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Associations of beef calf wellness and body weight gain with internal location in a truck during transportation

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ABSTRACT: Cattle transportation by commercial truck carrier is common in the United States, and often cattle are placed within 1 of 8 potential compartments within the truck for the journey. The objective of this research was to determine potential associations between animal wellness (as measured by ADG and health outcomes) during a relatively short backgrounding phase (46.6 ± 8.5 d) and location within the truck during transit. Data from 21 loads (average calves per load = 101.5; average BW = 210.1 ± 19.4 kg) were included in the analysis. For each shipment, calves were divided among 8 compartments within the trailer: nose on top deck (NOT), nose on bottom deck (NOB), bottom deck middle forward (BDF), bottom deck middle rear (BDR), rear on the bottom (ROB), top deck middle forward (TDF), top deck middle rear (TDR), and rear on the top deck (ROT). General logistic (health outcomes) and mixed (ADG) models were employed to analyze the data accounting for effects due to truck section as well as the hierarchical data structure of multiple arrival times, loads, and pens. Cattle in the ROT section had less short-term BW gains compared with NOT and tended ($P < 0.10$) to be less than NOB. Cattle in the forward sections (NOT, NOB) were less ($P = 0.02$) likely [odds ratio (OR): 0.67, 95% confidence limits (CL): 0.50, 0.94] to be treated at least once compared with cattle in the middle sections (TDF, TDR, TOP, BDF, BDR, BOT). Calves in compartments with 15 head or less tended ($P < 0.10$) to have reduced odds of being treated compared with cattle in compartments with 16 to 30 head (OR: 0.79, 95% CL: 0.60, 1.0) or greater than 31 head (OR: 0.73, 95% CL: 0.53, 1.0). Our current project reveals that the location within the truck may affect calf health and performance.

Key words: beef cattle, bovine respiratory disease, stocker, transportation

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INTRODUCTION

Cow-calf producers are distributed throughout the country (Feuz and Umberger, 2003), and United States feedlots are geographically concentrated in the Great Plains states (Mintert, 2003). Thus, cattle are commonly transported by commercial truck carriers. Both transportation-related handling and travel have been identified as potentially stressful events for cattle (Grandin, 1997), and recent literature reviews addressed the potential impact of transportation on cattle health and performance (Eicher, 2001; Swanson and Morrow-Tesch, 2001; Fike and Spire, 2006). Transportation has been associated with increased morbidity, stress leukogram responses, and modified humoral (IgG) immune responses (Kent and Ewbank, 1986; Cole et al., 1988; Mitchell et al., 1988; Mackenzie et al., 1997; Stanger et al., 2005), and can be detrimental to BW gain (Crookshank et al., 1979).

Several factors may contribute to the level of transport stress including noise, vibration, crowding, temperature, and humidity (Swanson and Morrow-Tesch, 2001). Cattle transport trucks are often divided into sections, and although many of the aforementioned factors may vary dependent on the compartment of the truck where the calf is housed, little research has been performed to evaluate health and performance impacts of cattle location within the truck.

The objective of the present study was to identify potential associations between location within the transport carrier and subsequent calf wellness in the short-term (40 to 60 d) after shipment. Our hypothesis was that posttransport calf wellness, as measured by health and ADG, would not be homogeneous based on calf location within the truck during transportation.

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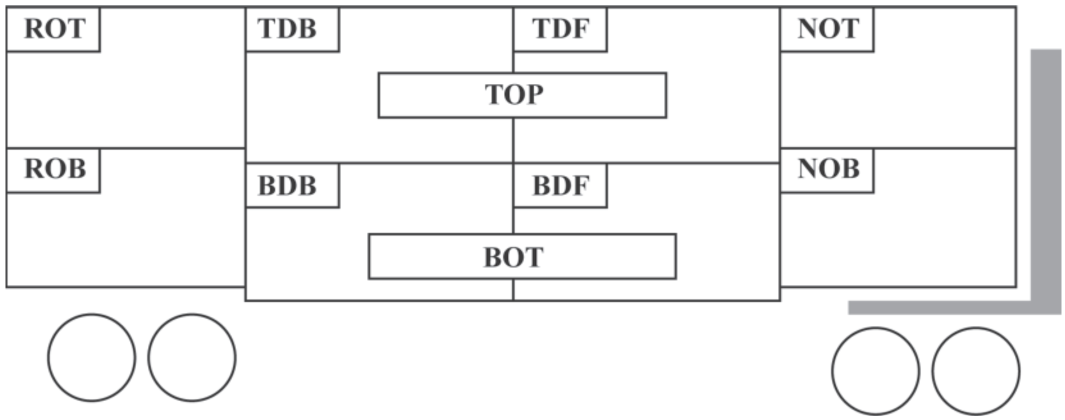

