ABSTRACT: Previous studies have determined that stress causes decreases in feed intake and efficiency in livestock, but the effect of repeated transport on these parameters has not been well studied. This study determined how repeated transport affected calf post-transport behavior, feed intake, ADG, and feed conversion. Thirty-six 4-mo-old Holstein steer calves were housed in groups of 6 with each group randomly assigned to either transport or control treatments. Each calf was assigned to an individual Calan gate feeder and feed intake was recorded daily. Transport calves were transported for 6 h in their groups in a 7.3 by 2.4 m gooseneck trailer divided into 3 compartments, at an average density of 0.87 m²/calf, every 7 d for 5 consecutive weeks. After return to their home pens, behavior was recorded for transported calves at 5-min intervals for 1 h. Calf ADG and feed conversion were analyzed in a mixed model ANOVA, whereas feed intake was analyzed as a repeated measure in a mixed model ANOVA. Post-transport, calves followed a pattern of drinking, eating, and then lying down. The highest (82 ± 5% calves) and lowest (0 ± 5% calves) incidences of eating behavior occurred 10 and 60 min post-transport, respectively. Control calves had a higher feed intake than transported calves overall (7.29 ± 0.22 kg for control and 6.91 ± 0.21 kg for transport; *P* = 0.01), for the feeding posttreatment (6.78 ± 0.27 kg for control and 6.01 ± 0.28 kg for transport; *P* = 0.007), and the day after treatment (7.83 ± 0.23 kg for control and 7.08 ± 0.15 kg for transport; *P* = 0.02). Feed intake for the feeding post-transport for transport calves significantly decreased after the second transport but increased with each successive transport (*P* < 0.0001). Overall, control calves had higher ADG than transported calves (1.34 ± 0.13 kg/d for control and 1.15 ± 0.12 kg/d for transport; *P* = 0.006). No significant difference (*P* = 0.12) between treatments was detected for feed conversion. These results suggest that calves exposed to repeated transport may decrease feed intake compared to nontransported calves as an initial response to transport; however, overall feed conversion was not affected and these Holstein calves may have quickly acclimated to repeated transport.

Key words: average daily gain, behavior, calves, feed conversion, feed intake, transport stress

INTRODUCTION

Stress has been shown to have a negative impact on cattle feed intake, growth, and production (Duff and Galyean, 2007). For example, overcrowding has caused dairy cattle to decrease their feeding and rumination activity, along with altering their resting behavior (Krawczel et al., 2012). Similarly, it is essential to understand the effects of transport on cattle feeding and resting behavior to optimize production. Calf behavior during transport and post-transport has been recorded in calves of different age groups and in calves transported for prolonged journeys. Calves less than 4 wk of age and calves 3 mo of age spend 33 to 36% and 13 to 42%, respectively, of their time lying during transport (Swanson and Morrow-Tesch, 2001). Kent and Ewbank (1986) noticed that 3-mo-old calves subjected to either a 6-h journey or an 18-h journey displayed differences in lying behavior during transport, but these differences did not translate to growth rate differences between the 2 groups.
3 wk post-transport. Transport studies have shown that horses hauled for 8 h decrease their feed intake for up to 6 h post-transport (van den Berg et al., 1998) and horses may habituate to repeated road transport (Schmidt et al., 2010). Acclimation, or habituation, to road transport has not been widely studied in livestock, but especially little information is known about calf behavior post-transport and the effects of repeated transport on calf growth.

Previous studies identified a variety of stressors that may hinder growth in calves. In 1 example, Fisher et al. (1996) demonstrated that the ADG for calves was reduced postcastration, regardless of the method of castration implemented. In another example, the stress associated with handling and transport caused calves to lose 8.1% of their weaning BW (Phillips et al., 1987). Furthermore, calves exhibit a decreased appetite or willingness to consume feed for up to 3 wk on arrival at the feedlot (Hutcheson, 1980). Individually, and especially in combination, these stressors affect not only calf growth and producer profits but also the well-being of the calves. However, some prior studies have shown that stress may actually stimulate, rather than suppress, appetite. For example, women with higher concentrations of cortisol consumed more calories and preferred sweet food on days they were exposed to stress (Epel et al., 2001). Rowland and Antelman (1976) also showed that rats exposed to stress (tail pinching) multiple times a day exhibited an increased appetite that led to obesity.

