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EFFECTS OF 24-H TRANSPORT OR 24-H NUTRIENT RESTRICTION ON ACUTE-PHASE AND PERFORMANCE RESPONSES OF FEEDER CATTLE

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ABSTRACT: The objective was to compare acute-phase and performance responses of weaned beef cattle exposed to transport or nutrient restriction. Angus × Hereford steers (n = 30) and heifers (n = 15) were balanced by sex and BW, and randomly assigned to 15 pens on d -12 of the experiment. On d 0, pens were randomly assigned to 1 of 3 treatments: 1) transport for 24 h in a livestock trailer (TRANS); 2) no transport, but feed and water deprivation for 24 h (REST); or 3) no transport and full access to feed and water (CON). Treatments were concurrently applied from d 0 to d 1. Total DMI was evaluated daily from d 1 to d 28. Full BW was recorded prior to treatment application and at the end of experiment. Blood samples were collected on d 0, 1, 4, 7, 10, 14, 21, and 28. Mean ADG was greater ($P < 0.01$) in CON vs. TRANS and REST cattle, but similar ($P = 0.46$) between TRANS and REST cattle. No treatment effects were detected on DMI, but CON had greater G:F vs. TRANS ($P < 0.01$) and REST cattle ($P = 0.08$), whereas G:F was similar ($P = 0.21$) between TRANS and REST cattle. Plasma cortisol concentrations were greater ($P \leq 0.05$) in REST vs. CON and TRANS cattle on d 1, 4, 7, 14, 21, and 28, and tended to be greater ($P = 0.10$) in TRANS vs. CON cattle on d 1. Serum NEFA was greater ($P < 0.01$) in REST and TRANS vs. CON cattle on d 1, but also greater ($P < 0.01$) in REST vs. TRANS cattle on d 1. Plasma ceruloplasmin peaked on d 4 for TRANS and REST cattle (day effects; $P < 0.01$) but did not change ($P = 0.58$) for CON cattle. Hence, CON cattle had reduced mean plasma ceruloplasmin concentration vs. TRANS ($P = 0.07$) and REST ($P = 0.01$) cattle. Plasma haptoglobin peaked on d 1 for TRANS and increased from d 1 to 14 in REST cattle (day effects; $P < 0.01$) but did not change ($P = 0.65$) for CON cattle. Hence, TRANS cattle had greater plasma haptoglobin vs. CON and REST cattle on d 1 ($P < 0.01$), whereas REST cattle had greater ($P \leq 0.05$) plasma haptoglobin vs. TRANS and CON cattle on d 7. In conclusion, 24-h transport and 24-h nutrient restriction elicited acute-phase protein reactions, and similarly reduced performance of feeder cattle.

INTRODUCTION

Cattle are inevitably exposed to stress during their productive life (Carroll and Forsberg, 2007), including psychologic, physiologic, and physical stressors associated with management procedures currently practiced within beef and dairy production systems. An example is road transport, one of the most stressful events in the productive life of a feeder calf. Upon long transportation periods, feeder cattle experience inflammatory and acute-phase responses that often lead to impaired health and productivity during feedlot receiving (Berry et al., 2004; Araujo et al., 2010; Cooke et al., 2011). These stress- induced immune responses may be elicited by several stressors that cattle are exposed to during road transport, including feed and water restriction. In fact, preliminary data from our research group indicated that water and feed deprivation for 24 h increased circulating concentrations of acute-phase proteins in overtly healthy beef steers (Cappellozza et al., 2011).

Therefore, we hypothesized that feed and water restriction are major stimulants of the acute-phase response elicited by road transport. Based on our hypothesis, the objective of this experiment was to compare the effects of 24-h road transport or 24-h water and feed restriction on acute-phase and feedlot receiving performance responses of feeder cattle.

