell, 
R. C. Vann, T. H. Welsh Jr, and R. D. Randel. 2006b. Relation- 
ship of cattle temperament and physiologic responses to 
driving conditions during typical management situations. J. Anim. Sci. 
84(Suppl. 2):32. (Abstr.)
Dhabhar, F. S. 2002. Stress-induced augmentation of immune func-
tion—The role of stress hormones, leukocyte trafficking, and 
1998. Associations between passive immunity and morbid- 
Med. 34:31–46.
Associations between temperament, performance and immune 
function in cattle entering a commercial feedlot. Aust. J. Exp. 
Agric. 39:795–802.
1134.
Glynn, L. M., E. P. Davis, C. D. Schetter, A. Chicz-DeMet, C. J. 
Hohel, and C. A. Sandman. 2007. Postnatal maternal cortisol 
levels predict temperament in healthy breastfed infants. Early 
Herlenius, E., and H. Lagercrantz. 2004. Development of neurotrans-
mittsystems during critical periods. Exp. Neurol. 190:85– 
S2.
King, D. A., C. E. Schuehle Pfeiffer, R. D. Randel, T. H. Welsh Jr., 
Hale, and J. W. Savell. 2006. Influence of animal tempera- 
ment and stress responsiveness on the carcass quality and beef 
Kizuki, T., T. Izawa, T. Sakurai, S. Haga, N. Taniguchi, H. Tao- 
γδ-T-Adrenergic receptor regulates Toll-like receptor-4-mediated 
nuclear factor-κB activation through 3-arrestin 2. Immunology 
Marisetam, J. I. W., and R. Glaser. 2008. Stress hormones and im-
Mastorakos, G., and I. Illias. 2003. Maternal and fetal hypothalamo-
Matthews, S. G. 2001. Antenatal glucocorticoids and the developing 
adversity, glucocorticoids and programming of neuroendocrine 
Paciók, K. 2000. Stressor-specific activation of the hypothalamic-
Parreño, V., C. Bejar, A. Vagnozzi, M. Barrandeguy, V. Costantini, 
M. I. Craig, L. Yuan, D. Hodigos, L. Saff, and F. Fernandez. 
2004. Modulation by colostromes-acquired maternal antibo-
dies of systemic and mucosal antibody responses to rotavirus in 
calves experimentally challenged with bovine rotavirus. Vet. 
Quantitative changes in early lactation and absorption by the 
Porter, P., and I. R. Hill. 1970. Serological changes in immunoglobu-
lins IgG, IgA and IgM and Escherichia coli antibodies in the 
young pig. Immunology 18:565–573.
Ronca, A. E., R. A. Abel, R. J. Ronan, K. J. Remer, and J. R. 
Albers. 2006. Effects of labor contractions on catecholamine 
release and breathing frequency in newborn rats. Behav. Neu-
rosci. 120:1308–1314.
Salmon, H. 1999. The mammary gland and neonate mucosal immu-
Schmidt, M., P. T. Sangild, J. W. Blum, J. B. Andersen, and T. 
Greve. 2004. Combined ACTH and glucocorticoid treatment 
and improves survival and organ maturation in premature newborn 
Shi, Y., S. Devadas, K. M. Greenslade, D. Yin, R. A. Mifsud, and 
17:S18–S26.
and chronic stress exert opposing effects on antibody responses 
associated with changes in stress hormone regulation of T-lympho-
Sorrells, S. F., and R. M. Sapolsky. 2007. An inflammatory review of 
glucocorticoid actions in the CNS. Brain Behav. Immun. 
immunoglobulin concentrations between dairy and beef calves 
Cortisol and ACTH responses to the Dex/CRH Test: Influence of 
Vaccine 21:3374–3376.
Vann, R. C., J. W. Holloway, G. W. Curstens, M. E. Bowld, and R. 
D. Randel. 1995. Influence of calf genotype on colostral immu-
noglobulins in Bos taurus and Bos indicus cows and serum 
Hyper innate responses in neonates lead to increased morbidity 
and mortality after infection. Proc. Natl. Acad. Sci. USA 
105:7528–7533.