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Long-duration transit and food and water deprivation alter behavioral activities and aggressive interactions at the feed bunk in beef feedlot steers

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Abstract

The objective of these experiments was to assess the effects of food and water deprivation and transit duration on the behavior of beef feedlot steers. In Experiment 1, 36 Angus-cross steers (353 ± 10 kg) were stratified to 6 pens and assigned one of three treatments (n = 12 steers per treatment): control (**CON**; stayed in home pens with ad libitum access to feed and water), deprived (**DEPR**; stayed in home pens but deprived of feed and water for 18 h), or transported (**TRANS**; subjected to 18-h transit event and returned to home pens). In Experiment 2, 60 Angus-cross steers (398 ± 5 kg; 6 steers per pen) were transported either 8 (**8H**) or 18 (**18H**) h. Four 8H pens (n = 24 steers) and six 18H pens (n = 36 steers) were used for behavioral analysis. In both experiments, the time to eat, drink, and lay down was recorded for each steer upon return to home pens. Total pen displacements from the feed bunk were also assessed for the 2 h following feed access in both experiments. Data were analyzed using Proc Mixed of SAS 9.4, with treatment as a fixed effect. Steer was the experimental unit for behavioral activities, while pen was the experimental unit for bunk displacements. Displacements were analyzed as repeated measures with the repeated variable of time. In Experiment 1, the time to eat and drink was similar across treatments ($P \geq 0.17$). However, TRANS laid down in 16.5 min while DEPR did not lay down until 70.5 min post-arrival to pen ($P < 0.01$). Deprived steers had greater bunk displacements in the first 70 min post-feed access than CON or TRANS, though displacements among treatments from 100 to 120 min post-feed access were similar (treatment × time: $P = 0.02$). In Experiment 2, both 8H and 18H steers laid down approximately 25 min post-home pen arrival (P = 0.14). There was no effect of transit duration or duration by time on bunk displacements ($P \geq 0.20$), though displacements were greater from 0 to 20 min than from 20 to 30 min post-feed access (time: $P = 0.04$). Steers that were deprived of feed and water were highly motivated to access those resources, while transported steers prioritized laying down. Producers should consider these priorities when preparing to receive cattle from a long transit event.

Lay Summary

Because of the segmentation of the cattle industry, cattle are transported at least once during their lives. The objective of these two studies was to determine if transportation, feed and water deprivation, and/or transit duration changed the behavior of feedlot steers. The first study found steers transported for 18 h preferred to lay down instead of competing for food, unlike steers that were deprived of food and water for 18 h. Bunk displacements were also increased in steers deprived of food and water, indicating increased aggression. In the second study examining effects of transit duration (8 vs. 18 h), steers from both treatments laid down within 25 min of arrival back to the home pens. There were no differences in the frequency of bunk displacements between treatments. Producers should consider the increased motivation for cattle to lay down after transportation and the increased aggression at the feed bunk in food-deprived cattle when developing post-arrival management strategies.

Key words: behavior, cattle, feed deprivation, feedlot, transportation

Abbreviations: AUC, area under the curve; BW, body weight; DM, dry matter; DMI, dry matter intake

Introduction

Beef cattle raised in the United States will be transported many times in their lives (Schuetze et al., 2017) because of the segmented nature of the industry, where different stages of production frequently occur in separate regions of the country. Due to the geographical separation of operations, cattle can be transported long distances. Cattle transportation laws allow for up to 28 and 36 consecutive hours of transportation without rest or unloading in the United States (United States Department of Agriculture, 2020) and Canada (Government of Canada, 2020), respectively. In a study assessing industry norms for cattle transport in Alberta, Canada, González et al. (2012) found cattle are transported for nearly 16 h (1,081 km) on average, while a study examining the effects of distance traveled on performance and morbidity found cattle traveled an average distance of 698 km in the United States (Cernicchiaro et al., 2012). To prevent being stepped on, cattle are more likely to stand than lay down during transit

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(Warriss et al., 1995; Schwartzkopf-Genswein and Grandin, 2019). Long periods of standing, maintaining balance, and the vibrations of the trailer can lead to muscle fatigue (Bulitta, 2015), increasing cattle motivation to lay down when given the opportunity.

The current study focused on behavior data collected from two previously conducted experiments designed to assess the effects of transit on feedlot performance and muscle and blood metabolites of beef steers (Deters, 2020; Beenken et al., 2021). The objectives of this study were to determine if steers display differences in bunk displacements, latency to eat, drink, and lay down upon return to home pen, and rumination and active behaviors after exposure to different aspects of transit stress, including transit duration and feed and water deprivation. The hypotheses were that steers would prefer to lie down rather than compete for feed after an 18-h transit event compared with those restricted from feed and water, and steers would lay down quicker after an 18-h transit event than steers transported for 8 h.

Materials and Methods

This article includes data from two experiments denoted by Experiment 1 and Experiment 2; both were secondary projects to larger experiments. The Iowa State University Institutional Care and Use Committee approved all experimental procedures (Exp. 1 IACUC Log Number 19-084; Exp. 2 IACUC Log Number 19-180).

