INTRODUCTION

Bunk space is a critical factor for feedlot cattle performance, welfare, and health. There is a wide range of recommended bunk space allowances depending on animal age, weight, and the type of feeding program (Taylor, 1984; Pritchard and Bruns, 2003). In a continuous feeding system, where the cattle have constant access to feed, linear bunk space of 15 cm per animal is considered adequate (Taylor, 1984; Zinn, 1989). However, many feedlots utilize limit-feeding programs, where intake is restricted by the producer, to increase feed efficiency, decrease intake fluctuations, and reduce manure output (Faulkner and Berger, 2003). When limit-feeding cattle, Taylor (1984) recommended all cattle have simultaneous access to the bunk with bunk space requirements of 45 to 65 cm per animal. Research has shown that a reduction in bunk space in limited-fed cattle increases competitive behavior and variation in rate of gain (Longenbach et al., 1999; Gottardo et al., 2004). Schwartzkopf-Genswein et al. (2003) found reducing variation in daily intake improves average daily gain (ADG) and feed efficiency. Previous research has focused on minimizing intake variation through feeding program type, feeding time, and ration composition (Pritchard and Bruns, 2003; Schwartzkopf-Genswein et al., 2003). Limited research experimental research has considered the effect of bunk space on beef cattle intake variation, performance, and behavior. The objectives of this study are to determine the effects of a reduction in linear bunk space on beef steer growth, performance, and carcass merit. We hypothesize that reducing the amount of linear bunk space, so that only half of the pen can simultaneously access the bunk, will have no effect on cattle performance and carcass quality.

MATERIALS AND METHODS

The study was conducted in accordance with an approved University of California, Davis (UCD) Institutional Animal Care and Use Committee protocol at the UCD Feedlot (Davis, CA). A relatively uniform set of Angus-influenced weaned steers were obtained from the UCD Sierra Foothill Research and Extension Center herd. Steers were used in a two-part study to evaluate the effect of bunk space in feedlot steers fed growing and finishing rations. In part 1, 56 steers (initial body weight (BW) = 268 ± 28 kg) were fed a low energy ration for 84 d (Table 1). On day 0 of the first trial, steers were weighed, ranked, and stratified by BW, and allocated to four pens, so each pen had a similar initial BW. Each of the four pens were randomly assigned to a control (CON) or restricted (RES) bunk space treatment (87 and 20 cm, respectively), where the RES treatment only allowed half of the pen to eat simultaneously, for a total of two pens per treatment. Bunk space was limited by placing a divider in the bunk and only distributing feed on one side of the divider.

On day 0, hip height (HH) and ultrasonic measurements for ribeye area and back fat...
thickness (BF) were taken. Ultrasound measurements were taken using an Ibex Evo (E.I. Medical Imaging, Loveland, CO) at the interface of the 12th and 13th ribs. On day 7 of the first trial, all steers received a Revalor-S implant (Merck Animal Health, Kenilworth, NJ). Cattle were managed to a slick bunk and fed twice daily. Cattle were weighed on days 25, 51, and 84, and ultrasound measurements were taken again on day 84. In part 1, four steers were removed from the trial for health problems.

In part 2, 48 steers (initial BW = 501 ± 41 kg) were fed a high-energy ration for 64 d (Table 2). Steers used in part 2 included 24 steers that were used in part 1 and 24 that were not used in part 1 but were from the same herd, received the same growing ration, and were implanted at the same time. On day 0, steers were weighed and measured for HH, ribeye area, and BF. Steers were stratified by BW and allocated to four pens, so that all pens had similar initial BW and composed equally from both groups of steers. Pens were randomly assigned to a CON and RES treatment (87 and 30 cm bunk space per animal, respectively). Steers were weighed on days 28, 55, and 63, and ultrasound measurements were taken again on day 63. At the conclusion of the second trial, steers were harvested at a commercial abattoir. Data on carcass camera data and USDA Quality Grade were collected.

Individual ADG was calculated by regressing shrunk BW on day using the BW that were collected throughout each trial. Once per week, a representative sample of the total mixed ration (TMR) was collected from the bunk directly after dispersion, before the cattle began eating. The TMR samples were dried in a forced air oven for 36 h at 60 °C. Percent dry matter was calculated using the retained weight. Daily dry matter intake (DMI) was calculated daily on a pen level. Total BW gain and DMI of each pen were used for gain-to-feed ratio (G:F) calculations.

All data were analyzed in R (version 3.6.1) lmer function from the lme4 package with individual steer as the experimental unit, with the exception of G:F and DMI data. For G:F and DMI, pen was used as the experimental unit, and a t-test was used to compare treatment means. Model selection was performed using backward selection. Observations above or below two SD from the mean were considered outliers and removed from analyses. Results are reported as least-square means, separated using the emmeans package. Significance was set at \( P \leq 0.05 \) and tendencies at \( P > 0.05 \) and \( \leq 0.10 \).