Figure 1. Depiction of compartment location within a standard cattle transport trailer. Truck compartments abbreviated as bottom deck rear (BDB), bottom deck front (BDF), bottom deck (bottom deck forward and back combined, BOT), rear on top (ROT), bottom deck nose (front, NOB), nose on top deck (NOT), rear on bottom (ROB), top deck back (TDB), top deck forward (TDF), and top deck (top deck back and forward combined, TOP).

MATERIALS AND METHODS

Animals were managed under the guidelines of a protocol approved by the Institutional Animal Care and Use Committee at Kansas State University, Manhattan.

Animal Management

Southeastern United States origin cattle were purchased and commingled in Tennessee and shipped to Kansas State Beef Stocker Unit in Manhattan (approximately 1,086 km). Three loads of cattle arrived over a period of 2 to 4 d during each backgrounding delivery period (8 periods, mean length of backgrounding 46.6 ± 8.5 d). Upon arrival, cattle from each load were unloaded by section of the transport carrier and placed in holding pens maintaining segregation of animals by original truck compartment. Cattle were weighed and individually identified by holding pen, and the section of the transport vehicle recorded for each animal based on the schematic depicted in Figure 1.

Transport vehicles utilized in this project represent common configuration of cattle hauling systems. The animals were divided into up to 8 compartments within the trailer: nose on top deck (**NOT**), nose on bottom deck (**NOB**), bottom deck middle forward (**BDF**), bottom deck middle rear (**BDR**), rear on the bottom (**ROB**), top deck middle forward (**TDF**), top deck middle rear (**TDR**), and rear on the top deck (**ROT**). Dividing gates exist between BDF and BDR as well as TDF and TDR; however, these gates were sometimes left open creating a large compartment referred to as bottom middle (**BOT**) or top middle (**TOP**), respectively (Figure 1). A categorical variable was created to identify animals as having come from the bottom (NOB, BDF, BDR, BOT, ROB) or top decks (NOT, TDF, TDR, TOP, ROT). Proximity to the front of the transport vehicle was recorded by a variable with all truck compartments placed into 1 of 3 categories: front (NOT, NOB), middle (TDF, TDR, TOP, BDF, BDR, BOT), or rear (ROT, ROB). The number of cattle in the section was recorded and transformed into a categorical variable for subsequent statistical analysis. A commercial trailer similar to those used in the study was measured to estimate the area (m^2) in each compartment, and stocking density was determined by dividing the number of cattle in that compartment on that load by the estimate of area. Stocking density was transformed into a categorical variable for subsequent statistical analysis.

Arrival BW and sex (steer/bull) were used to randomly allocate calves from a single load to a string of 8 pens, and load integrity was maintained for each string (no mixing of cattle between loads within pens). During the study period, cattle participated in a variety of health and nutrition research projects with an equal number of treatment groups within each arrival truckload. Approximately 24 h postarrival, cattle were processed with standard health protocols including castration, metaphylaxis, vaccination (infectious bovine rhinotracheitis, bovine viral diarrhea, para-influenza-3, and bovine respiratory syncitial virus modified-live vaccine; 7-way clostridial vaccine), and anthelmintic treatment. Secondary vaccinations were administered and individual animal BW were recorded between 10 and 16 d after arrival for each load.

Cattle were fed total mixed diets twice daily, which consisted of prairie hay, alfalfa hay, wet corn gluten feed, and cracked corn. Initial rations were formulated to contain 16% CP and 1.14 Mcal/kg of NE_g on DM basis. Composition of the diet was changed during the feeding period using the same ingredients in different proportions to create diets consisting of 15% CP and 1.19 Mcal/kg of NE_g and 1.24 Mcal/kg of NE_g on DM basis for the latter parts of the feeding phase. Feed bunks were monitored twice daily and feed amounts were adjusted based on the amount of feed remaining from the previous feeding. Calves were fed for approximately 6 wk (mean 46.6 ± 8.5 d). Each animal was individually weighed before leaving the facility.

