Animal welfare, etológia és tartástechnológia

Animal welfare, ethology and housing systems

Volume 4 Issue 2

Különszám

Gödöllő
2008

RELATIONSHIPS BETWEEN FEEDING BEHAVIOUR CHARACTERISTICS AND FEED INTAKE IN DAIRY COWS DURING EARLY LACTATION

Kaufmann, Otto, Osman, Azizi

Humboldt – Universität zu Berlin, Faculty of Agriculture and Horticulture, Institute of Animal Science
10115 Berlin, Invalidenstrasse 42.
otto.kaufmann@agrar.hu-berlin.de

Abstract

The transition period and early lactation is critical important to the health and productivity of dairy cows. In this period more than 80% of the total health disorders occur. In the most cases this disorders are metabolic related and caused by a negative energy balance. To get information about arising problems in an early stage, sensor based animal monitoring systems are used. These systems analyse among others characteristics of animal behaviour. Therefore it is necessary to analyse the relations between behaviour patterns and physiological parameters. In this context our research was directed on the relationships between feeding behaviour and feed intake. Data (feed intake and time spent on feeder) from 70 lactating dairy cows were collected from the 2nd to the 15th week of lactation. The monitoring was conducted by using an electronic feeding system, which was equipped with an electronic identification of each individual cow. The visits at feeder were clustered in meals based on a "meal criterion". The effects of parity, stage of lactation and milk yield level on feeding behaviour and feed intake were investigated. A second study determined the effects of metabolic - related production diseases on feeding behaviour and feed intake. The high correlation between feeding behaviour characteristics such as meal duration suggests that measuring the time spend eating could be used to estimate the feed intake. Moreover the monitoring of feeding behaviour might be helpful to detect the cows` risk for metabolic – related production diseases at an early stage.
Keywords: lactation, feeding behaviour, feed intake

Introduction

A high feed intake of dairy cows is essential to maintain high milk production, particularly during early lactation, and to keep the cows in good condition. The DMI of group-housed dairy cows is affected among others by the feeding behaviour of the cows, which is modulated by the environment, management practices, health, and social interactions (*Grant and Albright*, 2001; *DeVries et al*., 2005). *Grant and Albright* (2000) stated that the time spent eating, and the pattern of meals, can obviously have important effects on the daily feed intake of dairy cows. The development of computerised systems for recording the feed intake of dairy cattle has made it possible to increase information on feeding behaviour (*Nielsen*, 1999). The analysis of feeding behaviour has been found to be appropriate when studying the regulation of feed intake on a short-term basis (*Forbes*, 1985; *Tolkamp et al.*, 2000). *Kertz et al*. (1991) revealed that older cows ate faster than primiparous cows during the first 5 weeks p.p.

The purpose of this study was to investigate the feeding behaviour characteristics and feed intake parameters as well as their relationships regarding dairy cows depending on their parity and their level of milk yield as well as their state of health.

Materials and methods

Animals, housing, and feeding

Data were collected during a feeding experiment between 10 July 2005 and 16 January 2006. The experiment took place in the Centre of Research for Animal Husbandry and Technology of the Regional Office for Agriculture and Horticulture (Sachsen-Anhalt, Iden). Seventy high-producing dairy cows [23 primiparous and 47 multiparous with 572 ± 42 and 687 ± 63 kg of BW (mean ± SD), respectively] were used for this experiment. The cows were housed in a free-stall barn. The ratio between cows and feeder was 2:1. The feeder units were equipped with electronic identification of individual cows and an electronic control. The cows could enter any feeder. The study was conducted between the 7^{th} and 105^{th} day of lactation. Cows were fed a TMR (based on the objectives of a feeding experiment) consisting of 24% corn silage, 31% grass silage, 5% grass and alfalfa hay, and 40% concentrate on a DM basis. The ration contained an average of 6.99 MJ NEL/kg, 16.68% CP and 17.46% CF, and was fed once a day between 06.00 and 08.00 a.m. ad libitum. The cows were milked three times a day (04.00 a.m., 12.00 p.m., and 08.00 p.m.) and the individual milk yields were recorded throughout the study. Both the content of the milk (fat, protein, and lactose) and the chemical composition of the feedstuffs were analysed weekly.

