

Evaluating equine feeding behavior utilizing GrowSafe Systems: a pilot study¹

Emily C. Dickson, William C. Kayser, Christine M. Latham, Jessica L. Leatherwood,
Courtney L. Daigle, and Sarah H. White^{2,*}

Department of Animal Science, Texas A&M University and Texas A&M AgriLife Research, College Station, TX
77843

ABSTRACT: Equine research and management is limited to single-housing systems if individual animal intake is to be precisely recorded. Even then, dry forage intake is difficult to quantify accurately due to stomping or mixing hay with fecal matter and bedding. In cattle management, GrowSafe Systems (GrowSafe) is a commonly used tool to closely monitor individual animal feeding data using radio frequency identification (RFID) tag technology. Animals are equipped with a unique RFID tag that is read by the feed bunks each time the animal lowers its head into the bunk to consume feed. The objectives of this pilot study were 1) to test the feasibility of use of the GrowSafe system with horses by measuring intake of dry hay and 2) to characterize feeding behaviors of horses in an individually housed (without competition) or group-housed (with competition) setting. To test the hypothesis that horses would consume more hay when individually (NOCOMP) compared to group-housed (COMP), 10 mature Quarter Horses (14 ± 1.5 yr) were placed in one of four pens containing GrowSafe feed bunks in a 4-wk crossover design consisting of two 2-wk treatment periods. Pen 1

contained five horses with access to two GrowSafe bunks (Period 1: $n = 4$ mares, $n = 1$ gelding; Period 2: $n = 5$ geldings); pens 2, 3, and 4 contained one horse each with access to one bunk. Horses were individually fed 0.25% body weight (BW; dry matter [DM] basis) of a commercial concentrate once per day and were allowed Coastal bermudagrass hay in the GrowSafe bunks ad libitum. Although five horses were used in the group-housed (COMP) pen to more closely mimic a true group environment, only data from horses that experienced both housing systems ($n = 3$ mares and $n = 3$ geldings) were used for statistical analyses. Hourly ($P = 0.008$) and daily ($P = 0.003$) durations of hay feeding were higher for NOCOMP compared to COMP horses, and total daily intake (g DM/kg BW) of NOCOMP horses tended to be greater ($P = 0.09$) than COMP horses. Conversely, eating rate (g DM/kg BW/min) was greater ($P = 0.04$) for COMP compared to NOCOMP mares but was unaffected by housing in geldings. The GrowSafe system may provide an opportunity for efficient and effective monitoring of individual horse feed intake and feeding behavior in group-housing situations in horses.

Key words: equine, feeding behavior, GrowSafe

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²Corresponding author: shwhite@tamu.edu

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INTRODUCTION

Objectively quantifying intake and feeding behavior of horses is a challenge in both research and management settings. Horses often drop,

dunk, or trample hay, making it difficult to discern actual intake. In addition, horses are social animals that are commonly housed in groups, which presents an additional challenge to monitoring individual intake. Group dynamics and social ranking affect horses' feeding decisions (Krüger and Flauger, 2008); thus the manager's knowledge of horse dynamics and individual horse consumption patterns within the group is paramount to evaluating individual health and well-being.

The development of electronic radio frequency identification (RFID) systems has enabled researchers and producers to monitor individual animal intake and behavior to more precisely evaluate feed efficiency and health status (Mendes et al., 2011). GrowSafe Systems (GrowSafe) is a feed intake acquisition technology that has previously been validated for monitoring feeding behavior in beef cattle (Mendes et al., 2011). GrowSafe records feeding behavior traits such as total intake, frequency and duration of feeding, and eating rate for each individual animal through the use of RFID tags that provide a continuous transmission of data to a computer located at the facility.

The objectives of the current pilot study were twofold: 1) determine if GrowSafe could be used in horses to accurately monitor individual horse forage intake, and 2) evaluate differences in feeding behavior between individually housed (without competition) or group-housed (with competition) horses. The hypothesis was that group-housed horses that had to compete with other horses for feedstuffs would consume less hay than horses that were individually-housed and did not experience competition for feedstuffs.

MATERIALS AND METHODS

All care, handling, and sampling of horses were approved by the Texas A&M University Institutional Animal Care and Use Committee (2016-0282).