Experiment 1

Animals and experimental design

This study utilized 36 Angus-cross steers (initial BW: 353 ± 10 kg) housed in partially covered concrete pens (12.2 × 3.7 m; 6 steers per pen; 7.4 m^2 per steer). Each pen had a single GrowSafe bunk (GrowSafe Systems Ltd., Airdrie, Alberta, Canada) to record individual feed disappearance, and water was provided ad libitum via an automatic waterer (Ritchie Industries Inc., Conrad, IA). Steers were adapted to GrowSafe bunks over 7 d. Each pen was assigned to one of three treatments (n = 12 steers per treatment): control (**CON**; ad libitum access to feed and water in their home pens), deprived (**DEPR**; restricted from feed and water in their home pens for 18 h), and transported (**TRANS**; transported in a commercial livestock trailer continuously for 18 h [1,790 km] and returned to home pens). Since there were only 12 steers to transport, one compartment (the doghouse) in the commercial livestock trailer (Silverstar PSDLC-402; Wilson Trailer Company, Sioux City, IA) was used to achieve a space allowance of 1.30 m^2 per steer; all 12 steers were loaded together at one time. No boarding was used in the trailer to restrict airflow, nor was the trailer bedded. Treatments were imposed on day 0 (September 3, 2019) and ended on day 1. Transportation started at 1300 hours on day 0 and ended 0700 hours on day 1; the route remained within the state of Iowa and was mostly completed on US 20. According to weather data collected at the Ames Municipal Airport (Ames, IA), day 0 had a low ambient temperature of 21.1 °C, a high ambient temperature of 27.2 °C, and an average temperature of 23.9 °C. All steers were fed a common diet meeting or exceeding NASEM (2016) nutrient guidelines containing corn silage (40% DM basis), Sweet Bran (Cargill Corn Milling, Blair, NE; 40% DM basis), and dried distiller's grains (20% DM basis), along with a vitamin and mineral premix with Rumensin (Elanco Animal Health, Greenfield, IN).

All steers from each treatment were weighed pre-feed access on day 1. Upon arrival back to pens after weighing, cameras (LaView Security, Industry, CA) continuously recorded video for each pen. Cameras were mounted on the wall opposite of the front of pens such that one camera would view and record all steers in two adjacent pens. Cameras captured from the bunk (front of the pen) to the back of the pen. The continuous video was time-stamped and broken into approximately 1 h and 7 min videos automatically. Those individual videos were stored on a DVR device until copied to an external hard drive. One trained observer scored each video in a randomized pen order. A VLC media player was utilized to play videos, and playback was paused to record the time of latency behaviors and slowed during displacements. The observer was blinded to treatments. Behaviors (Table 1) recorded were the number of bunk displacements per pen in the first 2 h post-feed access (continuous sampling) and latency for each individual steer in a pen to eat, drink, and lay down (activity preferences) upon return to the home pen after BW was recorded. Individuals were numbered one through six in the order they arrived back to the pen after weighing and watched individually to record latency to eat, drink, and lay down (i.e., each video was watched six times). However, visual identification tags could not be read on video, so individuals could not be linked back to performance or feed intake data. Activity preferences were not scored for CON steers as feed had not been delivered by the time they arrived back to their pens.

All steers were equipped with CowManager tags (Select Sires, Inc., Plain City, OH) prior to treatment initiation. CowManager tags record eating, rumination, active, and non-active behaviors. Data were automatically compiled by hour such that each hour had the number of minutes spent eating, ruminating, active, and non-active. From these data, the percent of each hour spent performing each behavior was calculated and compiled for every animal. These tags associate movement with only one behavior at a time, so rumination minutes are not included in non-active minutes, even if the animal was laying down or stationary. As such, an increase in non-active minutes does not necessarily indicate a decrease in active minutes as there could be a decrease in rumination or eating minutes.

To address the objective of the primary study, steer BW was recorded on days 0, 1, and 3, relative to treatment initiation. Individual feed disappearance was recorded via GrowSafe to be used to calculate daily steer dry matter intake (**DMI**).

Table 1. Ethogram of recorded behaviors for Experiments 1 and 2

Behavior	Definition
Bunk displacement	The forceful removal of one steer from the GrowSafe bunk by another steer
Eating	The steer's head, including ears, went past the GrowSafe head bars and was in the GrowSafe bunk
Drinking	The steer's muzzle touched the water located in the pen waterer
Laying down	The body of the steer was not being supported by the limbs; the torso was resting on the ground; laying posture was disregarded

Briefly, when a steer placed his head in the GrowSafe bunk, his electronic identification tag was read, and the entering bunk weight was recorded. When the steer removed his head from the bunk, the system recognized the steer had left and recorded an exit weight for the bunk. The system automatically subtracted the exit bunk weight from the entering bunk weight to determine feed disappearance. Feed disappearance values of each individual are automatically summed for a 24 h period.

Statistical analysis

Data were analyzed using Proc Mixed of SAS 9.4, with the fixed effect of treatment. For activity preferences and CowManager behaviors, the steer was the experimental unit. Because individual visual identification tags could not be read due to the lighting in the barn, individuals at the bunk could not be identified, and pen was used as the experimental unit for bunk displacements. For CowManager behaviors, the area under the curve (**AUC**) was calculated using R for every 6 h, such that four AUC values were obtained for each 24 h period. Compiling data as such decreased the incidence of data points equal to zero while enabling examination of behavioral changes over the day. The AUC values were obtained for CON and DEPR for 18 h post-treatment initiation and for all treatment groups for the 48 h after treatments had ended. Bunk displacements and CowManager behaviors were analyzed as repeated measures using the compound symmetry covariance structure. The repeated variable was time (in 10 min intervals) for bunk displacements and time (in 6 h intervals) for CowManager behaviors. Cook's D value greater than 0.5 was used to determine outliers in the data. Statistical significance was set at $P \leq 0.05$, and tendencies were reported at $0.05 < P \leq 0.10$.

Experiment 2

Animals and experimental design

For this study, 60 Angus-cross steers (pre-transit BW: 398 ± 5 kg) were utilized. Steers were housed (6 steers per pen) in partially covered concrete pens (12.2 × 3.7 m; 7.4 m^2 per steer) equipped with one GrowSafe bunk per pen. This study investigated two continuous transit durations, 8 hours (**8H**) and 18 hours (**18H**; 727 vs. 1,770 km, respectively). To prevent diurnal effects from influencing blood parameters relating to the main experiment (Beenken et al., 2021), steers were stagger transported so the 8H and 18H groups both arrived back to the feedlot at approximately 0700 hours. Transportation was completed using a commercial livestock trailer (Silverstar PSDLC-402; Wilson Trailer Company). The trailer was not bedded, and no boarding was used to restrict airflow. Steers were stocked at an average of 1.37 m^2 per steer and were loaded in groups by compartment. Steers transported 18H left the farm at 1300 hours on February 4, 2020, and 8H steers left the farm at 2300 hours on February 5, 2020. The high ambient temperature was −2.2 °C while the low ambient temperature was −9.4 °C. Both transit journeys remained within the state of Iowa and were mostly completed on US 20. All steers were fed the same corn silage-based diet which met or exceeded NASEM guidelines for beef cattle (NASEM, 2016). The diet contained (DM basis) 30% corn silage, 35% Sweet Bran, 15% dry-rolled corn, and 20% dried distiller's grains (including vitamin and mineral premix with Rumensin). Because CowManager tags were placed on 34 steers prior to initial treatment sorting at the beginning of the trial, one to four steers were equipped with a CowManager tag in each pen (n = 20 steers in 8H; n = 14 steers in 18H). CowManager data were compiled similar to Exp. 1.

