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Short communication: The diurnal intake and behavior of dairy cows when access to a feed of consistent nutritive value is restricted

A. J. John,*[1] S. C. Garcia,* K. L. Kerrisk,* M. J. Freeman,† M. R. Islam,* and C. E. F. Clark*
*Dairy Science Group, School of Life and Environmental Sciences, Faculty of Science, The University of Sydney, Camden 2570, New South Wales, Australia
†Tasmanian Institute of Agriculture Dairy Centre, University of Tasmania, Burnie 7320, Tasmania, Australia

ABSTRACT

The diurnal variation in pasture nutritive value adds a confounding factor to studies elucidating the effect of time of day on behavior. Our work separates the effect of time of day on both feeding and lying patterns for cows outdoors to enable the alignment of feeding behavior with feed management. We determined the diurnal intake patterns and behavior of dairy cows when the nutritive value of feed remained constant throughout 24 h in an outdoor environment, and when feed access was restricted. Nine nonlactating Holstein-Friesian cows (live weight 626 ± 53 kg, age 96 ± 33 mo; mean ± SD) were split into 3 groups of 3 and offered lucerne hay cubes (cube volume 32 mm^3) ad libitum according to 3 treatments: full access (FA, feed access 24 h), day access (DA, feed access between 0600 and 1800 h), and night access (NA, feed access between 1800 and 0600 h). Treatments were applied to individual cows in a crossover design with 7-d periods. During the last 4 d of each period, data were collected on feed intake, as well as feeding and lying behaviors. Total daily intake was greater for cows on the FA treatment (3.5% of BW) compared with the DA and NA treatments at 3.1 and 2.9% of BW, respectively. The cows with FA consumed 69% of their total intake during the day (0600–1800 h), with the greatest intake (39%) occurring during 1200 to 1800 h and only 12% of intake occurring during 2400 to 0600 h. Cows with DA consumed 56% of feed during 0600 to 1200 h and 44% during 1200 to 1800 h. In contrast, NA cows consumed more feed (74%) during the first 6 h period (1800–2400 h), thus maximizing lying time between 2400 and 0600 h. The time spent lying throughout daylight periods varied between treatments; however, total daily lying time was similar across the 3 treatments. This experiment shows the feeding and lying behaviors of cows when feed quality remains constant throughout 24 h, which will assist the formulation of variable feed allocation strategies for future testing in both robotic and conventional milking systems. Varying the quantity of feed offered throughout 24 h may benefit robot utilization at night in automatic milking systems through increased feeding activity, and as we observed, is likely to have little effect on lying time or DMI, with cows readily adapting to changes in feed management. Conversely, aligning feed on offer with preferred feeding time in conventional milking systems may increase the intake of high quality pasture.
Key words: feeding behavior, lying behavior, dairy cow, ad libitum feeding

Short Communication

Understanding the interaction between feeding management and cow feeding behavior is important with the increasing prevalence of precision dairy farming technologies, such as automatic milking systems (**AMS**). In pasture-based AMS, where robots perform milking, dairy cows have greater freedom to choose when to access fresh pasture. As feed availability is the primary motivation for cows to return for milking (Prescott et al., 1998), offering fresh feed is the main incentive used to encourage voluntary cow traffic in pasture-based AMS (Kerrisk, 2009). However, determining the ideal feed allocation throughout 24 h to optimize AMS utilization is still unknown, often resulting in low robot utilization between 2400 and 0600 h (John et al., 2016). Managing feeding practices to complement the natural feeding behavior of dairy cows could improve production in pasture-based dairy systems. To solve this issue, we need a clear understanding of cow feeding behavior and how to manipulate it.

Cows follow a distinct diurnal grazing pattern; for example, Gibb et al. (1998) observed 5 grazing bouts per day, most occurring during daylight, and only 1 grazing bout occurring between 2200 and 0600 h. The dusk grazing event is the longest, occupying approximately 40% of daily total feeding time (Taweel

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[1]Corresponding author: ajoh7559@uni.sydney.edu.au

et al., 2004), whereas grazing at night accounts for as little as 16% of total daily feeding time (Stobbs, 1970). The dusk grazing event is also the most intense, with bite rates greater at dusk, in comparison to dawn feeding events for dairy cows (Taweel et al., 2004) and beef heifers (Gregorini et al., 2006). Gregorini (2012) outlined several factors explaining why cows follow a diurnal pattern of grazing: diurnal fluctuations in feed quality, photoperiod, predatory instincts, and satiety hormones.