Horses and Experimental Design

Data were collected from six mature Quarter Horses (mean \pm SEM; 14 ± 1.8 yr) ranging from 425 to 505 kg, with an average body weight (BW) of 470 ± 3 kg in this crossover study consisting of two 2-wk treatment periods. Horses were placed in one of four feedlot pens (12×28 m) containing electronic feed bunks (GrowSafe 4000E, GrowSafe System Ltd, Airdrie, Alberta, Canada) at the Texas A&M Beef Cattle Systems Research

Center (College Station, TX). Prior to this trial, mares and geldings had been housed together by sex at the Texas A&M University Freeman Arena (College Station, TX) for at least 6 mo. The only exception is that horse 8 (see later) was a gelding that was previously housed with the mares in this study. In order to best mimic a group housing scenario and due to the number of horses and pens with GrowSafe bunks available for research at the time of this trial, pen 1 contained five horses with 1.0 m total access to two GrowSafe bunks (Period 1: $n = 4$ mares, $n = 1$ gelding [Figure 1A]; Period 2: $n = 5$ geldings [Figure 1B]), as pens only contained a maximum of four GrowSafe bunks. The two additional horses added to pen 1 to mimic the group setting were different for Period 1 and Period 2 (i.e., horses 7 and 8 added to pen 1 in Period 1 and horses 9 and 10 added to pen 1 during Period 2). For Period 1, horse 7 was a mare (15 yr and 515 kg BW) and horse 8 was a gelding (13 yr and 405 kg BW) that did not get along with other geldings. For Period 2, horse 9 and 10 were both geldings (16 and 19 yr and 531 and 551 kg BW, respectively). Pens 2, 3, and 4 contained one horse each with 0.50 m

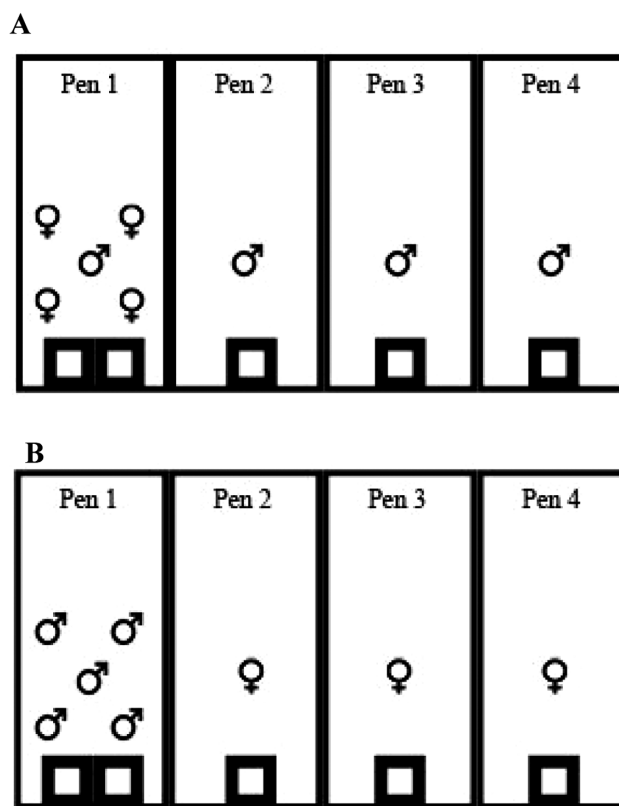


Figure 1. Schematic of GrowSafe Systems housing pens and feed bunks. (A) Pen 1 contained four mares and one gelding with access to two feed bunks and pens 2 through 4 contained one gelding each with access to one feed bunk during treatment period 1. (B) Pen 1 contained five geldings and pens 2 through 4 contained one mare each during treatment period 2.

total access to one GrowSafe bunk (Period 1: $n = 3$ geldings [Figure 1A]; Period 2: $n = 3$ mares; [Figure 1B]). Prior to the beginning of the study, horses were allowed a 1-wk adjustment period to learn how to consume forage out of the GrowSafe bunks. Data collection commenced 7 days after horses were initially placed in GrowSafe pens. Treatments were applied for 2 wk and data were collected for the duration of each period. Data from horses that participated in both treatments ($n = 6$; three mares, three geldings) were used for statistical analysis. Therefore, data from horses 7, 8, 9, and 10 were not included in the dataset.