As described in Exp. 1, all behaviors were monitored using continuous video analysis and cameras were mounted in the same positions. Because of trailer weight restrictions, several steers were not transported and remained on the farm. Since these steers could influence the behavior of their transported pen mates, pens containing a steer that was not trucked were removed from behavioral analysis. As such, a total of 10 pens (n = four 8H pens, 24 steers; n = six 18H pens, 36 steers) were utilized in the behavioral analysis. All steers in each of the 10 pens were used for video analysis, though only 1 to 4 steers in each pen were equipped with CowManager tags to record rumination and activity. Using recorded video, one trained observer assessed behaviors (Table 1) including bunk displacements for each pen continuously for 2 h post-feed access, and latency to eat, drink, and lay down (activity preferences) upon return to home pen was assessed for each individual steer. Similar to Exp. 1, visual identification tags could not be read in the lighting of the barn, so steers were numbered one through six upon return to home pens after weighing. Steer BW was recorded on days −5, 0, 1, 7, and 15, relative to transport. Steer feed disappearance was recorded via GrowSafe bunks, as noted in Exp. 1.

Statistical analysis

Proc Mixed of SAS 9.4 was used to analyze all data. The fixed effect of transit time was included in the model for behavioral analysis. Steer was the experimental unit for activity preferences and CowManager behaviors; pen was the experimental unit for bunk displacements. The AUC values were calculated for CowManager behavior using R, similar to Exp. 1, for the 48 h post-transit period. Bunk displacements and CowManager behaviors were analyzed using repeated measures with the repeated variable of time (in 10 min intervals) for bunk displacements and time (in 6 h intervals) for CowManager behaviors; the compound symmetry covariance structure was used. Because all steers laid down within 25 min of arrival back to their pens, only the first 30 min of displacements were analyzed. Outliers were identified using Cook's D; outliers were removed if Cook's D value was above 0.5. Statistical significance was set at $P \leq 0.05$, while tendencies were reported at $0.05 < P \leq 0.10$.

Results

Experiment 1

Bunk displacements are displayed in Figure 1. Control and TRANS had fewer bunk displacements than DEPR during the first 70 min post-feed access, though displacements were similar among treatments from 100 to 120 min, respectively (treatment × time: $P = 0.02$). Time to perform eat, drink, and laying behavior are reported in Figure 2. There were no differences in the time to eat or drink between DEPR and TRANS (Figure 2A; $P \geq 0.17$); however, DEPR took longer to lay down compared with TRANS (Figure 2B; 70.5 vs. 16.6 min; $P < 0.01$).

CowManager behavioral data are displayed in Figures 3 and 4. While CON had greater activity immediately after treatments began, both CON and DEPR steers had similar overnight activity (Figure 3A; treatment × time: $P < 0.01$).

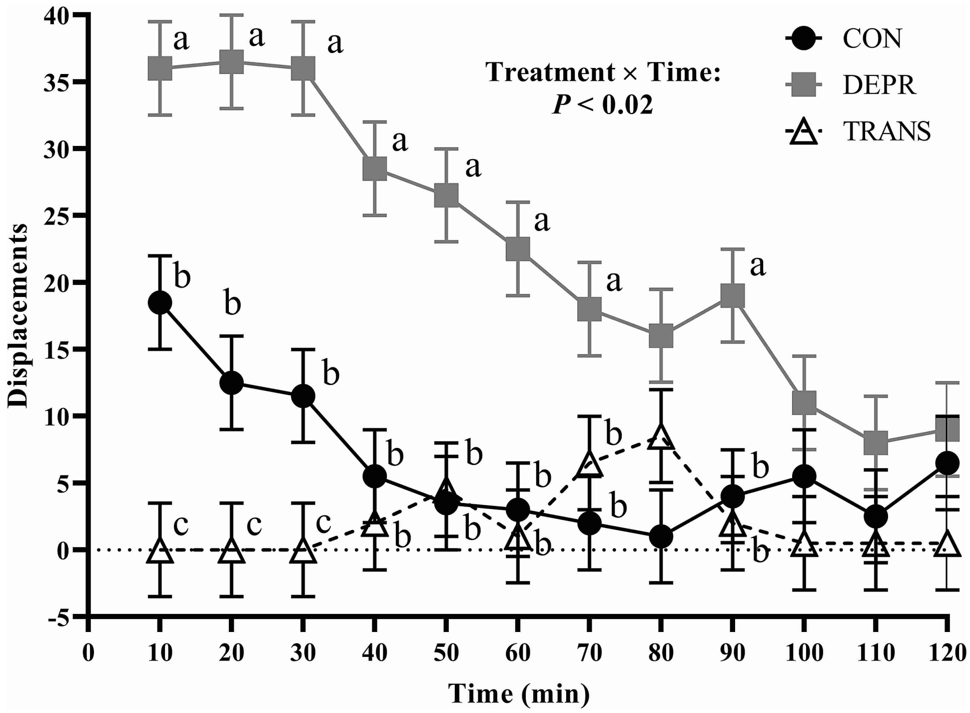

Figure 1. Exp. 1: Effect of treatment on total bunk displacements in 10 min intervals for the 2 h post-feed access in beef feedlot steers. CON: ad libitum access to feed and water; DEPR: deprived of food and water for 18 h; TRANS: transported for 18 h, no access to food or water. Different letters within timepoint represent significant differences between treatments at that timepoint (treatment × time: $P < 0.02$).