The objective of this study was to determine if calves acclimate to weekly transport and how repeated transport affects feed intake, ADG, and feed conversion in Holstein calves. The hypothesis was that calves experiencing repeated transport conditions would decrease their post-transport feed intake after the first few transports but would return to normal feeding behavior post-transport if acclimation to the weekly transports occurred.

MATERIALS AND METHODS

Subjects, Housing, and Management

This study was approved by the Texas A&M University Animal Care and Use Committee (Animal Use Protocol number 2010-202). Thirty-six 4-mo-old Holstein steer calves housed at the Texas A&M University Animal Science Teaching, Research and Extension Center (9.7 km west of College Station, TX) were blocked by BW and assigned to 1 of 6 pens such that each pen had a similar mean BW. There were 6 calves in each of the 12 by 6 m pens. The mean initial calf BW was 146 ± 2.6 kg. The pens were located on the south side of a covered open-sided barn that provided roofing over the feeders and northern half of the pens. The pens were constructed of corral panels on 3 sides and were equipped with automatic watering systems, with 1 water basin shared by 2 pens. Six Calan gate feeders (American Calan Inc., Northwood, NH) were mounted on the north or covered side of each pen. Two weeks after being regrouped into pens of 6, calf feed bunk preferences (number of times each calf attended each feeder) were recorded by direct observation for 4 h during 4 separate feedings, over the course of 2 d. Following each calf’s feeder preferences, each calf was assigned an individual feeder and the corresponding feed bunk key placed on the calf’s neck. Pens were scraped clean weekly and the water basins were cleaned daily.

Transportation of Calves and Recording Behavioral Observations

Individual feed intake and BW data were collected for 7 d before the first transport trial and 6 d after the final transport trial. The calves were fed an ad libitum starter feed (Cornerstone Ampli-calf DX 30; Purina Mills, St. Louis, MO) mixed with cottonseed hulls and molasses yielding a 19.37% CP and 4.12% crude fat diet that was fed twice daily. Excess feed was weighed every evening. Each pen of 6 calves was randomly assigned to either transport (n = 18 calves) or control (n = 18 calves) treatments.

One week after feed bunk assignments were established, transport trials commenced. Calves were transported for 6 h in their assigned groups of 6 in a 7.3 by 2.4 m gooseneck trailer divided into 3 equal compartments, at an average density of 0.87 m²/calf, every 7 d for 5 consecutive weeks. Before each transport and while in their home pens, each calf was gently restrained by 1 researcher as another researcher obtained a blood sample via jugular venipuncture to be used in a study on gene expression. The calves in this study were handled on a daily basis and accustomed to the researchers, so the calves displayed a minimal reaction to the researchers handling them. After the blood samples were obtained from a group, each group was ushered into a chute for weighing, after which the transported calves were directed onto the trailer and the control calves were returned to their home pens. The trailer returned at 2-h intervals for 20 min to allow for visual inspection of the calves and additional blood sampling within the trailer for the transported calves. Immediately after transport resumed, blood samples were then obtained from the control calves while they were in their home pens. No calves (including the control calves) had access to feed until the transported calves were returned to their home pens after each 6-h transport.
Temperature–humidity index (THI) was calculated using ambient temperature and relative humidity from data loggers (H08-003-02 HOBO devices; Onset Computer Corporation, Pocasset, MA) mounted in the shade in the feed alley next to the feeders of the middle pen and along the front wall of the trailer. Each data logger was attached to Styrofoam (15.24 by 10.16 cm) to prevent direct contact with the feeder post or trailer wall. The data loggers recorded ambient temperature and relative humidity at hourly intervals from 1 h pre-transport to 1 h after the transported calves returned to their home pens. The THI equation used in this study was \(\text{THI} = \text{ambient temperature} - [0.55 - (0.55 \times \text{relative humidity/100})] \times (\text{ambient temperature} - 58.8)\), in which ambient temperature was recorded in degrees Fahrenheit and relative humidity was recorded as a percentage (NOAA, 1976).

After the calves were unloaded and returned to their home pens after each transport, observers recorded behavioral observations for the transported calves for 1 h at 5-min intervals using a scan-sampling method (Lehner, 1996). Each calf was identified by its ear tag number and behavior was classified as standing still (not simultaneously performing any other behaviors), walking, trotting/loping, lying, grooming, eating (head inserted inside the feeder), or drinking (nose within 15 cm of water) every 5 min. Before the start of the study, all the observers walked the pens together conducting a mock data collection. Rumination was not observed in these calves, probably because of the form of their diet, so rumination was not recorded. Because the behavioral observations were discrete categories and informal observations of the observers agreed, measures of interobserver reliability were not calculated. The recording of the behavior for each pen started immediately after a particular group returned to its pen and the gate to the alley was closed. Behavior observations were classified into 5 categories: eating, lying, standing, drinking, and other. Walking, trotting/loping, and grooming were combined into the “other” category because incidences of those behaviors were minimal.