MATERIALS AND METHODS

This experiment was conducted at the Eastern Oregon Agricultural Research Center, Burns in accordance with an approved Oregon State University Animal Care and Use protocol. Forty-five Angus x Hereford steers (n = 30) and heifers (n = 15) weaned at 7 mo of age were ranked by sex and initial BW (217 ± 3 kg) on d -12 of the study, and randomly allocated to 15 dry lot pens (3 animals/pen; 2 steers and 1 heifer). From d -12 to 0, all pens received alfalfa-mixed hay for ad libitum consumption and 2.3 kg/hd daily (DM basis) of a supplement containing (as-fed basis) 84% corn, 14% soybean meal, and 2% mineral mix. On d 0, pens were assigned to 1 of 3 treatments: 1) transport for 24 h in a commercial livestock trailer for approximately 1,200 km (**TRANS**), 2) no transport, but feed and water deprivation for 24 h (**REST**), or 3) no transport and full access to feed and water (**CON**). Treatments were concurrently applied from d 0 to d 1. On d 1, TRANS and REST cattle returned to their original pens, and all pens received the same diet offered prior to treatment application.

Total and forage DMI were evaluated daily from d1 to 28. Full BW was recorded prior to (d -1 and 0) treatment application and at the end of experiment (d 28 and 29) for ADG calculation. Total BW gain and DMI from d 1 to 28 were used for G:F calculation. Blood samples were collected on d 0 (prior to treatment application), 1 (immediately at the end of treatments), 4, 7, 10, 14, 21, and 28, via jugular venipuncture into commercial blood collection tubes (Vacutainer, 10 mL; Becton Dickinson, Franklin Lakes, NJ) containing or not sodium heparin for serum and plasma collection, respectively. Plasma samples were analyzed for concentrations of cortisol (Endocrine Technologies Inc., Newark, CA), haptoglobin (Cooke and Arthington, 2012), and ceruloplasmin (Demetriou et al., 1974). Serum samples were analyzed for concentrations of NEFA (Wako Chemicals: Dallas, TX).

Data were analyzed using the PROC MIXED procedure (SAS Inst. Inc., Cary, NC) and Satterthwaite approximation to determine the denominator df for the tests of fixed effects. The model statement used for BW shrink from d 0 to d 1 and ADG contained the effects of treatment, sex, and the interaction. Data were analyzed using calf(treatment × pen) as random variable. The model statement used for DMI and G:F contained the effects of treatment, as well as day and the resultant interaction for DMI only. Data were analyzed using calf(treatment × pen) as the random variable. The specified term for repeated statements wasday, pen(treatment) or calf(treatment × pen) as subject for DMI or hormones and metabolites, respectively, and the covariance structure utilized was based on the Akaike information criterion. Results are reported as least square means and were separated using PDIFF. Significance was set at $P \leq 0.05$. Results are reported according to treatment effects if no interactions were significant, or according to the highest-order interaction detected.

RESULTS AND DISCUSSION

Body weight shrink from d 0 to d 1 was similar ($P = 0.16$) between TRANS and REST, and greater ($P < 0.01$) for both treatments vs. CON (Table 1). Mean ADG was greater ($P < 0.01$) in CON vs. TRANS and REST cattle, and similar ($P = 0.46$) between TRANS and REST cattle (Table 1). No treatment ($P \geq 0.25$) effects were detected on forage, concentrate, and total DMI (Table 1). However, CON had greater G:F vs. TRANS ($P < 0.01$) and tended to have greater G:F vs. REST cattle ($P = 0.08$), whereas G:F was similar ($P = 0.21$) between TRANS and REST cattle (Table 1). Similar to previous research, road transport reduced ADG and G:F during feedlot receiving (Cole et al., 1988). Further, REST cattle experienced similar feedlot receiving performance compared with TRANS cohorts, suggesting that feed and water deprivation are major causes for the reduced performance of transported cattle.

Treatment × day interactions were detected ($P < 0.05$) for cortisol, NEFA, haptoglobin, and ceruloplasmin. Plasma cortisol concentrations were greater ($P < 0.05$) in REST compared with CON and TRANS cattle on d 1, 4, 7, 14, 21, and 28, and tended to be greater ($P = 0.10$) in TRANS compared to CON cattle on d 1 (Figure 1). Serum NEFA concentrations were greater ($P < 0.01$) in REST and TRANS compared with CON cattle on d 1, but also greater ($P < 0.01$) in REST compared with TRANS cattle on d 1 (Figure 1). Plasma ceruloplasmin concentrations peaked on d 4 for TRANS and REST cattle (day effects; $P < 0.01$) but did not