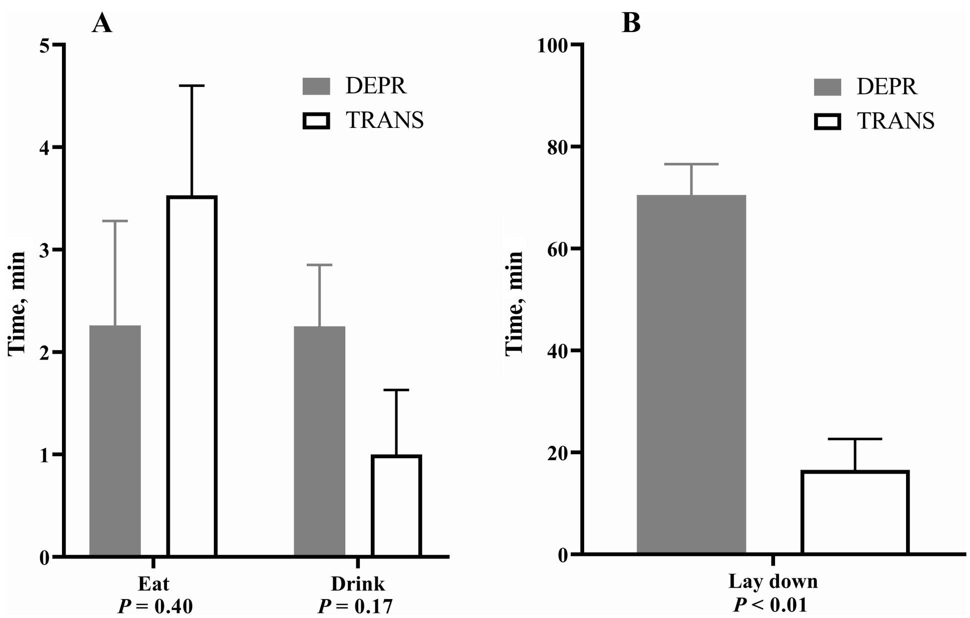

Figure 2. Exp. 1: Effect of treatment on average total time taken to eat ($P = 0.40$), drink ($P = 0.17$), or lay down ($P < 0.01$) upon arrival back to pen in beef feedlot steers. DEPR: deprived of food and water for 18 h; TRANS: transported for 18 h, no access to food or water.

The DEPR steers had greater non-active minutes overnight than CON (Figure 3B; treatment × time: $P = 0.02$). Though DEPR had greater rumination activity than CON in the immediate hours following feed restriction, DEPR rumination time decreased overnight compared with CON (Figure 3C; treatment × time: $P < 0.01$). While no differences were seen due to the interaction of treatment and time ($P = 0.64$), there was more eating behavior directly after treatments started (Figure 3D; time: $P < 0.01$). After treatments ended, TRANS steers were less active compared with CON and DEPR for the first 12 h and continued to be less active than DEPR for the majority of the next 24 h (Figure 4A; treatment × time: $P < 0.01$). The TRANS steers had greater non-active minutes than CON and DEPR in the first 6 h immediately following return to pens and continued to have greater non-active minutes than CON for most of the first 24 h after returning to home pens (Figure 4B; treatment × time: $P < 0.01$). Rumination minutes were lesser in TRANS than CON in the