**Mean Daily Gain, Feed Conversion, and Statistical Analyses**

Mean feed intake for each week was calculated using feed intake values for the feeding immediately after transport and 6 d following transport. That is, Week 1 represented the feed intake for the remainder of the day after the first transport (Transport 1) and the next 6 d. Linear regression of each calf’s BW (measured pre-transport each week) over the 5-wk study was used to determine average weekly gain. Average weekly gain for each calf was then divided by 7 to calculate ADG. For each calf, ADFI over the entire 35-d study was divided by the ADG to calculate each calf’s feed conversion (kg feed per kg gain) over the 35 d.

The percentage of transported calves eating, lying, standing still, and drinking during each 5-min observation after each transport was presented descriptively and no formal statistical analysis was conducted due to confounding factors (increasing age of the calves and the advent of cooler environmental temperatures during the later part of the study). Final BW was analyzed using a \(t\) test for 2 independent samples. Because each calf had its individual feeder, each calf served as an experimental unit (total \(n = 36\)). Feed intake was analyzed in a mixed model ANOVA, with repeated measures for calf(treatment) and an autoregressive covariance structure, whereas ADG and feed conversion were analyzed in a mixed model ANOVA using a diagonal covariance structure (SAS 9.2; SAS Inst. Inc., Cary, NC).

**RESULTS**

All calves became accustomed to their feeders before the study began. During transport, all calves were monitored for signs of hyperthermia (including increased respiration rate and shallow breathing), but none were detected. During each transport trial, most calves were standing in the trailer after 2 h of transport but were lying after 4 and 6 h of transport. Also, informal observations indicated that more calves were lying in the trailer during Transport 5 than Transport 1. During the 5 transport trials, the mean hourly THI within the pens was \(66 \pm 1.06\) and the mean hourly THI within the trailer was \(70 \pm 1.63\). The highest mean pen THI for a trial occurred during Transport 3 (73) and the lowest occurred during Transport 5 (54).

**Calf Post-Transport Behavior**

In general, a majority of the transported calves displayed a similar pattern of drinking, eating, and then lying down after each transport. The calves transitioned from eating to lying during the 35-min observation after Transport 1 (Fig. 1) and after the 25-min observation after Transport 5 (Fig. 2). Across all observation times, calf eating behavior peaked 10 min after unloading (82 ± 5% calves) and then decreased with each subsequent observation until no calves (0 ± 5% calves) were observed eating during the 55- and 60-min observations. No calves were observed lying down until 20 min after unloading (3 ± 5% calves) and then the percent of calves lying increased with each consecutive observation until all calves were lying down during the 60-min observation (100 ± 5% calves). Calf standing still behavior peaked during
the 30-min observation (28 ± 4% calves) and then decreased with each subsequent observation until no calves (0 ± 4% calves) were observed standing still during the 55- and 60-min observation periods. The highest percent of calves drinking occurred immediately after the calves returned to their home pens (86 ± 3% calves) and then the percent of calves drinking sharply dropped during the 5-min observation (13 ± 3% calves) and continued to decrease with each consecutive observation until no calves (0 ± 3% calves) were observed drinking during the 60-min observation.

**Body Weight, Feed Intake, ADG, and Feed Conversion**

The 6-mo-old transported and control calves had a mean final (6 d after Transport 5) BW of 177 ± 2.8 and 183 ± 2.4 kg, respectively, which did not differ significantly ($P = 0.12$). As expected, calves in both groups showed the same trend of increasing feed intake with age. Calves had significantly higher feed intake during Week 5 (8.27 ± 0.09 kg) than during Week 1 (5.61 ± 0.12 kg; $P < 0.0001$; Fig. 3). A significant ($P = 0.05$) treatment × day interaction for feed intake occurred in which all calves decreased their feed intake on the day of transport and increased their feed intake the day after each transport trial, with the exception of Week 5 (Fig. 4). On the day of Transport 5, feed intake increased. Control calves had a higher feed intake than transported calves on the day of each transport (control = 6.78 ± 0.27 kg and transported = 6.01 ± 0.28 kg; $P = 0.007$; Fig. 4) and the day after each transport (control = 7.83 ± 0.23 kg and transported = 7.09 ± 0.15 kg; $P = 0.01$; Fig. 4). Over the course of the study, control calves (1.34 ± 0.13 kg/d) had a significantly ($P = 0.006$) higher mean ADG than transported calves (1.15 ± 0.12 kg/d). Treatment did not significantly ($P = 0.12$) affect calf feed conversion.