Table 1. Feedlot receiving performance of cattle submitted to transport for 24 h for approximately 1,200 km (TRANS), no transport but feed and water deprivation for 24 h (REST), or no transport and full access to feed and water (CON). [1]

Item	CON	REST	TRANS	SEM	*P* =
DMI, kg/d					
Forage	5.5	4.9	5.4	0.3	0.32
Concentrate	2.3	2.3	2.3	0.1	0.52
Total	7.9	7.2	7.8	0.4	0.25
ADG, [2] kg/d	1.27[a]	0.97[b]	0.91[b]	0.05	< 0.01
G:F, [3] g/kg	163[a]	143[ab]	127[b]	7	0.03
Shrink, [4] %	0.07[a]	8.1[b]	9.6[b]	0.7	< 0.01

[1] Within rows, values with different superscripts differ ($P < 0.05$).
[2] Calculated using full BW values obtained prior to (d -1 and 0) treatment application and at the end of experiment (d 28 and 29).
[3] Calculated using total DMI and BW gain from d 0 to d 28.
[4] Based on BW loss from d 1 relative to d 0.

change ($P = 0.58$) for CON cattle (Figure 2). Hence, CON cattle had reduced mean plasma ceruloplasmin concentration compared to TRANS ($P = 0.07$) and REST ($P = 0.01$) cattle.

Plasma haptoglobin peaked on d 1 for TRANS and increased from d 1 to 14 in REST cattle (day effects; $P < 0.01$) but did not change ($P = 0.65$) for CON cattle (Figure 2). Hence, TRANS cattle had greater plasma haptoglobin compared to CON and REST cattle on d 1 ($P < 0.01$), whereas REST cattle had greater ($P \leq 0.05$) plasma haptoglobin compared with TRANS and CON cattle on d 7 (Figure 2).

These results suggest that TRANS and REST stimulated mobilization of body reserves, elicited a neuroendocrine stress response, and induced an acute-phase protein reaction that impaired feedlot receiving ADG and G:F (Ellenberger et al., 1989; Sapolsky, 2000; Carroll and Forsberg, 2007). Previous research also reported increased circulating cortisol, ceruloplasmin, and haptoglobin in feeder cattle following road transport, and attributed these outcomes to impaired feedlot receiving performance (Crookshank et al., 1979; Araujo et al., 2010; Cooke et al., 2011). Conversely, the specific effects of feed and water restriction on neuroendocrine and acute-phase parameters have not yet been determined. Supporting these outcomes, recent research from our group demonstrated that neuroendocrine stress reactions can stimulate breakdown of body reserves and activate acute-phase and inflammatory processes in bovine (Cooke et al., 2012). In addition, feed and water deprivation may result in death of rumen microbes and subsequent release of endotoxins (Meiske et al., 1958), which may be absorbed by the ruminal wall and small intestine, incorporated into the circulation (Chin et al., 2006), and elicit neuroendocrine and acute-phase reactions (Carroll et al., 2009). Hence, the acute-phase protein reaction detected in TRANS and REST cattle can be attributed to the increase in circulating cortisol, NEFA, and altered ruminal flora following treatment application.