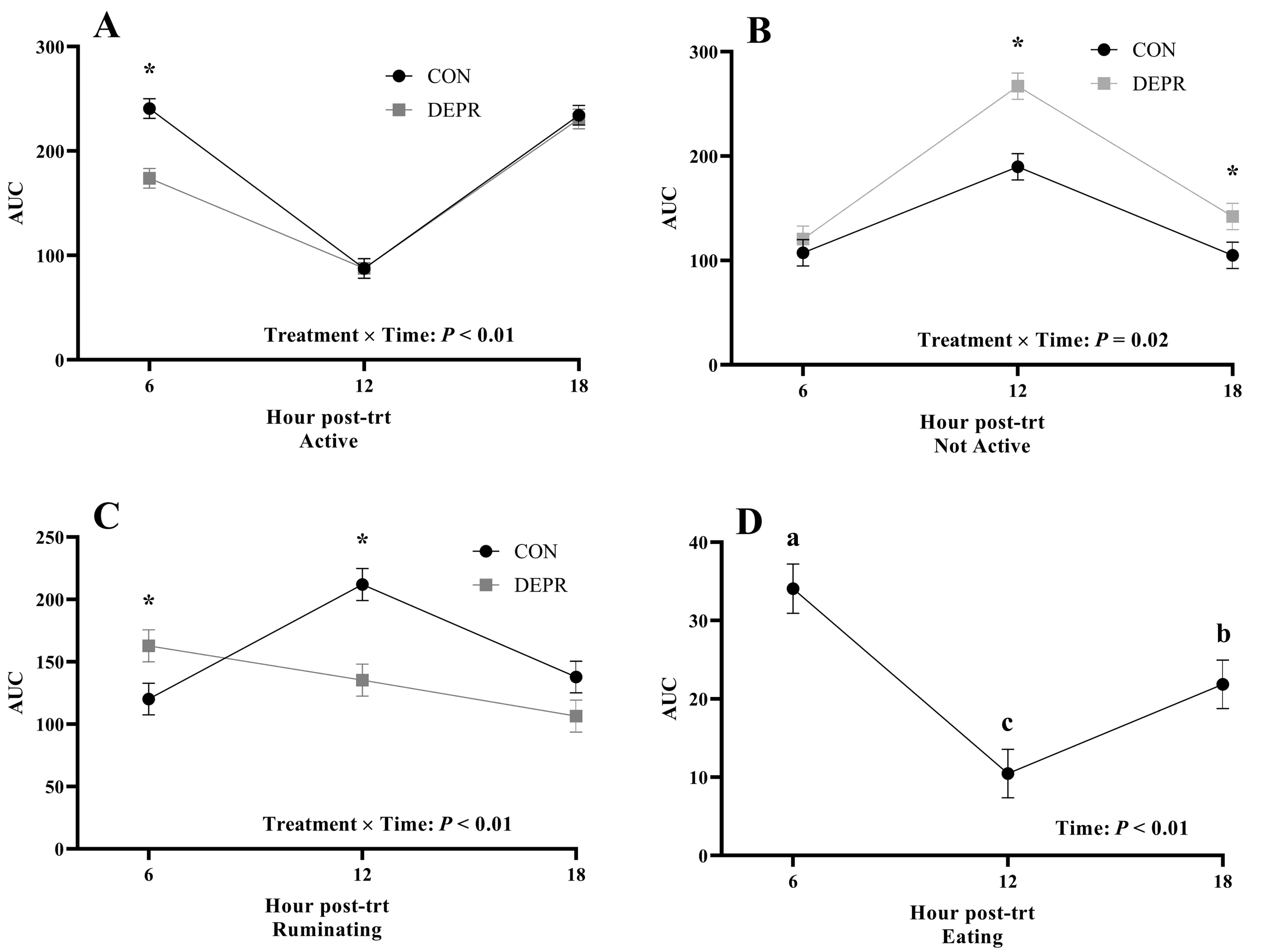

Figure 3. Exp. 1: Behavioral differences by 6 h time intervals post-treatment initiation of 18 h feed and water deprived (DEPR) feedlot steers compared with feedlot steers given ad libitum access to food and water (CON). A greater AUC indicates more time performing that behavior. Active behavior (A); non-active behavior (B); ruminating behavior (C); eating behavior (D). (A–C) asterisk indicates differences between treatments within time point (treatment × time: $P \leq 0.02$). Different letters across timepoints indicate differences in eating behavior over time (D; time: $P < 0.01$; treatment × time: $P = 0.64$).

6 h after treatments ended, though rumination activity increased regardless of treatment over 2 d after treatments had ended (Figure 4C; treatment × time: $P < 0.01$). Transported steers had greater eating time 12 h after treatments ended than CON and DEPR and generally greater eating time than DEPR after 30 h of treatments ending (Figure 4D; treatment × time: $P < 0.01$).

Cattle performance is reported in detail elsewhere (Deters, 2020). Briefly, CON had greater BW than DEPR and TRANS immediately after treatments ended, though BW was similar among treatments by day 3 post-trucking (treatment × day: $P < 0.01$). DMI was greater in CON on day 0 (treatment initiation). While CON and DEPR had similar DMI on day 1, TRANS generally had lesser DMI than DEPR steers until day 8 post-transit (treatment × day: $P < 0.01$).

Experiment 2

Bunk displacements were not affected by transit duration ($P = 0.20$) or the interaction of transit duration and interval ($P = 0.52$). However, bunk displacements were greater in the first 20 min post-arrival to pen than at the 30 min interval (Figure 5; $P < 0.04$). There was no difference in the time to eat or lay down (Figure 6; $P \geq 0.14$), but 8H steers took longer to drink than 18H steers (Figure 6; $P = 0.05$).

CowManager behaviors are shown in Figure 7. Steers transported 18H had greater active minutes than 8H in the 6 h immediately post-transit, though activity minutes were similar between treatments during the following 48 h (Figure 7A; treatment × time: $P < 0.01$). Over the 48-h following transit, 18H steers had greater non-active minutes than 8H steers at nearly all hours (Figure 7B; treatment × time: $P < 0.01$). Overall, 8H steers spent more time ruminating compared with 18H steers (treatment: $P < 0.01$), and rumination activity decreased in the morning and afternoon hours and increased in the evening and overnight hours, regardless of treatment (Figure 7C; time: $P < 0.01$). There were no differences in rumination due to the interaction of treatment and time ($P = 0.29$). Eating times were similar between treatments, though 8H steers had greater eating time at 24 h post-arrival back to the feedlot than 18H steers (Figure 7D; treatment × time: $P < 0.01$). Performance and blood parameter results are described by Beenken et al. (2021).

Discussion

These experiments were secondary to primary studies by Deters (2020) and Beenken et al. (2021), and experimental designs were established to address the primary objectives of each study. The objectives of the secondary studies addressed

