Plasma metabolites of receiving heifers and the relationship between apparent bovine respiratory disease, body weight gain, and carcass characteristics


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ABSTRACT: Six hundred sixty-five crossbred beef heifers initially weighing 225 kg were used in a completely randomized design to measure plasma glucose, lactate, and urea N concentrations at time of initial processing, determine the incidence of apparent bovine respiratory disease (BRD) in receiving cattle, and evaluate the effect of apparent BRD on subsequent cattle growth and carcass characteristics. Heifers were processed within 24 h of arrival, and processing included vaccination against common viral and clostridial diseases, recording rectal temperature, and sampling whole blood for subsequent measurement of plasma glucose, lactate, and urea concentrations. Heifers were monitored for clinical signs of apparent BRD, including depression, lethargy, anorexia, coughing, rapid breathing, and nasal or ocular discharge. Heifers exhibiting signs of apparent BRD received antibiotic therapy, and the number of times a heifer was treated for apparent BRD was recorded. Following the 36-d receiving period, heifers were transported to native grass pastures and allowed to graze for 136 d. At the end of the grazing season, heifers were transported to a commercial feedlot where they were adapted to a common finishing diet offered for ad libitum consumption. Following the 124-d finishing period, heifers were slaughtered and carcass data were collected. Heifers treated for apparent BRD had decreased plasma glucose (linear, \(P < 0.01\)), lactate (linear, \(P < 0.01\)), and urea N concentrations (linear, \(P < 0.06\)) measured at time of initial processing. Rectal temperature measured at time of initial processing tended to be greater (linear, \(P < 0.11\)) for heifers treated for apparent BRD. Heifers treated for apparent BRD during the receiving period had decreased overall ADG (linear, \(P < 0.10\)), final BW (linear, \(P < 0.01\)), HCW (linear, \(P < 0.01\)), fat thickness (linear, \(P < 0.01\)), and marbling score (linear, \(P < 0.03\)). These data suggest that initial plasma glucose and lactate concentrations might be affected by the health status of receiving cattle and that increased incidence of apparent BRD in cattle decreases ADG and carcass quality.

Key words: bovine respiratory disease, plasma metabolite, receiving heifer

INTRODUCTION

Bovine respiratory disease (BRD) continues to be a significant problem in receiving cattle. Stress associated with weaning, transportation, commingling, processing, and feed and water deprivation can compromise the immune system, thereby predisposing cattle to outbreaks of BRD (Hutcheson and Cole, 1986; Galyean et al., 1999). Stress associated with transportation of cattle has been shown to increase concentrations of glucose, urea N, and lactate (Galyean et al., 1981; Cole et al., 1988; Mitchell et al., 1988). The objectives of our experiment were to measure plasma glucose, lactate, and urea N concentrations at the time of initial processing and determine the incidence of apparent BRD in receiving cattle, as well as to evaluate the effect of apparent BRD on subsequent cattle growth and carcass characteristics.