The goal of this experimental design was to create and compare two environments: 1) one that mimicked a research setting or performance horse setting where horses may be housed and fed individually, and in which horses must not compete for feedstuffs (individually housed; NOCOMP), and 2) one that mimicked normal horse herds where social hierarchies and competition for feedstuffs may affect feeding behavior (group-housed; COMP). Horses did not experience an “alone” environment that lacked socialization with other horses due to the pens being adjacent to one another; instead, the only factor that changed was whether the horse had competition, or not, for access to the forage bunk. Due to the limited number of GrowSafe pens at this facility (four), as well as our desire to have more than three horses exert social pressure in the COMP treatment, an additional two horses were added to the COMP treatment to create a group of five horses competing for the same feed bunks. The extra horses added to the COMP treatment were not used for statistical analysis because they did not experience both housing treatments.

To ensure all daily minimum nutrient requirements were met, horses were individually fed 0.25% BW (dry matter [DM] basis) of a commercial concentrate once per day between 06:00 and 08:00 in buckets attached to the fence, which were not associated with the GrowSafe bunks. GrowSafe bunks were filled with Coastal bermudagrass hay (*Cynodon dactylon*; nutrient composition presented in Table 1) twice daily to most closely offer continuous or ad libitum access to forage. In an attempt to minimize tossing of hay from the bunks into the space outside of each pen and discourage playful feeding habits, hay was chopped using a Farmhand HG 3040 grinder with a 2" screen (AGCO Corporation, Duluth, GA). Any hay that was tossed out of the bunks by horses was collected and weighed to account for discrepancies in GrowSafe data acquisition. Hay tossed from bunks

Table 1. Nutrient composition of Coastal bermudagrass hay offered ad libitum to horses in GrowSafe feed bunks

Nutrient ¹	Bermudagrass hay
DE, Mcal/kg	1.87
Crude fat, %	1.7
CP, %	9.8
Lysine, %	0.34
NDF, %	71.8
ADF, %	38.3
Ca, %	0.38
P, %	0.20
Zn, ppm	47
Cu, ppm	10
Mn, ppm	83

ADF = acid detergent fiber, Ca = calcium; CP = crude protein; Cu = copper; DE = digestible energy, P = phosphorus; Mn = manganese; NDF = neutral detergent fiber; Zn = zinc.

¹Values presented on a 100% DM basis.

and collected ranged from approximately 13% to 24% of the hay offered with tossed hay being greater in NOCOMP animals (24.1% in NOCOMP vs. 13.5% in COMP).

Horses were evaluated weekly for BW (Tru-Test, Auckland, New Zealand) and body condition score. Body condition score was assigned by three independent, trained investigators using the 1 to 9 scale described by Henneke et al. (1983), and averaged for each horse.

The GrowSafe System

The GrowSafe system used in this study consisted of feed bunks equipped with load bars to measure feed disappearance and an antenna located within each feed bunk to record animal presence through the detection of electronic identification (EID) tags. Upon arrival, horses were fitted with rope halters equipped with passive EID tags (Allflex USA Inc., Dallas-Fort Worth, TX). Although traditionally attached to the ear in cattle studies, EID tags were secured on the noseband of each horse's halter to ensure that the antenna located within the feed bunk would be able to read each horse's unique tag number during feeding events. All feeding behavior and intake data were automatically transmitted wirelessly to data acquisition software (GrowSafe DAQ, v. 9.25) located at the facility.

Feeding behavior traits evaluated in this study included frequency and duration of bunk visits (BVs), total intake (g DM/kg BW), and eating rate (g DM/kg BW/min). A single BV event began when the EID tag of an animal was first detected at a feed

bunk and ended when the time between the last two consecutive EID recordings exceeded 100 s, the EID tag was detected at another feed bunk, or the EID tag of another animal was detected at the same feed bunk (Mendes et al., 2011). BV frequency was defined as the number of independent events recorded regardless of whether or not feed was consumed, and duration was defined as the sum of the lengths of all BV events recorded within a 24-h period. Feed intake was assigned to individual animals based on continuous recordings of feed disappearance during each BV event. Eating rate was calculated as the ratio of daily DM intake (g/kg BW) to daily BV duration.