Animals were evaluated twice daily for signs of potential illness including depression, anorexia, coughing, or musculoskeletal ailments. Calves noted with disease symptoms were removed from the pen and taken to a chute for further examination. Treatments were administered based on predetermined treatment protocols. Calves with symptoms consistent with bovine respiratory disease (**BRD**) and a rectal temperature ≥40°C were eligible for treatment using a standard protocol. At initial treatment for BRD, enrofloxacin (7.5 to 12.5 mg/kg subcutaneously; Baytril, Bayer Animal Health, Shawnee Mission, KS), was administered. Cattle meeting the treatment criteria a second and third time received florfenicol (40 mg/kg subcutaneously; Nuflor, Schering Plough Animal Health, Union, NJ) and oxytetracycline (20 mg/kg subcutaneously; Biomycin 200, Boehringer Ingelheim Vetmedica Inc., St. Joseph, MO), respectively. After 3 treatments for BRD, calves that continued to illustrate clinical signs were deemed as chronic and not treated further.

Because morbidity effects of transport conditions are potentially transient, health outcomes were evaluated in 2 manners: treatment during the entire period and treatment only in the first 14 d. This latter health figure coincides with a similar period of time monitored through ADG between arrival and revaccination. Gross necropsies were performed on all cattle that died during the feeding phase.

Statistical Analyses

Individual animal health and performance data were imported into a statistical software package (SAS Institute Inc., Cary, NC) to determine potential associations between these variables and transport conditions (location within the truck and number of head in truck section). General logistic models (PROC GLIMMIX) were employed to estimate the probability of occurrence of health outcomes. Associations of continuous measures (ADG) were evaluated using mixed linear models (PROC MIXED). Truck compartment was the experimental unit in each statistical model. Although middle sections of trucks were occasionally divided (TDF, TDR, BDF, BDR), cattle were categorized into 1 of 6 compartments (NOT, TOP, ROT, NOB, BOT, ROB) in the models used to determine potential differences in outcome by individual compartment. In the models evaluating proximity to front of truck, animals were categorized into 1 of 3 truck sections (BACK, MID, NOSE). Potential differences due to deck were performed using models based on 2 categories of placement (TOP, BOT). Models evaluating the number of animals in the compartment and stocking density utilized categorized groupings by individual compartments (NOT, TDF, TDR, TOP, ROT, NOB, BDF, BDR, BOT, ROB) were categorized into groups reflecting the number of animals in the compartment (15 or less, 16 to 30, or 31 or more) and stocking density (less than 0.65 m^2, 0.65 to 0.80 m^2, or greater than 0.80 m^2) for models evaluating the potential association of these factors on outcomes. Random effects were included in each model to account for the effects of arrival sex (steers/bulls), group arrival time, and lack of individuality of each animal within a truckload, within each arrival time period, and pens within each load. Logistic regression estimates from comparisons were also transformed into odds ratios (**OR**) with confidence limits for interpretation. Significant differences were identified at $P < 0.05$ and trends at $P < 0.10$.

RESULTS

Data were collected on 24 individual loads of calves procured between May 2006 and May 2008. Truckloads of calves were fed for a period of 41 to 63 d, and calves spent a mean of 46.6 (±8.5) d in the backgrounding phase. Three lots were excluded from the data set due to unloading conditions that resulted in mixing of cattle between truck segments before individual identification. Demographic information on the included 21 loads is included in Table 1. The number of loads, mean (and SD) number of head within each compartment, truck deck, and sections from front to rear of truck are listed in Table 2. Mean stocking density by load was 0.73 m^2 (SD = 0.04). Mean stocking density for each compartment is listed in Table 2.

When effects of arrival time, sex, individual load, and pen were included in the models, no significant associations ($P > 0.10$) were identified between transport vehicle compartment and the probability of dying, being treated for the first, second, or third time, or being identified as clinically ill in the first 14 d after arrival (Table 3). Individual animal ADG over the entire period was not associated with transport vehicle compartment; however, period ADG from arrival to revaccination tended ($P = 0.09$) to be associated with compartment (Table 3). Cattle in the ROT section had less short-term BW gains compared with NOT, TOP, and NOB (Figure 2). Two sections (ROB, BOT) did not have different BW gains ($P > 0.10$) compared with other sections (Table 3).