MATERIALS AND METHODS

The following experiment was approved by the Kansas State University Animal Care and Use Committee. Six hundred sixty-five crossbred beef heifers initially weighing 225 ± 24 kg were used in a completely randomized design. Heifers were obtained from commercial sale barns in Kansas and the southeastern United States. Heifers were processed within 24 h of arrival.
Processing included measurement of individual BW, vaccination against bovine respiratory syncytial virus, bovine virus diarrhea virus, infectious bovine rhinotracheitis, and parainfluenza using modified live viruses (Bovishield 4, Pfizer Animal Health, Exton, PA), vaccination against common clostridial diseases using a clostridial bacterin-toxoid (Fortress 7, Pfizer Animal Health), recording rectal temperature, and treatment for internal and external parasites (Phoenectin, Phoenix Scientific, St. Joseph, MO). In addition, whole blood was collected in heparinized (143 USP units of sodium heparin) 10-mL vacuum tubes (Becton Dickinson, Franklin Lakes, NJ) via jugular venipuncture for analysis of plasma glucose, lactate, and urea nitrogen concentrations. Whole blood was stored in an ice-filled cooler during collection and the cooler containing the whole blood was transported to the laboratory where the whole blood was centrifuged at 2,000 × g for 15 min at 4°C. The supernatant was removed, placed into microcentrifuge tubes, and subsequently frozen at −20°C. Immediately following initial processing, heifers were assigned randomly among 28 pens so that each pen contained 21 to 27 heifers, depending on pen size. Heifers were offered a diet containing (DM basis) 44% steam-flaked corn, 45% alfalfa hay, 6% corn steep liquor, 3.8% soybean meal, and 1.2% vitamins and minerals for ad libitum consumption. Heifers were monitored at least once daily for clinical signs of BRD, which included depression, lethargy, anorexia, coughing, rapid breathing, and nasal or ocular discharge. Heifers exhibiting signs of apparent BRD and having a rectal temperature ≥39.7°C received antibiotic therapy and were returned to their home pen. Antibiotic therapy consisted of 10 mg/kg of BW of tilmicosin phosphate (Micotil 300, Elanco Animal Health, Indianapolis, IN) as a first-time and second-time treatment for apparent BRD, and 20 mg/kg of BW of oxytetracycline (Biomycin 200, Boehringer Ingelheim Vet Medica Inc., St. Joseph, MO) as a third-time treatment for apparent BRD. The number of times each heifer was treated for apparent BRD ranged between 0 and 3. Following the 36-d receiving period, heifers were weighed and 6 heifers identified as moribund were removed. The remaining heifers were implanted with Synovex C (100 mg of progesterone and 10 mg of estradiol benzoate, Fort Dodge Animal Health, Overland Park, KS) and transported approximately 100 km to native grass pastures for a 136-d grazing period. At the end of the grazing season, cattle were transported approximately 150 km to a commercial feedlot where carcass data were collected. Hot carcass weights were obtained at time of harvest. Longissimus muscle area, subcutaneous fat thickness over 12th rib, KPH, and marbling score were measured following a 24-h chill. Final BW was calculated by dividing HCW by a common dressing percent of 63.5%.

**Analysis of Plasma Constituents**

Plasma glucose and plasma l-lactate were analyzed per manufacturer instructions using a glucose-lactate auto analyzer (2300 Stat Plus, YSI Inc., Yellow Springs, OH) with a precision of 0.20 and 0.10 mM for glucose and lactate, respectively. Plasma urea N was analyzed using a using a Technicon III AutoAnalyzer (Technicon Instruments Corp., Tarrytown, NY) according to procedures described by Marsh et al. (1965). The intra- and interassay CV were 0.37 and 2.0%, respectively.

**Statistical Analysis**

All data were analyzed as a completely randomized design with heifer serving as the experimental unit. Plasma metabolite concentrations, rectal temperature, ADG, HCW, fat thickness, KPH, LM area, and marbling score were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC). Fixed effects consisted of the number of times each heifer was treated for apparent BRD; pen during the receiving period served as a random effect. Contrasts were used to test for linear and quadratic effects of repeated treatment for apparent BRD. An α level of 0.10 was used to decrease the probability of committing a Type I error.