Diurnal variation in feed nutritive value can influence the feeding behavior of grazing dairy cows, with dusk the most efficient time for ruminants to graze (Gregorini, 2012). Daily variation in the nutritive value of ryegrass (*Lolium perenne*) swards has been measured by Delagarde et al. (2000), with total soluble carbohydrates in the upper strata increasing by 30%, whereas NDF and CP decreased by 6 and 8%, respectively, between 0800 and 1900 h. Greater DMI at dusk has also been attributed to a corresponding increase in pasture DM content (Gibb et al., 1998). This diurnal variation in pasture nutritive value adds a confounding factor to studies elucidating the effect of time of day on behavior. Feeding behavior studies with cows retained indoors circumvent this issue; however, the feeding patterns of these cows differ markedly from cows situated outdoors (O'Connell et al., 1989). Further work is required to determine the natural feeding behavior of cows situated outdoors, in the absence of the variation in feed quality present in pasture-based studies.

Studies restricting time at pasture have found cows will alter their feeding behavior to suite the feed restriction applied, feeding more intensely during the initial phase of pasture access when restricted to 8 h at pasture, compared with 24-h access (Clark et al., 2010). In addition, restricting access to pasture from 22 to 9 h reduced daily pasture intake by 12% and grazing time from 9.2 to 7.3 h/d (Kennedy et al., 2009). If increased robot utilization at night is desired due to the tendency of cows to lie down and sleep at that time (John et al., 2016), the restriction of pasture to favor activity at these times may be a solution; however, the effect of day or night time restriction of feed on intake and behavior of cows outdoors is unknown.

In this study we determined the diurnal feeding behavior and intake patterns of dairy cows when offered a feed of consistent nutritive value. A secondary objective was to determine the effect of restricting feed access, to either day or night time, on animal behavior and intake. We hypothesized that cows restricted to feeding during the night would have reduced lying time to maintain DMI as compared with those cows restricted to feeding during the day. We also hypothesized that cows with restricted feed access would have lower intakes than unrestricted cows.

Use of animals was approved by the University of Sydney's Animal Ethics Committee (2014/753). The experiment was conducted between May 25 and June 14, 2015, at the University of Sydney research farm Mayfarm, Camden, New South Wales, Australia. The daily minimum and maximum temperatures were 4.1 ± 3.0°C and 18.1 ± 2.2°C, respectively (mean ± SD). The daily relative humidity at 1500 h was 51 ± 12% (mean ± SD). Two millimeters of rain was recorded on d 12. The light and dark cycle was approximately 10 and 14 h with sunrise and sunset occurring at 0700 and 1700 h, respectively.

Nine nonlactating, multiparous, nonpregnant, Holstein-Friesian cows (626 ± 53 kg of live weight, 96 ± 33 mo old; mean ± SD) were introduced to lucerne cube feed (MultiCube Stockfeeds, Yarrawonga, Australia; cube volume 32 mm^3, DM = 88.7%, NDF = 46.4%, ADF = 39.5%, CP = 18%, DMD = 58.6, ME = 8.4 MJ/kg on DM basis; average of daily subsamples collected during the experimental period). Lucerne cube was gradually increased to ad libitum levels over a 10-d acclimatization period before the start of the experiment. Ad libitum lucerne hay was also provided during the acclimatization period with a sub-sample taken before the trial to determine nutritive value (DM = 70.1%, NDF = 51.3%, ADF = 37.3%, CP = 20%, DMD = 61.2%, ME = 8.8 MJ/kg on DM basis). Day 7 of the acclimatization period, cows were weighed and randomly assigned to 3 treatments (n = 3 cows per treatment) and moved to individual pens (1 cow per pen) and lucerne hay was removed from the diet. Pens measured 30 × 10 m in dimension, arranged adjacent to each other in a 2 × 5 grid (60 × 50 m total dimension, 10 pens total) and separated by a 2-wire fence. Also on d 7 of the acclimatization period, a pilot study using the same 9 cows determined the approximate quantity of lucerne cubes the experimental cows could consume in a 6-h feeding period following a 16-h period (overnight) of fasting. Following the pilot study, the cows remained in their allocated pens and offered ad libitum lucerne cubes with lucerne hay removed from the feed allocation. Water was available ad libitum in each pen. Pen pasture surfaces were mown to 3 cm height on the first day of each 7-d period to ensure feed offered was the only source of DM. A lick block (Olsson's Trace Element with Copper and Cobalt; Olsson's, Yennora, Australia) was freely available in each pen.

The experiment duration was 21 d, divided into 3 periods of 7 d in a 3 × 3 Latin square design. Cows were weighed using a Thunderbird SS1000 system (Thunderbird, Mudgee, NSW, Australia) on the first