Placement of cattle on the top or bottom deck was not significantly associated with any health or performance outcomes measured (Table 3). When the truck was categorized as forward, middle, or rear, no associations were identified between placement in 1 of these 3 areas and the probability to die or to be treated a second or third time (Table 3). Proximity toward the front of the truck tended ($P = 0.06$) to be associated with initial treatment risk, and cattle in the forward sections (NOT, NOB) were less ($P = 0.02$) likely (OR: 0.67, 95% CL: 0.50, 0.94) to be treated at least once compared with cattle in the middle sections (TDF, TDR, TOP, BDF, BDR, BOT). Calves housed in the rear sections did not have a different initial treatment risk compared with the middle or front sections. Cattle in the forward section were also less likely to be treated within the first 14 d compared with cattle in the middle,

Table 1. Number of calves, average initial BW, and morbidity and mortality outcomes for each truckload of calves enrolled in the study

Item	Arrival month	Arrival animals, n	Initial BW, kg (SD)	Treated at least once, No. (%)	Died, No. (%)
Lot					
105	May 2006	99	215.3 (14.2)	7.0 (7.1)	0.0 (0.0)
106	May 2006	102	199.5 (15.2)	7.0 (6.9)	0.0 (0.0)
107	May 2006	100	205.9 (14.3)	16.0 (16.0)	1.0 (1.0)
108	Oct. 2006	95	228.8 (15.8)	3.0 (3.2)	0.0 (0.0)
109	Oct. 2006	96	233.1 (12.2)	1.0 (1.0)	0.0 (0.0)
110	Oct. 2006	92	236.3 (15.1)	0.0 (0.0)	0.0 (0.0)
113	Feb. 2007	111	191.1 (18.2)	2.0 (1.8)	1.0 (0.9)
116	June 2007	102	216.0 (13.9)	37.0 (36.3)	3.0 (2.9)
117	June 2007	101	212.5 (15.9)	43.0 (42.6)	6.0 (5.9)
118	Aug. 2007	96	220.6 (14.2)	45.0 (46.9)	4.0 (4.2)
119	Aug. 2007	98	215.0 (12.7)	56.0 (57.1)	14.0 (14.3)
120	Aug. 2007	99	222.1 (12.1)	51.0 (51.5)	10.0 (10.1)
121	Nov. 2007	107	200.9 (12.8)	14.0 (13.1)	0.0 (0.0)
122	Nov. 2007	108	204.8 (12.2)	50.0 (46.3)	3.0 (2.8)
123	Nov. 2007	101	195.2 (16.7)	31.0 (30.7)	1.0 (1.0)
124	Mar. 2008	103	207.3 (17.6)	21.0 (20.4)	0.0 (0.0)
125	Mar. 2008	104	204.5 (15.1)	22.0 (21.2)	1.0 (1.0)
126	Mar. 2008	105	201.0 (17.2)	21.0 (20.0)	1.0 (1.0)
128	May 2008	107	199.6 (15.3)	29.0 (27.1)	0.0 (0.0)
129	May 2008	102	212.3 (20.7)	33.0 (32.4)	0.0 (0.0)
130	May 2008	104	200.8 (16.5)	64.0 (61.5)	4.0 (3.8)
Overall average (SD)		101.5 (4.7)	210.1 (19.4)		
Total				553.0 (25.9)	49.0 (2.3)

whereas risk in the rear section did not differ from the other 2 sections (Table 3). The entire period ADG was not associated with being housed in the front, middle, or rear sections. However, Figure 3 illustrates cattle in the most forward sections had greater ($P < 0.01$) least squares means arrival to revaccination ADG compared with cattle in the middle section and tended ($P = 0.06$) to have greater arrival to revaccination ADG than cattle in the rear sections (Table 3).