Video Analysis

Horse behavior in the pens was video recorded using a closed-circuit camera system (EnGenius Technologies, Costa Mesa, CA; GeoVision Inc., Taiwan, China) on the final day of each treatment period. Video recordings were decoded from 00:00 to 23:59. Recordings from both NOCOMP and COMP horses were used to validate the GrowSafe System for horses, while only recordings from the COMP animals were used to quantify agonistic behaviors. GrowSafe use in horses was validated by recording the duration of time (seconds) each horse spent at the bunk using continuous observations for one horse per pen for one day of the trial. A total of four horses were to be used for GrowSafe validation. Recording of a feeding event started when the horse lowered its head into the feed bunk and ended when the horse raised its entire head out of the feed bunk. Discrete feeding events were delineated when the horse's head was out of the bunk for a duration of 10 s or longer. The total number of seconds spent eating were collated by hour and then compared to hourly feeding duration data obtained from the GrowSafe system. On the final day of each 2-wk treatment period, the total number of displacements from the GrowSafe bunk that were performed and received by each individual horse were recorded in the COMP pen only. A displacement was defined as an event when a horse physically moved its feet away from the feed bunk and discontinued eating because of an incoming threat or aggressive behavior.

Statistical Analysis

Although there were 10 total horses used in the study, only data from horses that experienced both housing treatments ($n = 6$) were used in statistical

analysis. Means were calculated for each variable as an average of that variable over the duration of each 2-wk period. Intake per hour was calculated by averaging the sum of feed intake consumed over each respective hour (i.e., 00:00 to 00:59, 01:00 to 01:59) for each horse over the 2-wk data collection period. Differences in means of frequency, duration, and intake, per hour and per day, in addition to eating rate were analyzed using PROC MIXED in SAS (v 9.4; SAS Institute Inc., Cary, NC). The statistical model for this dataset contained treatment (COMP or NOCOMP), sex, and the interaction as fixed effects. PROC CORR (SAS v 9.4) was utilized to determine relationships between intake and displacement events, and between GrowSafe and video measures. All variables were normally distributed and all data are expressed as least square means \pm SEM. Significance was declared at $P \leq 0.05$, and trends declared at $P \leq 0.10$.

RESULTS

Validation of GrowSafe for Horses

Because of inconsistencies in video recording (e.g., poor lighting, intermittent blocking of the camera by machinery), valid visualization of time spent at the GrowSafe bunk could only be quantified from two horses, one gelding in a group setting and one mare in an individual pen. Using that data, the duration of time spent at the GrowSafe bunk (minutes per hour) from the GrowSafe system and video observations were positively correlated ($r = 0.7124$, $P < 0.001$; [Supplementary Figure S1](#)).

Feeding Behavior Traits

Group-housed (COMP) horses spent less time at the feed bunk per hour ($P < 0.01$; [Figure 2A](#)) and per day ($P < 0.01$; [Figure 2B](#)) than NOCOMP horses. A treatment \times sex interaction ($P = 0.04$; [Figure 2B](#)) was detected for BV duration where NOCOMP mares spent more time at the feed bunk compared to COMP mares ($P < 0.01$), whereas BV duration per day was unaffected by housing type for geldings ([Figure 2B](#)).

Intake (relative to BW) per hour was unaffected by housing treatment ([Figure 3A](#)) but intake per day tended to be greater for NOCOMP compared to COMP horses ($P = 0.09$; [Figure 3B](#)). There were no intake \times sex interactions detected for intake and no differences in intake between mares and geldings.

Frequency of BV per hour (COMP: 5.88 ± 0.29 ; NOCOMP: 5.84 ± 0.84) and per day (COMP:

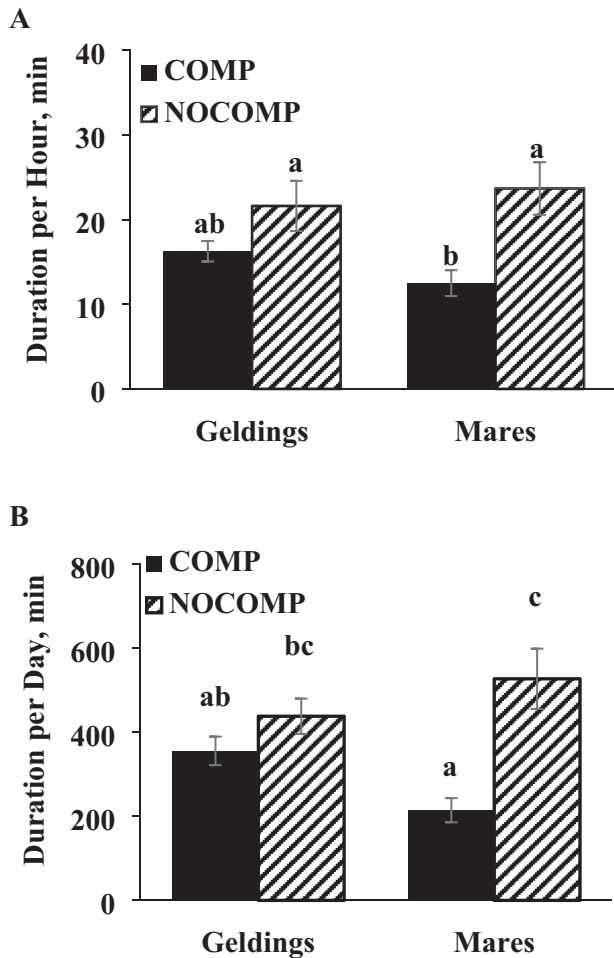


Figure 2. Total time (minutes) spent at feed bunks per hour (A) and per day (B), as measured by GrowSafe Systems, for mature geldings and mares experiencing both group (COMP) and individual (NOCOMP) housing in a 4-wk crossover design consisting of two 2-wk treatment periods. Overall effects of treatment ($P = 0.008$, $P = 0.003$), sex ($P = 0.727$, $P = 0.596$), and treatment \times sex ($P = 0.252$, $P = 0.040$) for panels A and B, respectively. ^{ab}Means with different letters differ ($P \leq 0.05$).

105.63 \pm 9.70; NOCOMP: 121.54 \pm 18.59) were not affected by housing treatment or by sex. However, housing type impacted eating rate; COMP mares consumed feed at a greater rate than NOCOMP mares ($P = 0.04$; Figure 4), but housing type did not affect eating rate in geldings.

Social Behavior

Average total intake (g DM/kg BW) across the study tended to be negatively associated with the number of times a horse was displaced from the feed bunk ($r = -0.7832$; $P = 0.06$) and tended to be positively correlated with the number of times a horse performed a bunk displacement ($r = 0.7350$, $P = 0.09$). The number of times a horse was displaced from the feed bunk tended to be negatively associated with the number of times the horse performed a displacement ($r = -0.7428$; $P = 0.09$).