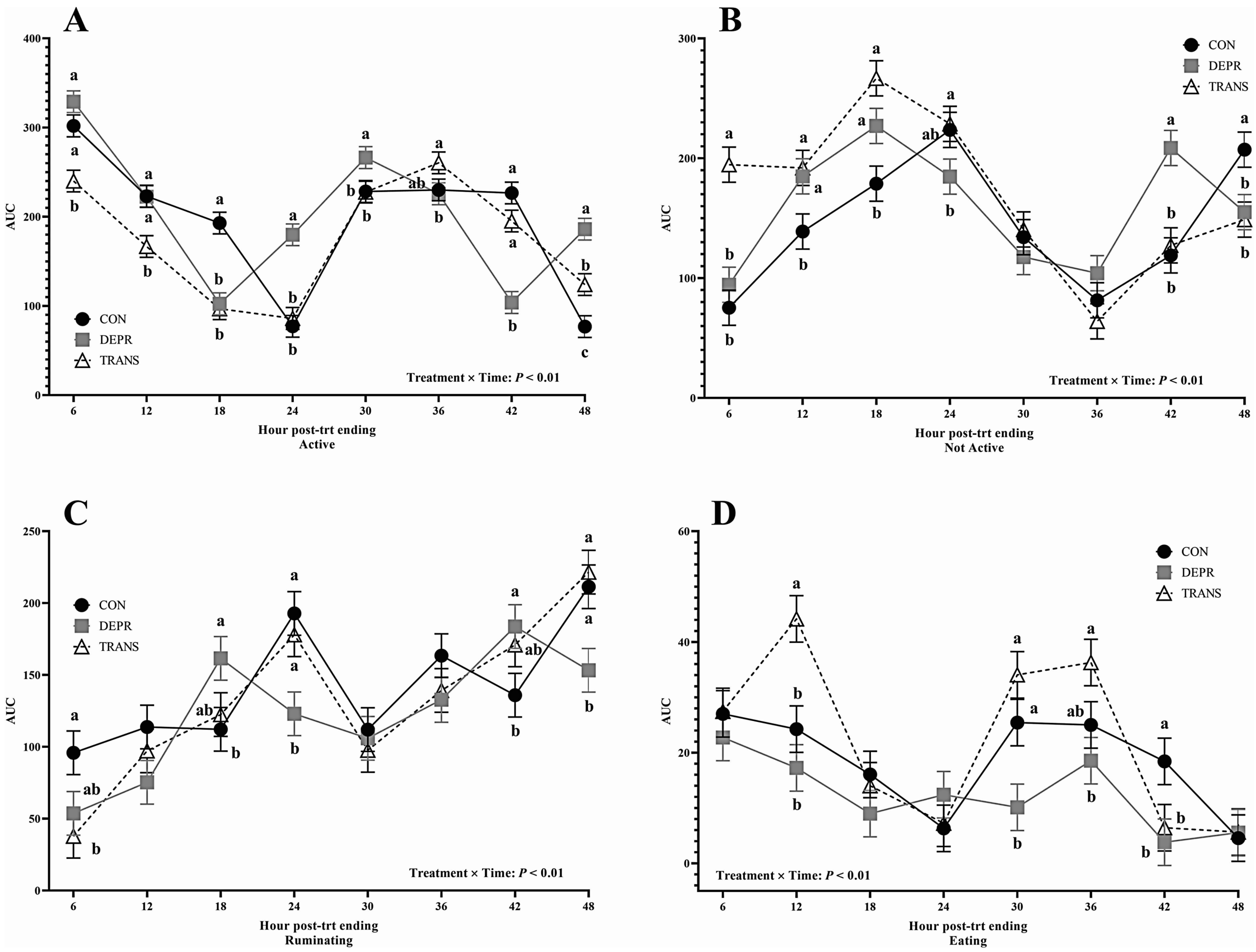

Figure 4. Exp 1: Behavioral differences by 6 h intervals post-treatment ending in feedlot steers either allowed ad libitum access to feed and water (CON), restricted from feed and water for 18 h (DEPR), or transported for 18 h without food or water access (TRANS). Active behavior (A); non-active behavior (B); ruminating behavior (C); eating behavior (D). Different letters within timepoint indicate treatment differences (treatment × time: $P < 0.01$).

here were to determine if steers display behavioral differences after being transported for 18 h or feed and water deprived for 18 h and if differences in behavior are displayed in steers transported 8 or 18 h. The hypotheses were that after being transported for 18 h, steers would prefer to lay down rather than compete for feed and steers that were transported for 18 h would lay down faster than 8 h steers.

In both studies, transported steers quickly laid down after returning to their home pens, regardless of transport length. This preference to lay down is likely due to increased muscle fatigue caused by transport. In a study investigating the effects of 14, 21, 26, and 31 h of transport in the United Kingdom on cattle behavior, cattle chose to stand during transportation, though they began to lay down toward the end of the 31 h journey (Knowles et al., 1999). In humans, vibrations from vehicles while driving (Park et al., 2020) and hand power tools (Adamo et al., 2002) increase muscle fatigue. In pigs, it is thought fatigued pig syndrome, where a pig is non-ambulatory after trucking but does not have any outward signs of injury or disease, may be increased by trailer vibrations (Ritter et al., 2005). As such, it was hypothesized in Exp. 2, the 18H steers would lay down more quickly than the 8H steers as the 18H steers were exposed to trailer vibrations and required to stand for 10 h more than the alternative treatment. However, there was no difference in time to lay down between the 8H and 18H steers; both groups laid down within 25 min of arriving back to their home pens and had similar active minutes over the next 48 h. This supports the European Commission's guidelines that any cattle transit duration of 8 h or greater is considered a long journey (European Commission, 2018). A possible explanation for the similar times to lay down may be that 18H steers potentially had increased motivation to access feed as they had been deprived for longer than 8H steers. Collings et al. (2011) found lactating dairy cows allowed 14 h of feed access had increased DMI, minutes spent eating, and bunk visits in 2 h following morning feed delivery compared with cows allowed 24 h of feed access. This indicates greater time restricted from feed increased motivation to access feed.

Length of transit and the use of rest stops can affect the welfare and behavior of transported animals. While the United States (United States Department of Agriculture, 2020) and Canada (Government of Canada, 2020) allow for 28 and 36 h, respectively, before a rest stop is needed, the European Union (European Commission, 2018) requires a minimum hour-long rest stop for every 14 h of transport. In a review of the effects of transit duration on animal welfare, Nielsen et al. (2011) state that it is not necessarily the duration of transit affecting welfare, but the inseparable nature of food, water, and rest deprivation with transit duration. As

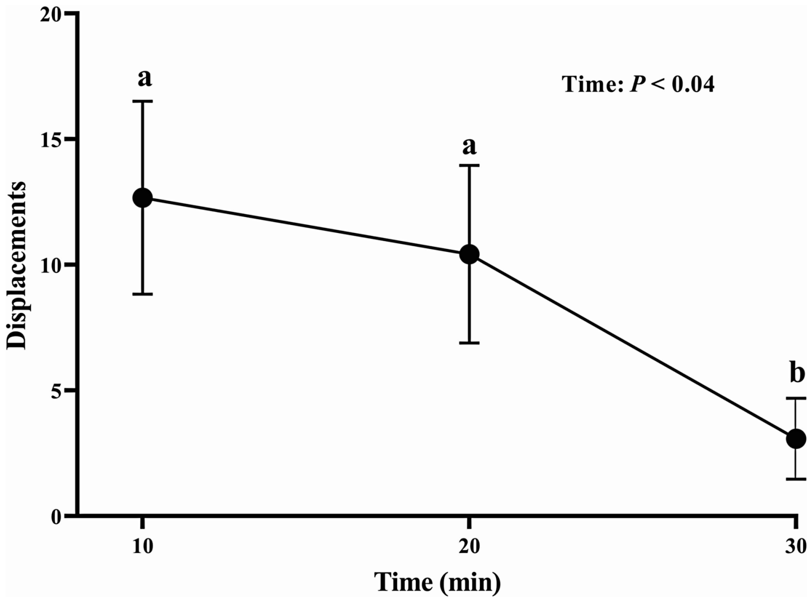

Figure 5. Exp. 2: Effect of time post-feed access on total bunk displacements every 10 min for the first 30 min post-feed access in beef feedlot steers. Transit duration × time was not significant ($P = 0.52$). 8H: steers transported for 8 h without access to food/water. 18H: steers transported for 18 h without access to food/water. Different letters indicate a difference in total number of bunk displacements across 10 min intervals ($P < 0.04$).

