J. Dairy Sci. 101:1–7
https://doi.org/10.3168/jds.2017-13743

Short communication: Associations of feeding behavior and milk production in dairy cows

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ABSTRACT

Identification of the associations of cow feeding behavior with productivity is important for supporting recommendations of strategies that optimize milk yield and composition. The objective of this study was to identify associations between measures of feeding behavior and milk production using data collated from studies of the feeding behavior of lactating dairy cows. A database containing behavior and production data for 132 dairy cow-week observations (mean of 7 d of consecutive data per cow) was assembled from 5 studies. Cows averaged (mean ± standard deviation) 1.8 ± 0.9 lactations, 108.4 ± 42.7 d in milk, and 654.6 ± 71.4 kg of body weight during each observation week. Production data included dry matter intake (27.0 ± 3.1 kg/d), milk yield (43.0 ± 7.0 kg/d), milk fat content (3.60 ± 0.49%), and milk protein content (3.05 ± 0.25%). Behavioral data included feeding time (230.4 ± 35.5 min/d), feeding rate (0.13 ± 0.03 kg/min), meal frequency (9.0 ± 2.0 meals/d), meal size (3.2 ± 0.9 kg/meal), daily mealtime (279.6 ± 51.7 min/d), and rumination time (516.0 ± 90.7 min/d). Data were analyzed in multivariable mixed-effect regression models to identify which behavioral variables, when accounting for other cow-level factors (days in milk, parity, and body weight) and dietary characteristics (forage level, nutrient content, and particle distribution), were associated with measures of production. Dry matter intake was associated with feeding time (+0.02 kg/min) and tended to be associated with rumination time (+0.003 kg/min) and meal frequency (+0.2 kg/meal). Similarly, milk yield was associated with feeding time (+0.03 kg/min) and rumination time (+0.02 kg/min), and tended to be associated with meal frequency (+0.3 kg/meal). Milk fat yield was associated with meal frequency (+0.02 kg/meal). Overall, our results suggest that milk yield and component production may be improved in situations where cows are able to increase their time spent feeding, in more frequent meals, and time spent ruminating.
Key words: feeding behavior, production, rumination

Short Communication

Milk production, composition, and efficiency can be affected by breed, stage in lactation, age, nutrition, and management strategies (NRC, 2001). Behavior patterns of dairy cattle, such as resting, ruminating, and eating, may also have an effect on these productive outcomes (Grant and Albright, 1995). It is well established that milk production is largely driven by the amount of nutrients consumed, that is, total DMI (Veerkamp, 1998). Dry matter intake is largely a function of feeding behavior, affected by changes in meal size, duration, and frequency, as well as feeding time and rate (Nielsen, 1999). Changes in DMI are linked to concomitant changes in different aspects of feeding behavior (Nielsen, 1999). Feeding behavior may not only affect DMI and subsequent production (Dado and Allen, 1994), but also affect the rumen environment. For example, consuming large meals quickly may cause large postprandial drops in rumen pH (Allen, 1997); alternatively, consuming more frequent, smaller meals, in a more consistent pattern across the day may stabilize rumen conditions, reducing risk of SARA and improving milk fat production (Krause and Oetzel, 2006; DeVries and Chevaux, 2014). Further, greater time spent eating and ruminating per unit of feed consumed has been associated with improved fiber digestibility in Jersey cows (Aikman et al., 2008).

The body of literature on the effect of housing, nutrition, and management strategies on dairy cow feeding behavior is continually increasing. Identification of the associations of cow feeding behavior with productivity is important for supporting recommendations of strategies that optimize milk composition and yield. Thus, the objective of this study was to identify associations between measures of feeding behavior and milk production using data collated from studies of the feeding behavior of lactating dairy cows.

Received August 25, 2017.
Accepted December 10, 2017.
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A database containing behavior and production data for 132 dairy cow-week observations was assembled from 5 studies conducted at the University of Guelph, Kemptville Campus Dairy Education and Innovation Center (Kemptville, Ontario, Canada). In all studies, cows were kept in the same experimental pen, where cows had access to free stalls with waterbeds (DCC Waterbeds, Advanced Comfort Technology Inc., Reedsburg, WI), which were bedded with wood shavings, TMR was provided (1 to 3×/d) in roughage intake feed bins (Insentec B.V., Marknesse, the Netherlands), and milked on a set schedule (2 or 3×/d) using an automatic milking system (Lely A3 Next, Lely Industries N.V., Maassluis, the Netherlands) with no additional feed provided at the milking unit. Table 1 describes details of the studies used to create the database, including number of animals, parity distribution, and details of dietary composition. All diets fed were similar in ingredient composition, but varied in nutrient content and physical particle structure. Table 2 describes the average parity, DIM, and BW of cows during periods when data were collected in each study. Use of cows in each study was approved by the University of Guelph's Animal Care Committee; cows were managed according to the guidelines set forth by the Canadian Council on Animal Care (CCAC, 2009).