The number of animals present in the compartment tended ($P < 0.10$) to be associated with the probability for incurring at least 1 treatment during the first 14 d

Table 2. Raw mean and SD of the number of calves per compartment[1] and number of loads represented for all truckloads of calves (lots) enrolled in the study

Truck section	Loads, n	Average animal count	Animals SD	Compartment area, m^2	Average stocking density, m^2/animal	Stocking density SD
Individual compartment						
BDB	10	17.6	1.3	11.7	0.66	0.05
BDF	10	17.4	1.0	13.2	0.76	0.04
BOT	11	38.5	2.5	24.8	0.65	0.04
ROT	20	3.8	1.0	6.5	0.95	0.23
NOB	21	8.8	1.2	7.5	0.85	0.12
NOT	21	7.7	1.1	7.5	0.97	0.12
ROB	21	9.7	1.8	3.5	0.67	0.10
TDB	18	18.2	2.2	11.7	0.64	0.07
TDF	18	16.8	2.8	13.2	0.78	0.14
TOP	3	34.3	5.5	24.8	0.72	0.10
Deck						
BD	21	58.9	3.6			
TD	21	42.6	2.7			
Rear, middle, or nose						
BACK	21	13.3	2.8			
MID	21	71.7	5.3			
NOSE	21	16.5	2.1			

[1]Truck compartments abbreviated as bottom deck rear (BDB), bottom deck front (BDF), bottom deck (bottom deck forward and back combined, BOT), rear on top (ROT), bottom deck nose (front, NOB), nose on top deck (NOT), rear on bottom (ROB), top deck back (TDB), top deck forward (TDF), and top deck (top deck back and forward combined, TOP). Decks are abbreviated as top deck (TD) or bottom deck (BD). Front to rear compartments are identified as back (BACK), middle (MID), or front (NOSE).

Table 3. Model[1] estimated risk probability (Prob) for calf health outcomes (initial, second, and third treatment, treatment within 14 d of arrival, and mortality) and least squares means (LSM) of calf ADG (kg/d) by individual compartment, truck deck, and proximity to forward portion of truck

	Initial treatment risk, %		Second treatment risk, %		Third treatment risk, %		Treatment from d 0 to 14, %		Mortality risk, %		Arrival to revaccination ADG, kg/d		Entire period ADG, kg/d	
Item	Prob	SEM	Prob	SEM	Prob	SEM	Prob	SEM	Prob	SEM	LSM	SEM	LSM	SEM
Compartment[2]														
BOT	17.1	8.3	4.9	2.8	1.4	0.9	10.1	6.2	1.2	0.9	1.79[ab]	0.23	1.35	0.10
ROT	15.1	8.4	8.0	5.1	2.3	1.9	8.7	6.0	2.4	2.1	1.61[b]	0.25	1.30	0.11
NOB	11.2	6.1	3.4	2.2	1.3	1.0	5.4	3.7	0.2	0.3	1.90[a]	0.24	1.37	0.11
NOT	11.3	7.2	4.4	2.7	1.5	1.1	7.8	5.2	0.9	0.8	1.86[a]	0.24	1.34	0.11
ROB	14.7	0.1	4.8	0.0	1.8	1.3	8.0	5.2	1.4	1.1	1.76[ab]	0.24	1.35	0.11
TOP	16.6	8.1	4.7	2.7	1.0	0.6	9.5	5.9	0.8	0.6	1.80[a]	0.23	1.34	0.10
P-value	0.28		0.56		0.66		0.16		0.28		0.09		0.84	
Deck[3]														
BD	15.6	7.7	4.8	2.8	1.5	1.0	8.9	5.6	1.2	0.8	1.79	0.23	1.35	0.10
TD	16.0	7.9	4.7	2.7	1.8	0.7	9.2	5.8	0.8	0.6	1.81	0.23	1.34	0.10
P-value	0.82		0.83		0.24		0.73		0.23		0.42		0.52	
Rear, middle, or nose[4]														
BACK	14.8[ab]	7.6	5.6	3.4	1.9	1.4	8.2[ab]	5.3	1.6	1.3	1.72[b]	0.24	1.34	0.11
MID	16.8[a]	8.2	4.8	2.8	1.2	0.8	9.8[a]	6.1	1.0	0.7	1.80[ab]	0.23	1.35	0.10
NOSE	12.2[b]	6.4	3.9	2.3	1.4	1.0	4.3[b]	4.3	0.5	0.5	1.88[a]	0.24	1.35	0.11
P-value	0.06		0.40		0.37		0.04		0.15		0.03		0.96	

[a,b]Superscripts in columns represent differences within the column ($P < 0.05$).