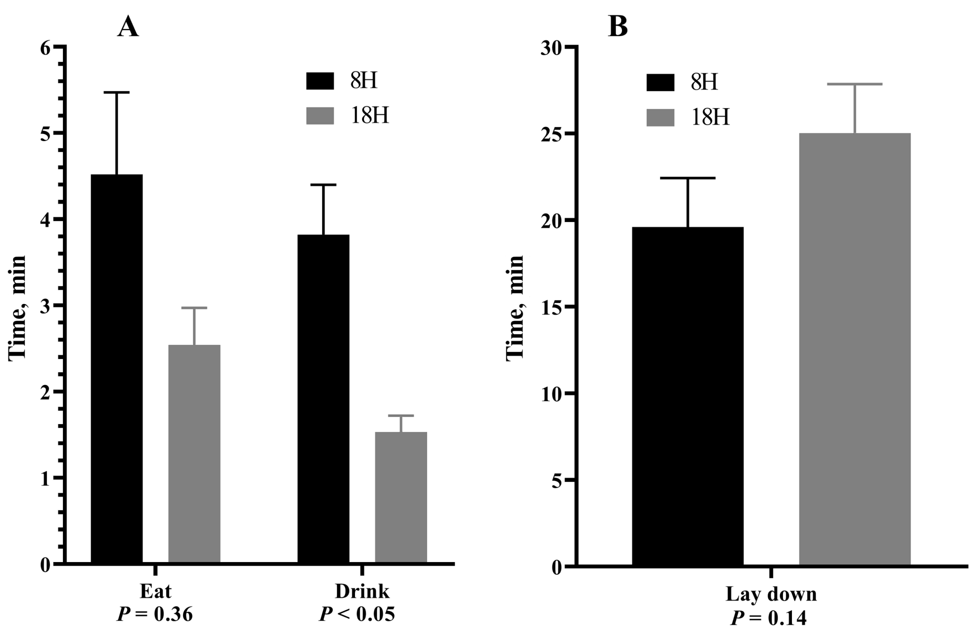

Figure 6. Exp. 2: Effect of transit duration on activity preferences. Average time to eat ($P = 0.36$) and drink ($P < 0.05$) upon return to pen post-transit (A). Average time to lay down ($P = 0.14$) after arriving back to home pen post-transit (B).

such, further research is needed to determine the practicality of rest stops, rest stop durations, and reasonable transit duration limits.

Serum lactate was greater in 18H steers off-truck (Beenken et al., 2021), and non-active minutes were greater in 18H compared with 8H steers, indicating 18H steers may have been experiencing greater muscle fatigue. In a study assessing two transit durations (12 vs. 36 h) and four rest stop durations (0, 4, 8, and 12 h), calves had a similar percent laying time (58.8% to 61.9%), the day after arriving back to their pens regardless of transit duration or the time allowed to rest (Meléndez et al., 2020). Similarly, Schwartzkopf-Genswein et al. (2007) found plasma cortisol concentrations were not different between cattle trucked for 2.7 and 15 h, suggesting steers had similar stress responses regardless of transit duration. The results from these studies indicate transit-induced muscle fatigue may affect behavior similarly regardless of transit duration. This observation may be notable to researchers designing transit-induced muscle fatigue studies.

In Exp. 1, DEPR and TRANS steers were withheld from feed and water for the same amount of time (18 h). However, upon return to the home pen, TRANS steers preferred to lay down rather than compete for feed and generally had greater non-active time and lesser active minutes than CON or DEPR. Meanwhile, the DEPR steers had increased aggressive interactions at the feed bunk when compared with the