Behavior data, as summarized in Table 2, were collected similarly in all source studies. Dry matter intake and feeding behavior were recorded automatically by the roughage intake feed bins (Insentec B.V.), as validated by Chapinal et al. (2007). Data from the feed bins were used to calculate DMI (kg/d), feeding time (min/d), and feeding rate (kg/min). Meal criteria were individually calculated for each cow, as described by DeVries et al. (2003), and applied to the feeding data to calculate meal frequency (no./d), meal length (min/meal), daily mealtime (min/d; daily mealtime includes feeding time as well as nonfeeding time within meals while cows had their head outside the feed bin), and meal size (kg of DM/meal). Rumination behavior data were collected by automatic rumination detection devices (Lely Qwes-HR collars, Lely Industries N.V.), as validated by Schirmann et al. (2009).

Production data, as summarized in Table 2, were collected similarly in all source studies. Milk yield data were automatically recorded daily, at each milking, by an automated milking system (Lely A3 Next, Lely Industries N.V.). Milk samples were collected from each milking for either 3 d (Hart et al., 2013, 2014; DeVries and Chevaux, 2014) or 2 d (King et al., 2016a,b), during each experimental period using the Lely Shuttle Sampling Device (Lely Industries N.V.) and sent to a DHI testing laboratory (CanWest DHI, Guelph, Ontario, Canada) for analysis of milk fat and protein percentage using a near-infrared analyzer (FOSS System 4000 Infrared Transmission Analyzer, Foss, Hillerød, Denmark). The yield of 4% FCM (kg/d) was calculated (NRC, 2001) as 0.4 × milk yield (kg/d) + 15.0 × fat yield (kg/d). Energy-corrected milk was calculated using the following equation: ECM = (0.327 × kg of milk) + (12.95 × kg of fat) + (7.2 × kg of protein) (Tyrrell and Reid, 1965).

Cows were individually exposed to either 2 or 3 treatments within the studies their data were sourced from. For the current analyses, the experimental unit was the cow-week observation, each of which was the average of daily data collected for a cow during 7-d data collection periods, per treatment, in each respective study. Data were averaged on a per-week basis to improve the accuracy of the estimate of the true mean for each predictor and outcome variable. Prior to analyses, all data were screened for normality using the UNIVARIATE procedure of SAS version 9.4 (SAS Institute Inc., Cary, NC).

Table 1. Cow and dietary characteristics[1] for data used from 5 previous studies[2]

				TMR nutrient composition				Particle size distribution[5] (%)			
Study[1]	Parity[3]	DIM at start[4] (mean ± SD)	Forage content (% DM)	DM (%)	CP (%)	NDF (%)	NE_L (Mcal/kg)	Long	Medium	Short	Fine
1	6 PP and 6 MP	104 ± 32	52.4	50.4	17.1	31.7	1.60	12.6	46.5	31.9	9.0
2	7 PP and 5 MP	171 ± 31	64.0	48.9	16.7	33.0	1.70	16.7	44.6	31.5	7.1
3	2 PP and 10 MP	95 ± 17	57.7	54.7	17.9	34.4	1.66	7.2	45.7	31.9	15.3
4	4 PP and 8 MP	77 ± 23	60.3	55.8	16.7	30.8	1.65	1.8	45.0	37.0	16.2
5	4 PP and 8 MP	98 ± 23	60.3	55.4	17.2	33.4	1.64	3.6	43.9	37.0	15.5

[1]All diets were TMR composed of corn silage, legume/grass haylage, high-moisture corn, grain supplement, and protein concentrate.

[2]Studies are as follows: (1) Hart et al., 2014; (2) Hart et al., 2013; (3) DeVries and Chevaux, 2014; (4) King et al., 2016a; and (5) King et al., 2016b.

[3]PP = primiparous; MP = multiparous.

[4]Mean DIM at the start of each data collection period for each cow (cow-week) on each treatment within each respective study.

[5]Particle size of TMR as determined by Penn State Particle Separator, which has a 19-mm screen (long), 8-mm screen (medium), 1.18-mm screen (short), and a pan (fine).