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Short communication: Limit feeding affects behavior patterns and feeding motivation of dairy heifers

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ABSTRACT

The study objective was to assess the effects of limit feeding dairy heifers on behavior patterns and feeding motivation. Ten Holstein heifers (291.6 ± 39.2 d of age, weighing 324.2 ± 61.2 kg; mean ± SD) were exposed to each of 2 dietary treatments, in a random order, over 2 successive 26-d treatment periods (14-d adaptation period and a 12-d data collection period) using a crossover design: (1) a high-forage total mixed ration (TMR), provided ad libitum (CON) and (2) a low-forage TMR, limit-fed at 2.05% body weight (LF). Heifers were fed daily at 1100 h and motivation to access a low-nutritive feedstuff (straw) was assessed using a push-door apparatus at 2 time points: 3 h after feed delivery (1400 h) and 21 h after feed delivery (0800 h). The amount of weight pushed, weight pushed as percentage of body weight, and latency to access the push door were recorded on 3 different days for each heifer at each time point on each treatment. When fed CON, heifers had greater dry matter intake (12.9 vs. 7.2 kg/d), greater feeding time (209.3 vs. 82.4 min/d), greater ruminating time (452.2 vs. 318.3 min/d), and slower rates of intake (0.06 vs. 0.09 kg of dry matter/min) than when fed LF. Heifers fed LF pushed more weight as a percentage of body weight at 3 h (4.5 vs. 1.9%) and 21 h (9.3 vs. 2.8%) after feed delivery. At both 3 and 21 h after feed delivery, latency to access the door was shorter for the LF heifers compared with the CON heifers (65 vs. 145 s). These results indicate that, in addition to decreasing feeding time, limit feeding increases motivation of heifers to access a low-nutritive feedstuff, possibly due to lack of satiety resulting from lack of physical fill or insufficient time spent foraging.
Key words: dairy heifer, feeding behavior, limit feeding, motivation

Short Communication

Limit feeding, by providing a nutrient-dense ration at a predetermined amount, is a feeding strategy for dairy heifers used within the dairy industry. This feeding strategy is relevant from both an environmental and economic perspective, because it supports targeted ADG while reducing fecal nitrogen excretion and feed costs, due to an increase in feed efficiency (Hoffman et al., 2007; Lascano et al., 2009). However, limit feeding may raise welfare concerns due to its effects on behavior: reduced feeding and lying time, and increased time spent standing without eating (Hoffman et al., 2007; Kitts et al., 2011; Greter et al., 2011). Further, limit-fed dairy cattle vocalize more frequently (Hoffman et al., 2007) and perform more oral stereotypies (Redbo et al., 1996). Given that cattle engage in foraging behavior for 4 to 9 h/d in natural conditions (Kilgour, 2012), the changes in behavior associated with limit feeding may be attributed to lack of satiety resulting from either a lack of gut fill or insufficient foraging time.

Recent research suggests that limit-fed heifers (fed at ~2% of BW) consume quantities of a low-nutritive feedstuff when it is offered alongside their TMR, resulting in greater feeding and rumination time without affecting targeted ADG (Greter et al., 2011; Kitts et al., 2011). Lindström and Redbo (2000) demonstrated that lactating dairy cows spend time manipulating feed even when their rumens are filled artificially, suggesting that cattle may have a behavioral need to perform foraging behavior even when metabolically satiated. Assessing the motivation of limit-fed dairy heifers to obtain access to a foraging substrate would clarify whether the opportunity to forage is important to the heifer and, consequently, whether limit feeding heifers and restricting foraging time could negatively affect their welfare.

Operant tests are an effective means for measuring feeding motivation (D'Eath et al., 2009) and providing insight into the subjective states associated with feeding motivation (Kirkden and Pajor, 2006). Jackson et al. (1999) assessed feeding motivation of sheep by increasing the amount of weight on a push door to obtain

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a feed reward and found that sheep were more willing to push heavier weights following a period of feed deprivation of 6 h. Similarly, latency to open a weighted push door decreases as the duration of food deprivation increases in hens (Olsson and Keeling, 2002). These results indicate that a weighted push door may be an effective means of assessing feeding motivation associated with limit feeding.

The objective of this study was to assess how feeding behavior patterns and feeding motivation of dairy heifers are influenced by limit feeding, in comparison with conventional ad libitum feeding of a high-forage diet. The hypothesis was that heifers would work harder for access to a low-nutritive feedstuff when limit-fed a low-forage diet, compared with when provided a high-forage diet ad libitum. Further, it was hypothesized that motivation to obtain access to the low-nutritive feedstuff would increase with time since feed delivery, especially when limit-fed.