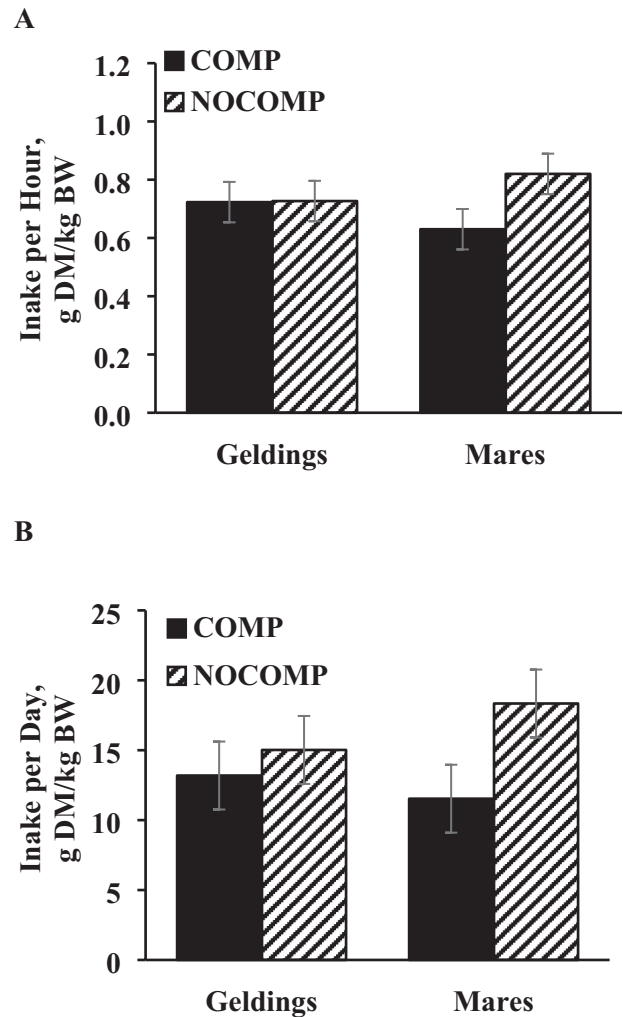


Figure 3. Total forage DM intake (g/kg BW) per hour (A) and per day (B), as measured by GrowSafe Systems, for mature geldings and mares experiencing both group (COMP) and individual (NOCOMP) housing in a 4-wk crossover design consisting of two 2-wk treatment periods. Intake per hour was calculated by averaging the sum of feed intake consumed over each respective hour (i.e., 00:00 to 00:59, 01:00 to 01:59) for each horse over the 2-wk data collection period. Intake per day was calculated as average feed intake over the duration of each 2-wk period. Overall effects of treatment ($P = 0.153$, $P = 0.093$), sex ($P = 0.980$, $P = 0.611$), and treatment \times sex ($P = 0.250$, $P = 0.592$) for panels A and B, respectively.

DISCUSSION

The GrowSafe System traditionally used to quantify intake in cattle may offer a more effective and accurate means of measuring exact consumption and can be applied to either group-housed or individually housed horses. In research settings, it is a common practice to measure forage intake as the difference between hay offered and refused after a specified period for each individual animal. However, quantifying intake using this methodology can result in a large margin of error as hay is typically trampled, mixed with dirt and feces, or subject to weather conditions (e.g., wind, rain). In this study,

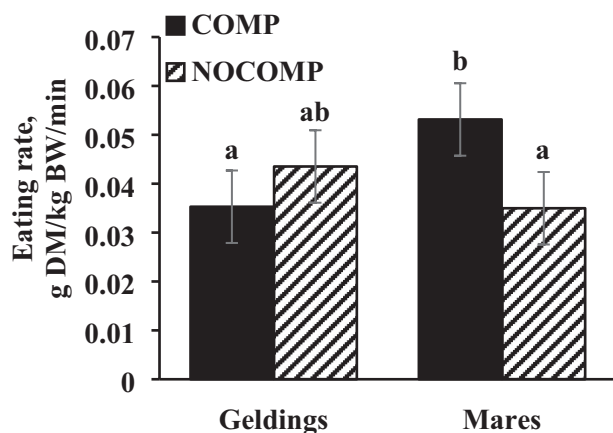


Figure 4. Forage eating rate (g DM/kg BW/min), as measured by GrowSafe Systems, for mature geldings and mares experiencing both group (COMP) and individual (NOCOMP) housing in a 4-wk cross-over design consisting of two 2-wk treatment periods. Eating rate was calculated as the ratio of daily DM intake (g/kg BW) to daily BV duration. Overall effects of treatment ($P = 0.501$), sex ($P = 0.498$), and treatment \times sex ($P = 0.035$). ^{a,b}Means with different letters differ ($P \leq 0.05$).

intake per day tended to be lower in group-housed (COMP) compared to single-housed (NOCOMP) horses (average 1.24 vs. 1.67% BW for COMP compared to NOCOMP horses, respectively). These data are in contrast to previously published voluntary DM forage intake values of about 2% of BW (NRC, 2007; Martinson et al., 2012). However, horses in the current study were also individually fed 0.25% BW (DM basis) of a concentrate grain, which resulted in total DM intake of 1.49% BW for COMP horses and 1.92% BW for NOCOMP animals. Regardless, the lower total intake for horses housed in the COMP setting should be considered when moving horses from being individually fed to being fed in a group or when intake is assumed to be equal for all horses housed in a group.

Limited access to resources increases competition and animals will adjust their behavior accordingly in order to meet their biological needs (Jørgensen et al., 2009). During group housing, horses spent less time feeding per hour and per day, and mares ate faster compared to when they were individually housed. Similar relationships between bunk competition and feeding behavior have also been observed in cattle. Lactating dairy cows provided with more space at the feeder spent 14% more time engaged in feeding activity and performed 57% fewer aggressive behaviors (DeVries et al., 2004). The current study was preliminary in nature but should be repeated allowing similar individual bunk access between individual- and group-housed environments to determine whether the differences noted in DM intake were due to social hierarchies or feed availability and opportunity.