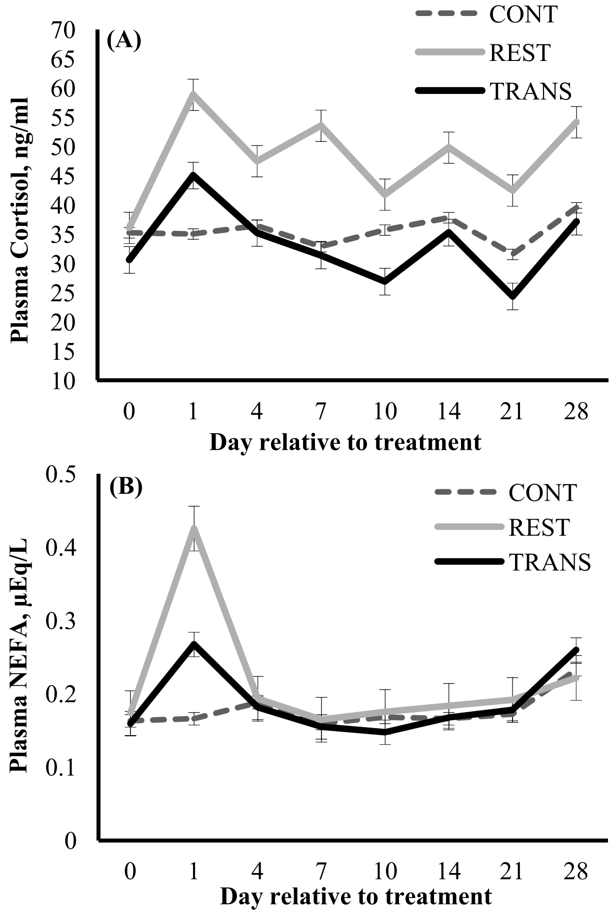

Figure 1. Plasma cortisol (Panel A) and serum NEFA (Panel B) in cattle submitted to transport for 24 h for approximately 1,200 km (TRANS), no transport but feed and water deprivation for 24 h (REST), or no transport and full access to feed and water (CON). Treatment × day interactions were detected ($P < 0.05$).

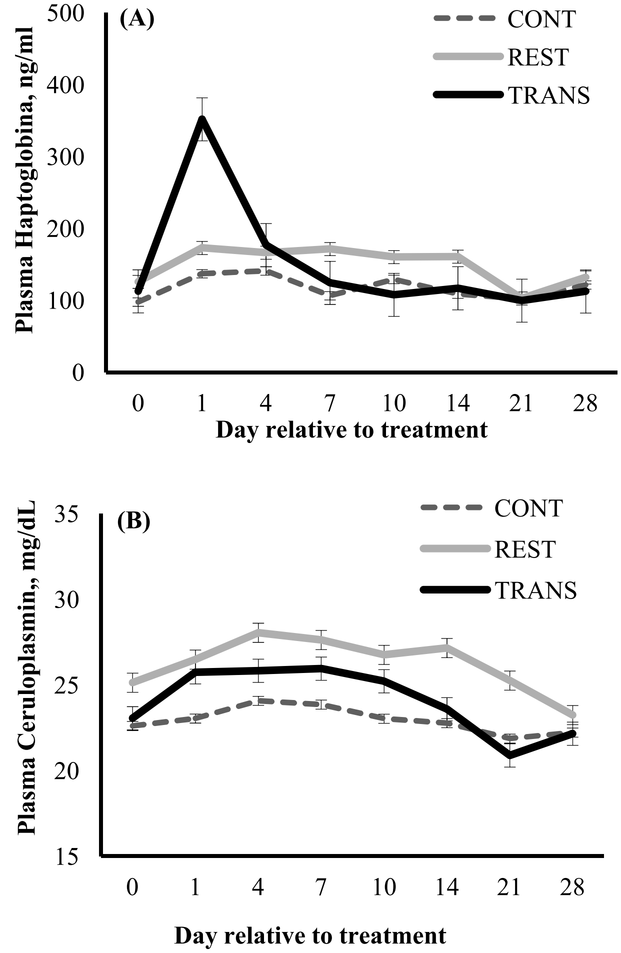

Figure 2. Plasma haptoglobin (Panel A) and ceruloplasmin (Panel B) in cattle submitted to transport for 24 h for approximately 1,200 km (TRANS), no transport but feed and water deprivation for 24 h (REST), or no transport and full access to feed and water (CON). Treatment × day interactions were detected ($P < 0.05$).

It is also important to note that the increase in circulating NEFA, cortisol, and ceruloplasmin concentrations was more severe in REST vs. TRANS cattle. Similarly, circulating haptoglobin remained elevated for a longer period in REST vs. TRANS cattle. These results suggest that neuroendocrine stress response was more severe in REST cattle, which caused or was caused by the greater mobilization of body tissues, and resulted in the greater acute-phase reaction compared with that observed in TRANS cohorts. The reasons for this outcome are unknown and deserve further investigation, particularly because TRANS steers also experienced a 24-h feed and water restriction during transport.

IMPLICATIONS

In conclusion, 24-h transport and 24-h nutrient restriction elicited acute-phase protein responses and similarly reduced performance of feeder cattle. Therefore, feed and water restriction are major causes for the acutephase reaction and reduced feedlot receiving performance typically detected in transported feeder cattle.

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