Ten Holstein dairy heifers were used in this study. Heifers were 291.6 ± 39.2 (mean ± SD) d of age and weighed 324.2 ± 61.2 kg at the beginning of the study and weighed 378.7 ± 63.0 kg at the end of the study. Heifers were housed in a tie-stall barn at the University of Guelph, Kemptville Campus (Kemptville, Ontario, Canada) and were managed according to the guidelines set by the Canadian Council on Animal Care (2009). Use of heifers was approved by the University of Guelph's Animal Care Committee (AUP#09R022). Each heifer was individually housed in a tie stall (203 × 124.5 × 91 cm; length × width × height), bedded with wood shavings, where she had ad libitum access to water (via her own water bowl) and access to feed via her own feed bunk (individual feed bunks were separated with dividers). Heifers were given a 2-h exercise period (0900 to 1100 h) each day in an outdoor dry lot pen. Heifers were given ad libitum access to trace mineral salt blocks while in the exercise yard (Windsor TM Stock Salt, The Canadian Salt Company Limited, Pointe-Claire, Quebec, Canada).

The number of animals required per treatment was determined through power analysis (Morris, 1999) for primary response variables, including feeding behavior measures. Estimates of variation for these variables were based on previously reported values (Greter et al., 2008; Kitts et al., 2011). Heifers were fed (Table 1) either (1) a low-forage TMR fed at a restricted level of 2.05% BW (**LF**) or (2) a high-forage control TMR ad libitum (**CON**), that were formulated to meet the nutrient requirements for a nonbred Holstein heifer growing at 0.9 kg/d (NRC, 2001).

The limit feeding protocol used in this study was representative of on-farm recommendations (Zanton and Heinrichs, 2008) and in line with feeding levels used in other studies providing low-forage diets (e.g., 2.02% BW, Kitts et al., 2011; and 1.93% BW, Lascano et al., 2009). In contrast, the predicted ad libitum intake of the high-forage ration was approximately 2.29% of BW (NRC, 2001). Heifers had been fed a low-forage TMR for 4 wk before the start of this experiment. Heifers were exposed to each of the 2 dietary treatments, in a random order, over 2 successive 26-d treatment periods using a crossover design. These periods included a 14-d adaptation period, and a 12-d data collection period. When heifers were switched from the CON ration to the LF ration, the amount of haylage was decreased by 5% each day over the first 7 d of the adaptation period, to facilitate gradual adaptation of rumen microbes to the low-forage ration.

Individual intakes were recorded daily throughout the study by weighing the amount of feed offered and amount of feed refused (if any) using a calibrated floor scale precise to the nearest 0.1 kg (model 31–0851-T17430, Toledo Scale Company of Canada Ltd., Windsor, ON, Canada). These data were used to calculate daily DMI (kg/d). Heifers were weighed on the same 2 consecutive days each week, and these weekly weights

Table 1. Ingredient, chemical composition, and calculated nutrients (mean ± SD) of the rations

Composition	Limit-fed TMR	Control TMR
Ingredient (% of DM)		
Corn silage[1]	20.0	20.0
Grass/alfalfa haylage[2]	20.0	50.4
High moisture corn	43.0	22.1
Protein supplement[3]	17.0	7.5
Chemical composition[4]		
DM (%)	59.3 ± 2.7	49.1 ± 2.8
OM (% of DM)	92.6 ± 0.3	92.1 ± 0.8
CP (% of DM)	16.9 ± 0.6	16.8 ± 0.3
ADF (% of DM)	12.6 ± 1.3	18.1 ± 0.8
NDF (% of DM)	22.4 ± 1.9	29.9 ± 2.3
NFC (% of DM)	49.6 ± 1.7	42.2 ± 3.0
Calculated nutrient		
TDN[5] (% of DM)	78.0 ± 0.5	73.3 ± 0.5
ME (Mcal/kg)	2.82 ± 0.02	2.65 ± 0.02
NE_G (Mcal/kg)	1.24 ± 0.01	1.11 ± 0.01
NE_M (Mcal/kg)	1.88 ± 0.01	1.73 ± 0.02

[1]Corn silage composition: 41.9 ± 2.9% DM, 8.7 ± 0.0% CP, 31.6 ± 1.3% NDF, 53.5 ± 1.3% NFC.

[2]Haylage composition: 36.4 ± 4.9% DM, 18.6 ± 2.4% CP, 49.0 ± 5.0% NDF, 19.5 ± 3.9% NFC.

[3]Supplied by Dundas Feed and Seed (Winchester, ON, Canada), containing (on as-is basis): 25.6% corn gluten meal, 24.4% Tri-Pro Gold (Tri-County Protein Corp., Winchester, ON, Canada), 24.4% soybean meal, 10.0% canola meal, 4.8% ground limestone, 4.5% trace mineral/vitamin premix, 4.4% sodium bicarbonate, and 1.9% cobaltized-iodized salt.

[4]Values were obtained from chemical analysis of TMR samples. NFC = 100 – (%CP + %NDF + %fat + %ash).

[5]Total digestible nutrients (calculated from ingredients).