**RESULTS AND DISCUSSION**

**Plasma Metabolites and Rectal Temperature**

Plasma metabolites and rectal temperature data measured at initial processing are shown in Table 1. Plasma glucose concentrations of heifers behaved in a linear (P < 0.01) manner, being greatest for heifers never treated for apparent BRD, decreased for heifers treated 1 and 2 times for apparent BRD, and further decreased for cattle that were subsequently treated 3 times for apparent BRD. The decrease in plasma glucose concentrations in heifers treated for apparent BRD might have been the result of a disease challenge before initial processing. Steiger et al. (1999) infused bacterial lipopolysaccharides into heifers to model a gram-negative bacterial infection and observed an increase in plasma tumor necrosis factor-α as well as a biphasic response for plasma glucose, with plasma glucose concentrations initially increasing and then subsequently decreasing to concentrations below that of saline-infused heifers. They suggested that the first phase resembled that of a stress response because of increased plasma glucose concentrations, and the second phase resembled an energy-deficit state because of decreased plasma glucose concentrations. Support for this was provided by Kushibiki et al. (2000), who injected recombinant tumor necrosis
factor-α into heifers and observed a similar biphasic response for plasma glucose. Collectively, these data suggest that a disease challenge provides for a period of hyperglycemia followed by a period of hypoglycemia in cattle, and might help to explain the decreased plasma glucose concentrations in heifers treated for apparent BRD in our experiment. Another explanation for decreased plasma glucose in heifers treated for apparent BRD is that these heifers may have been subjected to a more extensive period of feed withdrawal before arrival at the feedlot. Schaefer et al. (1990) reported decreased serum glucose concentrations in steers following a 36-h fast, and Cole et al. (1988) reported decreased serum glucose concentrations in steer calves following a 24-h fast. Similarly, Galyean et al. (1981) reported decreased serum glucose concentrations in steers fasted for 32 h. However, although fasting alone may decrease blood glucose concentrations, it appears that fasting in combination with the additional stress of transport increases blood glucose concentrations in cattle (Galyean et al., 1981; Cole et al., 1988). Cole et al. (1988) fasted steers weighing 195 kg for 24 h, during which time steers were transported 0, 12, or 24 h, and reported serum glucose concentrations to be 4.4, 4.2, or 5.0 mM, respectively. Cole et al. (1988) speculated that increased serum glucose concentrations in fasted and transported steers is likely related to numerous factors including adrenal gland activity, rate of glycogenolysis, lipolysis, or both, quantity and source of nutrients being absorbed from the gastrointestinal tract, and rate of tissue utilization of nutrients. The serum glucose concentrations of fasted and 24-h-transported steers as reported by Cole et al. (1988) are similar to the mean plasma glucose concentration of 5.1 mM in our experiment. Interestingly, Cole et al. (1988) reported the greatest incidence of morbidity and mortality for steers transported 12 h, which also had the least serum glucose concentrations.

Plasma lactate concentrations followed the same trend as plasma glucose and were decreased (linear, $P < 0.01$) for heifers treated for apparent BRD. Mitchell et al. (1988) reported greater plasma lactate concentrations in cattle subjected to handling and transport compared with cattle not handled and transported. According to Mitchell et al. (1988) plasma lactate concentrations were 0.3, 4.0, and 4.3 mM for cattle not handled or transported, handled, and handled and transported, respectively. Decreased plasma lactate concentrations in heifers treated for apparent BRD in our experiment might be attributed to depleted glycogen stores because of an extended period of fasting or stress, which would provide for decreased glycogenolysis and anaerobic glycolysis, and decreased production of lactate.

Plasma urea N concentrations were greater (linear, $P < 0.06$) for heifers treated for apparent BRD compared with heifers not treated for apparent BRD. Rule et al. (1985) fasted steers for 8 d and observed that plasma urea N concentrations were greater at d 2 and less at d 5 compared with d 0. Rule et al. (1985) suggested that greater plasma urea N concentrations during the first 2 d of fasting indicated increased protein catabolism. Cole et al. (1988) fasted steers weighing 195 kg for 24 h, during which time steers were transported 0, 12, or 24 h, and reported serum urea N concentrations to be 5.9, 5.3, and 5.1 mM, respectively. Orr et al. (1988) reported increased blood urea N concentrations in steers infected with infectious bovine rhinotracheitis virus and indicated increased catabolism of body protein in response to the stressors of infectious bovine rhinotracheitis virus infection. The increased plasma urea N concentrations in heifers treated for apparent BRD in our experiment suggests that heifers treated for apparent BRD were catabolic, and supports the previous statement regarding possible decreased glycogen stores at time of initial processing.