[1]Models included random effects for arrival sex (steer/bull), arrival time, load, and pen. The risk of occurrence of a specific outcome (Prob) is listed for categorical outcomes and the LSM is listed for continuous variables. Variation reflected in SEM of the Prob or LSM. The significance of association between categorical grouping (compartment, deck, or proximity to nose) and outcome of interest is represented by *P*-value for each column.

[2]Compartments abbreviated as bottom deck (bottom deck forward and back combined, BOT), rear on top (ROT), bottom deck nose (front, NOB), nose on top deck (NOT), rear on bottom (ROB), and top deck (top deck back and forward combined, TOP).

[3]Decks are abbreviated as top deck (TD) or bottom deck (BD).

[4]Front to rear compartments are identified as back (BACK), middle (MID), or front (NOSE).

and during the entire backgrounding period (Table 4). Calves in compartments with 15 animals or less tended ($P < 0.10$) to have a reduced odds of being treated compared with cattle in compartments with 16 to 30 animals (OR: 0.79, 95% CL: 0.60, 1.0) or greater than 31 animals (OR: 0.73, 95% CL: 0.53, 1.0). When only treatments within the first 14 d of arrival were considered, cattle in a compartment with less than 15 animals were less likely ($P = 0.04$) to be treated compared with cattle in sections with greater than 31 animals (OR: 0.67, 95% CL: 0.46, 0.97) and tended ($P = 0.09$) to be at reduced odds for treatment than cattle in compartments with 16 to 30 animals (OR: 0.73, 95% CL: 0.52, 1.0). Cattle in the ROT section also tended ($P = 0.06$) to have smaller short-term gains compared with the BOT section. Additionally, trends were identified with cattle in the NOB tending to have greater gains compared with cattle in the ROB ($P = 0.08$) and BOT ($P = 0.07$) sections. Stocking density was not significantly associated with any of the outcome variables measured (Table 4).

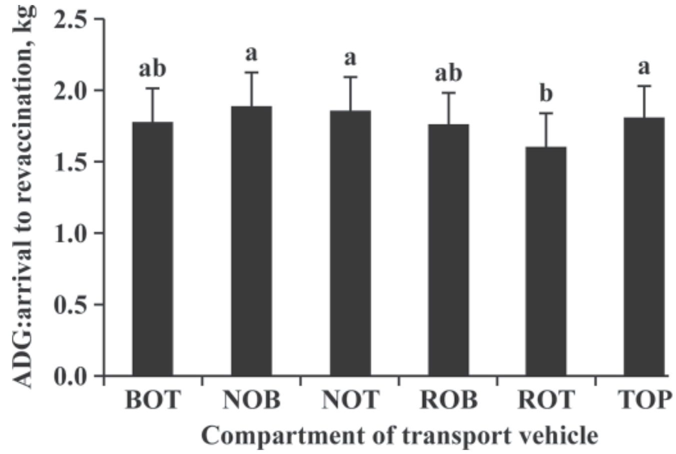

Figure 2. Model-adjusted least squares means of ADG from arrival to revaccination by section of the transport vehicle. Cattle transported in the top deck front (TDF) and top deck rear (TDR) were included in the top (TOP) section, whereas cattle in the bottom deck front (BDF) and bottom deck rear (BDR) were included in the bottom deck (BOT) for consistency of analysis. Model accounts for arrival sex (steer/bull), and random effects including arrival time period, load, and pen. Error bars represent the SE of the least squares means. [a,b]Bars with different letters significantly ($P < 0.05$) differ. NOB = nose on bottom; NOT = nose on top; ROB = rear on bottom; ROT = rear on top.

DISCUSSION

This research illustrates associations between health and performance in backgrounded beef calves associated with the location within a commercial transport vehicle. Much research has been done evaluating the potential welfare implications and stress associated with cattle transportation; however, very little information is available comparing the impact of areas within the truck on calf wellness. Camp et al. (1981) found no differences in feedlot performance or risk for BRD between calves housed in different trailer compartments; however, this work was done over 30 yr ago and evaluated an entire finishing phase. Results from the current study suggest that the environment within a commercial transport carrier is not likely homogeneous and may affect calf health and performance during the first 14 d after feedlot arrival. Loads included in the trial had similar arrival BW and distribution of animals throughout sections of the truck. Length of journey may modify the effect of transportation on cattle (Warriss et al., 1995), but cattle in the current study were transported similar distances from procurement to the backgrounding facility.