**DISCUSSION**

After each transport, the calves in this study showed a similar pattern in their priorities on returning to their home pens. The majority of calves demonstrated a consistent routine of drinking, eating, and then lying down. This pattern of behavior did not appear to change as calves became older and more accustomed to the weekly transports, with the exception of fewer calves drinking and more calves eating immediately on returning to their home pens with each successive transport.

Most calves began to eat after 10 min of returning to their home pens and the fewest number of calves ate after 55 to 60 min of returning to their home pens. In general, cattle show signs of fatigue and increased lying behavior after unloading (Swanson and Morrow-Tesch, 2001). However, further research is needed to examine why the calves in this study switched from eating to lying down at earlier intervals as the study progressed. This transition from eating to lying down occurred during the behavioral observation at 35 min after Transport 1 and Transport 2, during the observation at 30 min after Transport 3 and Transport 4, and during the observation at 25 min after Transport 5. One potential explanation for these differences may be attributed to the calves being more relaxed and accustomed to the transport routine and therefore switching from eating to lying earlier with each subsequent transport.

Although not quantified, the percent of calves lying down in the trailer during transport appeared to increase as they spent more time on the trailer and with each successive transport. These informal observations indicated that most of the calves were lying in the trailer after 4 and 6 h of transport. Kent and Ewbank (1986) documented that 3-mo-old calves spent 14% of the time lying down during a 6-h transport at a density of 0.72 m$^2$/calf and spent 42% of the time lying down during an 18-h transport at a density of 0.72 m$^2$/calf, but no information was available about how the calf behavior changed during the course of the transport. Lying behavior during transport.
Calf behavior responses to repeated transport

Calf behavior responses to repeated transport is also affected by road conditions. The calves in this study experienced mostly smooth roads, which may contribute to the lying behavior noticed during transport. In general, the behavior of calves (including the amount of time spent lying) during transport is important because it may be an indicator of the well-being of the calves, but few studies have examined how calf lying behavior during transport is influenced by repeated transport.

The calves used in this study decreased feed intake on the day of transport and then recovered to their normal feed intake the day after each transport trial. The exception to this occurred during Week 5, in which feed intake actually increased on the day of transport, potentially due to the cooler weather on the day of Transport 5. Furthermore, transported calves showed such a significant increase in feed intake during Week 5 that the overall difference between feed intake in transported calves and control calves became much smaller. The lower feed intake that occurred on the day of transport in all calves, regardless of treatment, is most likely caused by the lack of access to feed during the period of handling and transport. Decreases in feed intake on days of transport for transported calves were expected because previous studies determined that calves decreased their feed intake on arrival at feedlots (Cole, 1996). However, the calves in this study were returned to their home pen with the same group of calves each week, which may have been a factor in the increases in feed intake observed during Week 5. Perhaps the increases in feed intake during Week 5, coupled with more calves observed lying during Transport 5, could be attributed to the relatively cool day and the calves starting to habituate to the weekly transport routine.

No previous studies have monitored changes in feed intake in calves that experience repeated transport, but several studies have determined feed intake in newly received calves at the feedlot. Arthington et al. (2008) reported that calf feed intake decreased during the first week after transportation and began to increase after 2 wk, and Hutcheson and Cole (1986) found that calves returned to normal feed intake 2 to 4 wk after arrival at the feedlot.

In this study, overall, the transported calves had a lower ADG than control calves. Newly received calves at the feedlot can experience depressed ADG during the receiving period or the first 56 d after arrival (Pritchard and Mendez, 1990). Feed conversion, however, did not appear to be affected in this study, possibly because tame calves were used and they were returned to their home pen after each transport trial.

The calves in this study appeared to have started to habituate to the weekly transport, because their feed intake became comparable to the control calves during Week 5 and feed conversion did not appear to be affected by the transports. Further research on repeated transport over a longer time period (>5 wk) could help determine whether the calves were truly beginning to habituate to the repeated transport. Also, additional measurements of stress (such as hormone concentrations, etc.) in the calves could provide more insight to whether acclimation occurred.

LITERATURE CITED