Rectal temperature at initial processing tended to be higher (linear, $P < 0.11$) for heifers treated for apparent BRD compared with those not treated for apparent BRD. Rectal temperature is commonly used to identify and treat cattle for BRD during initial processing. However, Galyean et al. (1995) observed that rectal temperature of beef cattle at initial processing is affected by processing order, crowding, ambient temperature, and humidity, and suggested that these factors should be taken into consideration when using rectal temperature as a criterion for treatment of BRD. Because rectal temperature at initial processing only tended to be higher for heifers treated for apparent BRD in our experiment, our data are in agreement with Galyean et al.
and demonstrate the potential limitations of using rectal temperature to identify cattle at risk for BRD during initial processing.

### Growth Performance: Receiving Period

Growth performance data are shown in Table 2. Heifers treated for apparent BRD had decreased initial BW (linear, \( P < 0.01 \)), ADG (linear, \( P < 0.01 \)), and final BW (linear, \( P < 0.01 \)) during the receiving period compared with heifers not treated for apparent BRD. The initial BW data suggest that cattle with decreased BW are more prone to outbreaks of apparent BRD, which might simply be a result of age, assuming that cattle with decreased BW are typically younger than heavier cattle. The decreased ADG associated with apparent BRD in our experiment agrees with observations of Bateman et al. (1990), Smith (1996), and Hutcheson and Cole (1986), who reported decreases in 28-d receiving period ADG ranging from 0.14 to 0.58 kg. In our experiment, heifers treated 1, 2, or 3 times for apparent BRD gained 0.08, 0.35, or 0.58 kg/d less, respectively, than those not treated for apparent BRD. Although individual feed intake during the receiving period was not measured in our experiment, the effects of BRD on cattle feeding behavior have been documented. Hutcheson and Cole (1986) reported that feed intake for morbid cattle after 28 d in the feedlot was 32% less than that of healthy cattle. Using radiofrequency technology to monitor the feeding behavior of both healthy and morbid cattle in commercial feedlots, Sowell et al. (1999) and Buhman et al. (2000) observed that morbid cattle visited the feed bunk less frequently and for a shorter duration than healthy cattle. Percentage death loss for the receiving period, as would be expected, was increased (linear, \( P < 0.01 \)) for heifers treated for apparent BRD and was 0.4, 0.4, 2.5, and 4.0% for heifers never treated or treated 1, 2, or 3 times for apparent BRD, respectively.

### Growth Performance: Grazing Period

Heifers treated for apparent BRD during the receiving period had decreased initial BW (linear, \( P < 0.01 \)) and final BW (linear, \( P < 0.01 \)) during the grazing period. However, grazing-period ADG was increased (linear, \( P < 0.01 \)) for heifers previously treated for apparent BRD compared with heifers not treated for apparent BRD. This effect on grazing period ADG may be attributed to compensation for decreased growth rate or decreased gastrointestinal tract fill from decreased feed intakes during the receiving period as well as possible decreased competition for nutrients from larger heifers.

### Growth Performance: Finishing Period

Heifers treated for apparent BRD during the receiving period had decreased initial BW (linear, \( P < 0.01 \)), final BW (linear, \( P < 0.01 \)) and tended to have decreased ADG (linear, \( P < 0.01 \)) during the finishing period compared with heifers not previously treated for apparent BRD. Decreased ADG during the finishing period in cattle previously treated for BRD has been previously reported (Bateman et al., 1990; Morck et al., 1993; Gardner et al., 1999). In our experiment, heifers treated for apparent BRD 1, 2, or 3 times during the