A tendency between compartment and short-term ADG was identified. The entire backgrounding period ADG did not differ by section or compartment, but transient ADG differences were noted. This depression in short-term ADG was also identified when proximity to the forward portion of the truck was examined. The fact that ADG suppression may be transient is not surprising as other research has noted that physiologic indices associated with transport stress may themselves be transient (Gupta et al., 2007). Stanger et al. (2005) showed that total leukocyte numbers dropped below pretransit values within 72 h after shipment, but returned to pretransit levels 6 d after shipment. This finding is confirmed by research illustrating a transient activation of hypothalamic-pituitary-adrenal axis after transportation of calves (Mitchell et al., 1988; Odore et al., 2004). These short-term ADG differences could be related to stress factors that varied by location within the truck.

Several authors have speculated that the environmental conditions of the transport vehicle may play a role in transport stress (Eicher, 2001; Swanson and Morrow-

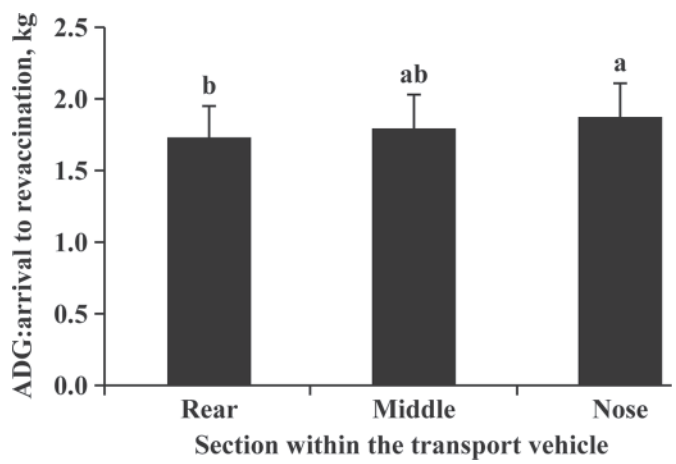

Figure 3. Model-adjusted least squares means of ADG from arrival to revaccination by forward (nose), middle, and rear of the transport vehicle. Model accounted for arrival sex (steer/bull), and random effects, which included arrival time period, load, and pen. Error bars represent the SE of the least squares means. Nose sections included NOT (nose on top) and NOB (nose on bottom). Middle sections included TDF (top deck front), TDR (top deck rear), TOP (top deck not divided), BDF (bottom deck front), BDR (bottom deck rear), and BOT (bottom deck not divided). Rear sections included ROT (rear on top) and ROB (rear on bottom). [a,b]Columns with different letters significantly ($P < 0.05$) differ.

Table 4. Model[1] estimated risk probability (Prob) for health outcomes (initial, second, and third treatment, treatment within 14 d of arrival, and mortality), and least squares means (LSM) of ADG (kg/d) by number of head in the section and stocking density

Item	Initial treatment risk, %		Second treatment risk, %		Third treatment risk, %		Treatment from d 0 to 14, %		Mortality risk, %		ADG, kg/d (arrival to revaccination)		ADG, kg/d (entire period)	
	Prob	SEM	Prob	SEM	Prob	SEM	Prob	SEM	Prob	SEM	LSM	SEM	LSM	SEM
Count[2]														
15 or less	13.6	6.8	4.5	2.6	1.4	1.0	7.4	4.7	0.9	0.7	1.79	0.23	1.34	0.10
16 to 30	16.6	8.0	4.9	2.9	1.4	1.0	9.6	5.8	1.1	0.9	1.82	0.23	1.36	0.10
31 or more	17.7	8.6	4.9	2.9	0.9	0.7	10.7	6.6	0.8	0.7	1.77	0.23	1.33	0.10
P-value	0.09		0.85		0.53		0.07		0.70		0.76		0.45	
Stocking density														
<0.65 m^2	15.7	7.7	4.4	2.6	1.4	1.0	9.5	5.9	1.5	1.2	1.78	0.23	1.36	0.10
0.65 to 0.80 m^2	17.4	8.3	5.5	3.1	1.2	0.8	9.7	6.0	0.8	0.6	1.80	0.23	1.34	0.10
>0.80 m^2	13.2	6.7	4.2	2.5	1.3	1.0	7.3	4.7	0.6	0.5	1.85	0.23	1.34	0.10
P-value	0.10		0.31		0.82		0.17		0.13		0.33		0.60	

