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Case Study: The effects of photoperiod on feeding behavior of lactating dairy cows in tie-stalls

K. Macmillan, O. S. Espinoza, and M. Oba[1]
Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada T6G 2P5

ABSTRACT

To determine the effects of photoperiod management on behavior of dairy cows, 30 lactating cows were subjected to a long-day (16 h/d light) or short-day photoperiod (8 h/d light). Feeding behavior was observed and feed refusals were collected before and after a 21-d adaptation to photoperiod treatment. Feeding behavior data were summarized for 4 daily time periods based on light schedule, and no effect of light treatment was observed for DMI, lying time, or overall feeding behavior. However, in time period 4 (1600 to 1900 h), the long-day treatment decreased lying time (28.3 vs. 37.7 min/h) and tended to increase eating time (17.5 vs. 9.03 min/h). There was also a tendency for the long-day treatment to reduce daily feed sorting. Providing supplementary light may reduce sorting and increase distribution of eating activities throughout the day, and the change in feeding pattern may be affected by the time of day the supplementary light is provided.

Key words: photoperiod, feeding behavior, feed sorting, supplemental light

INTRODUCTION

Providing lactating dairy cows with a long-day photoperiod, 16 h of light and 8 h of dark, has been shown to increase milk yield in comparison with a short-day photoperiod, 8 h of light and 16 h of dark (Dahl et al., 2000). Both behavioral and hormonal mechanisms have been explored as causal factors for the increase in milk yield. For behavioral responses, researchers hypothesized that providing more light would increase time spent eating because cattle prefer to graze during the day (Phillips and Denne, 1988). However, eating time did not increase for cows on a long-day photoperiod treatment (Collier et al., 2006). In addition, Phillips and Schofield (1989) reported an increase in lying time and a decrease in activity, measured with pedometers as number of steps daily, in cows on a long-day photoperiod treatment, but an additional peak in eating activity was also observed during the evening time, 1600 to 2330 h, when supplemental light was provided. This indicates that feeding pattern may be altered in cows exposed to supplemental light. However, few studies have looked at feeding pattern in relation to photoperiod management, and none to our knowledge have looked at a possible effect of photoperiod management on feed sorting. Feed sorting is the preferential selection for or against certain particle sizes, usually the selection for smaller particles and against larger particles (Miller-Cushon and DeVries, 2017). Sova et al. (2013) observed that efficiency of milk production, milk yield over average DMI, decreased as group-level feed sorting for smaller particles increased in a cross section of commercial dairy herds. Therefore, feed sorting may play a role in the increased milk production observed during long-day photoperiods. Based on previous literature, we are unable to speculate on a direct effect of photoperiod on sorting behavior; however, an increase in time spent eating may result in a reduction in daily feed sorting, similar to when cows are fed more frequently during the day (DeVries et al., 2005).

The objective of this case study was to determine how a long-day photoperiod would affect the feeding behavior of lactating dairy cows. We hypothesized that providing 16 h of light would increase time spent eating during the periods for which supplemental light was provided, increasing distribution of eating activity throughout the day and reducing feed sorting.

MATERIALS AND METHODS

All experimental procedures used in this study were approved by the University of Alberta Research Center Animal Care Committee and conducted according to the guidelines of the Canadian Council of Animal Care (CCAC, 2009). All cows were housed individually in a tie-stall barn bedded with wood shavings and with free access to water. Cows were milked twice daily in their stalls at 0400 and 1500 h. All cows were fed the same mid-lactation diet into individual feed bunks, formulated to meet requirements to produce 36.5 kg/d of milk according to Dairy NRC (2001), as reported by Espinoza and Oba (2017; Table 1). The particle size distribution for the

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[1]Corresponding author: moba@ualberta.ca

TMR was 9.65, 26.0, 47.5, and 18.7% on the top screen, middle screen, bottom screen, and in the pan, respectively. Cows were fed once daily at 0830 h, allowing for 5 to 10% daily orts.