It is important to note that in this trial, horses in both the COMP and NOCOMP setting were housed in neighboring pens, allowing individually housed horses to have visual and physical contact with other horses. The opportunity to engage in visual and physical social interactions while individually housed may have influenced horse behavior and feeding patterns. In contrast, animals housed in solitary confinement (e.g., without visual, tactile, or olfactory contact with conspecifics) may be subjected to increased stress (Yarnell et al., 2015), potentially decreasing appetite. Feeding behavior traits of horses in the current study may have been much different had they been subjected to isolation during the NOCOMP treatment period.

The GrowSafe system has been previously validated for use in cattle through video observation with an $R^2 = 0.98$ for meal duration (DeVries et al., 2003). A cattle validation study over a 6-d period at Texas A&M University using the same GrowSafe system reported a likelihood that an animal present at the feed bunk was detected present by the system of 86.4% (Mendes et al., 2011). This is higher than the correlation in the current project of 0.71, which can most likely be explained by species differences, or lack of sufficient replication. GrowSafe is designed for use in cattle and, as such, is suited for the anatomy of a cow's head. Optimization of attachment of the RFID to the horse would be beneficial and may improve accuracy of the system. Mendes et al. (2011) also observed video for 6 d from 10 cattle as compared to the 1 day of video data collected on 2 horses in the current trial due to logistical constraints associated with video recording. Further replication in both number of days and number of horses are needed to fully validate the GrowSafe system for horses.

In both wild and domestic horse bands or groups, clear dominance hierarchies are established quickly and disruptions to the hierarchy are rare, which results in a highly stable social structure (Henderson, 2007). For this reason, it was assumed that displacement events for COMP horses on the final day of each treatment period were considered representative of the entire period. In addition, the primary interest for this study was the social dynamics of the group once the relationships had been established. Thus, the process of establishing social relationships was not included in the behavioral evaluation of this study because it was not important to our research objective. Not surprisingly, the gelding that had the largest intake per day when housed in a group was also the gelding that was never displaced and displaced others the most. The gelding that had

the lowest intake per day in the group setting was the horse with the greatest number of displacements. In the mare group, the horse with the greatest number of displacements was not the mare with the lowest intake per day, yet her intake increased substantially when housed in a single pen.

Aggressive behaviors observed within two bands of free-ranging Przewalski horses occurred more often when a socially subordinate horse invaded the space of a more dominant horse (Keiper and Receveur, 1992). Low intensity aggressive behaviors, such as displacement, threats to bite, and threats to kick, make up the largest percentage of agonistic behaviors in horses (Keiper and Receveur, 1992). In a study that compared aggressive interactions of group-housed geldings, group-housed mares, and a mixed sex group, there were no differences in aggressive behaviors between groups, supporting the present finding that sex did not affect total daily intake nor intake rates (Jørgensen et al., 2009).

This study, although novel in approach, did have limitations as the GrowSafe was not specifically designed for horses, and horses pose a different set of challenges during research than cattle. Due to availability of the GrowSafe pens, horses were only allowed a 1-wk acclimation period. Although these particular animals seemed to adjust well to using the feed bunks, a longer acclimation period may be useful. In addition, the horse's head is of a different size and shape than cattle; an RFID tag, besides not being easily attached to a horse as it is in a cow's ear, must also be submerged below the feed bunk antenna in order for the GrowSafe to accurately measure intake. Attaching the tag to the nose-band of the halter was successful but would benefit from further evaluation because some horses were observed to manipulate the tags attached to their pen mates. Furthermore, successful data acquisition in the GrowSafe relies on only one animal reaching its head into the bunk at a time. Adjusting the size of the access to the feed bunks through the use of vertical bars to ensure that only one horse can reach its head in at a time will be critical for future research applications. Finally, horses tossed hay out of the feed bunks, which made calculating feed disappearance values in the GrowSafe System challenging. The development of a curtain or screen to keep hay inside the bunks would be an infrastructural modification that could broaden the applicability of the GrowSafe system to include both cattle and equids.

The GrowSafe System has potential for use in equids and appears to offer an alternative means

for accurately measuring individual forage intake. Further evaluations are needed regarding feed bunk infrastructure and RFID placement on the horse to optimize this system for use in horses. Future research and validation are warranted, as this system could provide an effective means of monitoring feeding behavior in horses, as well as decreasing hay wastage.

SUPPLEMENTARY DATA

Supplementary data are available at *Translational Animal Science* online.

Conflict of interest statement. None declared.

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