[1]Models included random effects for arrival sex (steer/bull), arrival time, load, and pen. The risk of occurrence of a specific outcome (Prob) is listed for categorical outcomes and the LSM is listed for continuous variables. Variation reflected in SEM of the Prob or LSM. The significance of association between categorical grouping (animals in compartment or stocking density) and outcome of interest is represented by *P*-value for each column.

[2]Categorical variable representing the number of animals per compartment.

Tesch, 2001), but little research has been done on exact conditions associated with ventilation and noxious gasses within the transport vehicle (Fike and Spire, 2006). A previous report on ventilation requirements recommends that acceptable ventilation rates should be based on specific transportation situation (Randall, 1993). One of the few associations between health outcomes and location on the truck was identified between cattle in the most forward sections (NOT, NOB) when compared with cattle in the middle (BDF, BDR, BOT, TOP, TDF, TDR) compartments. The front panels of the first 2 sections in many transport vehicles are solid or directly behind the cab of the truck, hereby potentially creating a different airflow pattern based on proximity to the front of the trailer. These health and performance findings for the forward truck sections illustrate a difference in wellness outcomes based on location calf was housed in the truck during transit. Further research should be performed to identify specific risk or causal factors for the observed differences.

The number of cattle in the compartment was associated with the odds that a calf would be treated during the backgrounding phase. Cattle transported with less than 15 animals in their section were less likely to be treated compared with compartments with 16 to 30 or greater than 30 animals during the first 14 d after arrival and during the entire period. Previous research has illustrated an association between stocking density (on a load level) and the physiological changes of increased cortisol and white blood cell counts (Tarrant et al., 1988, 1992). Calves in more animal-dense compartments could have stress responses, making them more susceptible to disease; however, stocking density was not associated with disease risk in the current study. This is in spite of the fact that the mean stocking density per load and in some compartments in the present study were numerically greater than the USDA recommended density of 0.70 m^2 (7.5 ft^2) for transport of 226-kg calves (USDA, 2009). The range in stocking density by compartment in the current study may not have been great enough to illustrate detrimental impacts of stocking density.

Another potential explanation for the seemingly protective effect of residing in a compartment with less than 15 head is that exposure to potential pathogens may have been greater with more calves per compartment leading to the increased disease risk. Cattle in this trial were procured from an order buyer in the southeastern United States and were likely commingled from multiple sources. The increased commingled nature of cattle procured in this fashion creates an environment of multiple animals with unknown disease status or exposure, and mixing of calves from multiple sources has been shown to increase risk for posttransit morbidity (Ribble et al., 1995). The likelihood of contact with animals shedding infectious diseases may increase in conjunction with the number of animals that the susceptible animals directly contact. Division of animals into separate compartments dictates that certain animals will have more proximal contact to animals within their compartment, and greater numbers of cattle in a compartment would likely increase risk of exposure.

Several factors beyond the control of this study may have confounded these findings; therefore, the results should be interpreted with care. First, the loading order was not controlled, and allocation of calves to individual compartments was not randomized. Individual animal factors (previous experiences and genetics) influence behavioral and physiologic responses to stress events (Grandin, 1997), and these same factors may have influence the propensity for cattle to load in specific sections of the transport vehicle thereby confounding results by area of the truck. Second, the number of head in the section may have confounded results as compartments in the nose had fewer cattle than in the middle sections (BDF, BDR, BOT, TOP, TDF, TDR). Because these variables are potentially confounded, the design of this study does not allow us to determine which, if either, was most important. Future work should be designed to determine if differences in health outcomes were related to physical location within the truck, number of head in the compartment, or differences in stocking density.

The findings of this research illustrate transient differences in ADG and some differences in disease risk during the backgrounding phase based on where cattle were housed during transport. Based on these results, the environment in each compartment of the transport vehicle is not likely homogeneous, and further research should be conducted to elucidate the reasons for these disparities in health and performance outcomes.

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