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**Table 2. Growth and death loss (±SEM) of heifers treated for apparent bovine respiratory disease (BRD)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Times treated for apparent BRD, n</th>
<th>Linear</th>
<th>Quadratic</th>
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<tbody>
<tr>
<td>Receiving period</td>
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<td></td>
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<tr>
<td>Heifers, n</td>
<td>268</td>
<td>247</td>
<td>78</td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>230 ± 2.3</td>
<td>223 ± 2.3</td>
<td>230 ± 3.1</td>
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<tr>
<td>Final BW, kg</td>
<td>278 ± 3.0</td>
<td>269 ± 3.03</td>
<td>256 ± 4.08</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>1.39 ± 0.042</td>
<td>1.31 ± 0.042</td>
<td>1.04 ± 0.062</td>
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<tr>
<td>Death loss, %</td>
<td>0.4 ± 0.64</td>
<td>0.4 ± 0.65</td>
<td>2.5 ± 1.15</td>
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<tr>
<td>Grazing period</td>
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<tr>
<td>Heifers, n</td>
<td>268</td>
<td>247</td>
<td>76</td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>277 ± 2.3</td>
<td>269 ± 2.3</td>
<td>256 ± 3.7</td>
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<tr>
<td>Final BW, kg</td>
<td>332 ± 2.8</td>
<td>330 ± 2.8</td>
<td>322 ± 4.1</td>
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<tr>
<td>ADG, kg</td>
<td>0.40 ± 0.012</td>
<td>0.45 ± 0.012</td>
<td>0.48 ± 0.018</td>
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<tr>
<td>Finishing period</td>
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<td>Heifers, n</td>
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<td>76</td>
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<tr>
<td>Initial BW, kg</td>
<td>332 ± 2.8</td>
<td>330 ± 2.8</td>
<td>322 ± 4.1</td>
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<tr>
<td>Final BW, kg</td>
<td>559 ± 4.9</td>
<td>552 ± 4.9</td>
<td>539 ± 7.2</td>
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<tr>
<td>ADG, kg</td>
<td>1.81 ± 0.025</td>
<td>1.78 ± 0.025</td>
<td>1.74 ± 0.040</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heifers, n</td>
<td>267</td>
<td>244</td>
<td>76</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>1.11 ± 0.012</td>
<td>1.11 ± 0.012</td>
<td>1.08 ± 0.020</td>
</tr>
</tbody>
</table>

1. Contrasts: linear = linear effect of number of treatments for apparent BRD; quadratic = quadratic effect of number of treatments for apparent BRD.
2. Calculated by dividing HCW by a common dressing percent of 63.5%.
receiving period gained 0.03, 0.07, or 0.06 kg/d less, respectively, during the finishing period compared with heifers not treated for apparent BRD.

**Growth Performance: Total**

Heifers treated for apparent BRD during the receiving period had decreased (linear, \( P < 0.10 \)) total ADG (ADG during the combined receiving, grazing, and finishing periods) compared with heifers not previously treated for apparent BRD. The decreased ADG of heifers treated for apparent BRD is in agreement with Bateman et al. (1990), Morck et al. (1993), and Gardner et al. (1999), and indicates that losses in growth performance in cattle treated for BRD are difficult to overcome and that cattle previously treated for BRD may never fully compensate for lost growth performance.

**Carcass Characteristics**

Carcass characteristics are shown in Table 3. Heifers treated for apparent BRD during the receiving period had decreased HCW (linear, \( P < 0.01 \)), fat thickness (linear, \( P < 0.01 \)), and LM area (linear, \( P < 0.08 \)) compared with heifers not previously treated for apparent BRD. The significant decreases in HCW, fat thickness, and LM area for heifers previously treated for apparent BRD are likely the result of smaller size heifers and decreased growth rates compared with heifers not previously treated for apparent BRD. Marbling score was decreased (\( P < 0.04 \)) in a quadratic fashion, with heifers treated once for apparent BRD during the receiving period having the highest marbling score and heifers treated 3 times for apparent BRD having the lowest marbling score. These carcass data are in agreement with Gardner et al. (1999), who reported that steers previously treated for BRD had decreased HCW, fat thickness, and marbling score.

In summary, plasma glucose, lactate, and urea nitrogen concentrations measured at initial processing seemed to be affected by the health status of receiving cattle. However, more research is required to characterize plasma metabolite concentrations in receiving cattle at time of initial processing and subsequent incidence of BRD. Cattle that were treated for apparent BRD had decreased growth rates and carcass quality compared with cattle that were not treated for apparent BRD.

**LITERATURE CITED**


Smith, R. A. 1996. Work with producers to reduce economic losses of BRD in stocker and feeder cattle. DVM 27:1F–3F.