Animals and Treatments

Thirty lactating Holstein cows (DIM = 115 ± 33, BW = 617 ± 70 kg) were used in this study. Espinoza and Oba (2017) conducted an experiment using 60 cows, 2014 (n = 30) and 2015 (n = 30), and behavior measurements in the current study were taken before and after the adaptation to light treatments in 2015. Treatments were a long-day photoperiod (**LP**), 16 h of continuous light (0300 to 1900 h) and 8 h of continuous dark, and a short-day photoperiod (**SP**), 8 h of continuous light (0800 to 1600 h) and 16 h of continuous dark. Before the light treatment was applied, all cows were on a SP. Fifteen cows were assigned to each treatment group and located on separate ends of the barn with a zone of approximately 32 m in between, where cows not on the study were housed, to minimize light interference from the LP treatment. Although barn location and treatment were confounded, to isolate the treatment effects, we evaluated how animal responses changed after they were exposed to the light treatment. The case study was conducted during winter months (December 9 to January 6) to minimize any interference from external light. All lights were controlled by a timer to ensure that hours of light and dark provided were consistent each day. Light photometers (Extech SDL 400, Extech Instruments, Nashua, NH) were used to measure the light intensity during the experiment, and, on average, the intensity was 225 and 160 lx during the light hours for the LP and SP groups, respectively, which is above the threshold of 150 lx to produce the response to photoperiod in cattle (Dahl, 2006). Although we do not suspect that the different light intensity between LP and SP affects animal responses to light treatment, this should be noted for interpretation of data. During dark hours the light intensity was around 10 lx for both treatment groups. The barn was temperature regulated, with an average temperature of 11.6°C.

Table 1. Ingredient and chemical composition of diet[1]

Item	Value
Ingredient (% DM)	
Alfalfa silage	30.0
Barley silage	15.0
Barley grain, steam rolled	35.0
Canola meal	4.1
Corn gluten meal	5.0
Beet pulp	9.8
Mineral and vitamin mix	0.9
Nutrient composition (% DM)	
DM	60.8
CP	15.9
NDF	25.6
Starch	31.1
Ether extract	4.0
NFC	49.8
Forage NDF	14.3

[1]Adapted from Espinoza and Oba (2017).

Data Collection and Analysis

Data were collected for 3 consecutive days before and after a 21-d adaptation to the light treatment to evaluate treatment effects on sorting and feeding behavior. Total mixed ration and ort samples were collected for 3 consecutive days, and ort samples were composited to form one sample per cow. Particle size distribution of the TMR and orts samples was determined using a Penn State Particle Separator with 3 sieves (aperture size of 19.0, 8.0, and 1.18 mm). A sorting index was calculated as the ratio of actual intake to predicted intake for particles retained on each sieve, where predicted intake was determined using the TMR samples collected (Leonardi and Armentano, 2003). A sorting index of 100, less than 100, and greater than 100 indicates no sorting, selective refusals, and selective consumption, respectively. Feeding behavior was measured by live observation over a single 24-h period. Cows were observed for eating, ruminating (while either lying or standing), or no feeding activity (while either lying or standing) every 5 min, and the behavior observed was assumed to last for the full 5-min period as described by Beauchemin et al. (2003). Multiple observers were used, and each observer attended the same training to define behaviors and reduce interobserver variation. Observers were able to pass by the front of the cows with enough space in the alleyway to prevent disturbing the cows. The low level of light was still enough to see by, so no flashlights were needed. The 24-h period was analyzed in 4 separate time periods (based on light schedule) to determine whether behavior changed depending on whether or not supplemental light was provided. This consisted of period 1 (1900 to 0300 h; both treatments had no light), period 2 (0300 to 0800 h; only the LP treatment had light), period 3 (0800 to 1600 h; both treatments had light), and period 4 (1600 to 1900 h; only the LP treatment had light). Long-day photoperiod increased milk yield after the 21-d adaptation, as reported by Espinoza and Oba (2017), whose experiment began after light adaptation and the current study period.

Data Presentation

Data are presented as a comparison of means between the LP and SP treatment groups, both in the pre- and postadaptation periods. In this way numerical differences can be viewed between the pre- and postadaptation LP cows and between postadaptation SP and LP cows. Because treatments were not applied to individual animals, statistical analysis was not conducted.