### RESULTS

In part 1, as designed, there were no differences \( (P = 0.61) \) in the initial BW between CON and RES groups. At the end of the feeding period, there were no differences in final BW \( (P = 0.30) \), change in BF \( (P = 0.32) \), ADG \( (P = 0.40) \), DMI \( (P = 0.44) \), and G:F \( (P = 0.29) \) between treatments (Table 3). In part 2, as designed, there were

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**Table 1. Ingredients of the growing ration on an as-fed basis**

| Feedstuff          | % Composition |
|--------------------|---------------|
| Rolled corn        | 41.99         |
| Dried distillers grains | 20.00     |
| Fat                | 1.50          |
| Molasses           | 8.00          |
| Alfalfa Hay        | 15.00         |
| Wheat Hay          | 12.00         |
| Calcium carbonate  | 0.82          |
| Urea               | 0.35          |
| Rumensin           | 0.02          |
| Beef trace salt    | 0.32          |

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**Table 2. Ingredients of the finishing ration on an as-fed basis**

| Feedstuff          | % Composition |
|--------------------|---------------|
| Rolled corn        | 72.20         |
| Dried distillers grains | 6.00       |
| Fat                | 3.00          |
| Molasses           | 3.00          |
| Alfalfa Hay        | 5.00          |
| Wheat Hay          | 6.00          |
| Calcium carbonate  | 1.80          |
| Magnesium oxide    | 0.20          |
| Beef trace salt    | 1.00          |
| Urea               | 1.80          |
| Potassium chloride | 0.50          |
| Rumensin           | 0.02          |

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**Table 3. Performance data of steers fed control and restricted bunk space treatments on a grower ration**

| Parameter          | Control Mean | Control SE | Restricted Mean | Restricted SE | \( P \)-value |
|--------------------|--------------|------------|-----------------|---------------|---------------|
| Final BW, kg       | 454          | 7.23       | 443             | 7.37          | 0.30          |
| Change in BF, cm   | 0.46         | 0.04       | 0.52            | 0.04          | 0.32          |
| DMI, kg/d          | 9.12         | 0.21       | 9.06            | 0.06          | 0.44          |
| ADG, kg/d          | 2.10         | 0.05       | 2.04            | 0.05          | 0.40          |
| G:F                | 0.23         | 1.14 × 10\(^{-2}\) | 0.22            | 1.77 × 10\(^{-3}\) | 0.29          |
Table 4. Performance data of steers fed control and restricted bunk space treatments on a finishing ration

| Parameter               | Control Mean | SE | Restricted Mean | SE | P-value |
|-------------------------|--------------|----|-----------------|----|---------|
| Final BW, kg            | 602.7±6.7    |    | 603.7±5.0       |    | 0.94    |
| Final BF, cm            | 1.56±0.07    |    | 1.63±0.06       |    | 0.39    |
| DMI, kg/d               | 10.08±0.42   |    | 9.83±0.76       |    | 0.36    |
| ADG, kg/d               | 1.72±0.04    |    | 1.58±0.04       |    | 0.01    |
| G:F                     | 0.171±1.68×10⁻³ |    | 0.159±8.05×10⁻³ |    | 0.09    |
| Hot carcass weight, kg  | 807±12.9     |    | 796±12.7        |    | 0.53    |

no differences (P = 0.51) in initial BW between treatments. At the end of the feeding period, there were no differences final BW (P = 0.94), final BF (P = 0.39), and DMI (P = 0.36). However, CON steers had greater (P = 0.01) ADG, which contributed to tendency for improved (P = 0.09) G:F of CON pens (Table 4). The difference in composition and energy content of the TMR fed in each of the trials likely contributed to the conflicting results between parts 1 and 2. The reduction in bunk space and increased competition likely disturbed normal eating behavior, causing daily intake fluctuations, which decreases ADG and G:F (Schwartzkopf-Genswein et al., 2003). At harvest, there was no difference (P = 0.53) in hot carcass weight. One carcass was unavailable for grading, but of the remaining 47 carcasses, 98% graded USDA Choice or greater.

Results from part 1 were consistent with those reported by Zinn (1989), who found with once daily feeding, increasing linear bunk space above 15 cm per animal did not negatively affect steer performance. However, Zinn (1989) only included four steers per pen, which minimized animal competition and capacity for evaluating pen level behavior. Gottardo et al. (2004) examined the effect of 60 versus 80 cm of linear bunk space in young Simmental bulls on behavior and performance. The authors found no differences in DMI, ADG, G:F, eating behavior, and carcass characteristics between groups. Similarly, Gunter et al. (1996) concluded restricting bunk space to as little as 12.7 cm per steer had no effect on steer ADG but found within-pen variation in BW and ADG increased with decreasing manger space allowances. Similarly, in part 2 of the current study, coefficient of variation of ADG was greater (P = 0.04) for the RES group, but there were no differences in the variation of final BW.

The difference that was seen in ADG in part 2 of the current study was consistent with those reported by Hanekamp et al. (1990) who allocated 75- and 55-cm bunk space per beef bull. A significantly improved ADG and G:F was observed for the cattle allocated 75-cm bunk space. They hypothesized the observed difference in G:F was due to the increased energy expenditure associated with increased standing time at the bunk due to the increased animal competition. That hypothesis was supported by Fisher et al. (1997) who found lying time decreased with decreased bunk space in beef heifers. These results illustrate the need for future research that uses more animals and evaluates behavior to examine the effects of aggression and lying time and their role in cattle performance under bunk space restriction.

**IMPLICATIONS**

Bunk space allowance is a concern in feedlot management, as it is a major factor affecting stocking density and is a perceived threat to cattle welfare. These experiments demonstrated a reduction in linear bunk space had no effect on the overall performance of steers on a growing ration. On a finishing ration, a reduction in bunk space decreased ADG but had no impact on end carcass weight or quality.

Conflict of interest statement. None declared.

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