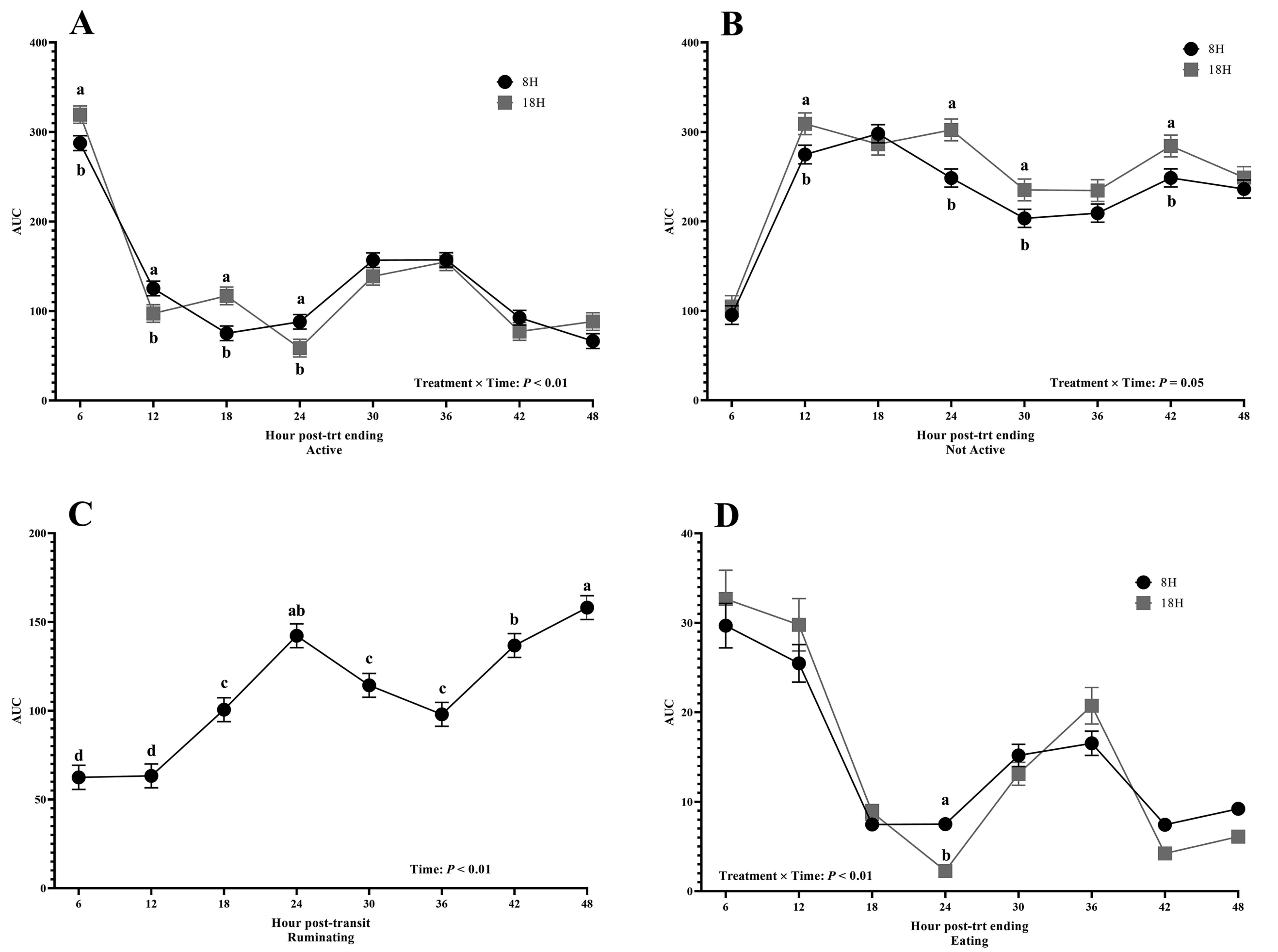

Figure 7. Exp. 2: Behavioral activities in 6 h intervals in the 48 h directly post-transit of beef feedlot steers. Active behavior (A); non-active behavior (B); ruminating behavior (C); eating behavior (D). (A, B, D) Different letters indicate treatment differences within timepoint (treatment × time: $P \leq 0.05$). (C) Different letters represent differences in ruminating behavior across time (time: $P < 0.01$; treatment × time: $P = 0.29$).

CON or TRANS steers. While using GrowSafe bunks, it inherently increases competition because only one animal can eat at a time (Zobel et al., 2011), the intensity at which the DEPR steers competed for feed after being withheld for 18 h is notable, and producers should be aware of how limited bunk space allowances may affect behavior and lead to increased incidence of injuries. Others have shown the effects of temporal feed restriction on aggressive interactions. Collings et al. (2011) allowed lactating dairy cows either 24-h feed access or a restricted 14-h feed access. Restricted cows had nearly double the number of displacements at the feed bunk than unrestricted access cows, suggesting feed restriction increases motivation for feed access as well as competition for the food resource. Caretakers should take into consideration the change in the behavior of a feed-restricted animal as the increased aggressiveness can lead to injuries in caretakers and pen mates. Surprisingly, while being withheld from food and water, DEPR had nearly identical overnight active minutes as CON. It was thought DEPR may spend more time pacing overnight in search of food, but instead, they had greater non-active minutes than CON and lesser time spent ruminating. This is similar to a study examining feed restriction in sheep; as the level of feed intake decreased (ad libitum, 70% ad libitum, or 55% ad libitum), rumination minutes also decreased while non-active minutes increased (Galvani et al., 2010).

In Exp. 1, TRANS steers did not recover previous DMI until the day after arriving back to home pens. The preference to lay down upon arrival back to their pens likely inhibited the return to previous DMI as steers recovered from potential muscle fatigue caused by long-distance transit. Morris et al. (2021) examined the vibrations of two commercial pig trailers to assess the pig discomfort level. The authors found the vertical vibrations were more intense than horizontal vibrations, and the bottom compartments that were located over the trailer wheels likely had the most uncomfortable vibrations (Morris et al., 2021). While humans can self-report pain due to muscle soreness (Gleeson et al., 1998), animals cannot, leading to the use of behavioral observation tools. Standing and competing at a feed bunk may have caused additional discomfort, so TRANS steers may have chosen to continue to lay down rather than eat.

It has been proposed that one temperament trait animals possess is the exploration-avoidance trait (Réale et al., 2007). This indicates animals in a new environment will typically explore that environment, displayed in the characteristic walking of pens that newly received cattle demonstrate. However, in the current experiments, steers were preconditioned and came back to a familiar environment. All steers had been weaned and adapted to GrowSafe bunks before transport, and pens had established members and hierarchies. This familiar environment could have affected the arrival behavior post-transit. When Meléndez et al. (2021) examined the effect of conditioned vs. unconditioned calves on behavior post-transit, the authors found conditioned calves had greater DMI than unconditioned calves. Unconditioned calves also had a greater percent time standing compared with conditioned calves (Meléndez et al., 2021). As such, the rapidity of steers to lay down might be partially attributed to preconditioning and being comfortable in a known environment with known pen mates.

To conclude, long-distance transit alters steer's post-transit home pen behaviors, particularly time to lay down, activity, feed bunk displacements, and post-transit DMI. Steers transported for 18 h prefer to lay down rather than compete for feed and had greater non-active minutes, while steers deprived of feed and water for 18 h but left in their home pens prefer to compete for feed, suggesting the transit event is fatiguing. Though food- and water-deprived steers had decreased overnight rumination and active minutes during deprivation, they increased bunk displacements upon feed access, suggesting they were highly motivated to access the food resource. Steers transported for 8 or 18 h laid down at similar times. Future research should consider the effects of transportation on bunk displacements using traditional concrete bunks and water displacements as well as the effects of different pen conditions at receiving to help determine optimal management strategies after a long-duration transit event.

Conflict of interest statement

The authors declare no conflicts of interest.

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