Measurement

Individual primary measurements, including number of visits and visit duration to the feeder, interval between visits as well as individual feed consumption at each visit were monitored continuously throughout the study by means of a computerised monitoring system described in our previous studies (*Kaufmann et al*., 2007). To determine whether a visit was part of the previous meal, part of the next meal or formed a meal itself, a meal criterion was calculated. Our estimation of the meal criterion was based on a method developed by *Tolkamp et al*. (1998) and *DeVries et al.* (2003). For our pooled data (for all animals and over the course of study), the meal criterion was 28.5 min on average.

Based on this meal criterion, the visits were clustered into meals. Then, meal frequency, meal duration, and daily mealtime were calculated. The meal frequency (meals/d) was calculated by counting the number of intervals per day that exceeded the length of the meal criterion and adding one.

The meal duration (min/meal) was calculated as the time from the beginning of the first feeding event until, but not including, an interval between events that exceeded the meal criterion.

The daily mealtime (min/d) was simply the sum of the meal durations in a day. The feed intake (meal size and daily DMI) was calculated based on dry matter (DM). The feeding rate was calculated as total daily DMI divided by total daily mealtime.

Statistical Analyses

Analyses were carried out on the individual animal as the observational unit using PROC GLM in SAS (SAS Institute, 2003). Data of cows in primiparous and multiparous condition were categorised into groups based on the mean of their milk yield over the first 15 weeks of lactation: primiparous cows with below-average milk yield (LP) and above-average milk yield (HP) with an average of 28.44 and 34.31 kg ECM per day, respectively, and multiparous cows with below-average milk yield (LM) and above-average milk yield (HM) with an average of 38.70 and 44.49 kg ECM per day, respectively.

To test for effects of parity and milk yield level on feeding behaviour characteristics and feed intake parameters, we used a linear model:

$Y_{ij} = \mu + P_i + M_j + P_i*M_j + e_{ij,}$

where

Y_{ij} = observation of the variable of interest

μ = overall mean

P_i = effect of parity i (i = 1, primiparous to 2, multiparous)

M_j = effect of milk yield level j (j = 1, low to 2, high milk yield)

P_i*M_j = interaction between parity i and milk yield level j

e_{ij} = error term

Correlations between feeding behaviour and feed intake parameters were calculated using PROC CORR in SAS (*SAS Institute*, 2003).

Results

Parity, milk yield level, and interaction between parity and milk yield level had significant effects on all characteristics of feeding behaviour and feed intake except meal duration (*Table 1*).

The meal frequency of multiparous cows was lower than of primiparous cows (P<0.001). Cows with a high milk yield had fewer meals per day than cows with a low milk yield (P < 0.001). No significant difference in meal duration between primiparous and multiparous cows was found (P = 0.63). However, the differences between milk yield groups (P < 0.001) as well as the interaction between parity and milk yield level were significant (P < 0.001). The daily mealtime of cows with a high milk yield level compared to cows with a low milk yield level was less (P < 0.001). Multiparous cows ate one kg DM per meal more than primiparous cows.

Table 1. **Mean values (± SE) feeding behaviour characteristics, feed intake and energy corrected milk yield of lactating dairy cows from the 7th -105th day of lactation**

	Primiparous		Multiparous			P-Value	
	LP[1]	HP	LM	HM	Parity	Milk-yield	Interaction[2]
Cows, no.	13	10	24	23			
ECM(kg/d)	28.44 ± 0.16	34.31 ± 0.18	38.70 ± 0.12	44.49 ± 0.12	0.000	0.000	0.746
Meal frequency per day	8.50 ± 0.04	8.35 ± 0.05	7.34 ± 0.03	7.07 ± 0.03	0.000	0.000	0.105
Meal duration (min/meal)	36.97 ± 0.38	36.87 ± 0.44	38.48 ± 0.28	35.72 ± 0.29	0.629	0.000	0.000
Daily Mealtime (min/d)	300.85 ± 2.20	298.60 ± 2.51	271.97 ± 1.62	244.62 ± 1.66	0.000	0.000	0.000
Meal size (kg/meal)	2.24 ± 0.02	2.35 ± 0.03	3.15 ± 0.02	3.42 ± 0.02	0.000	0.000	0.000
Daily DMI (kg/d)	18.28 ± 0.11	19.08 ± 0.12	22.27 ± 0.12	23.44 ± 0.08	0.000	0.000	0.054
Feeding rate (gDM/min)	64.67 ± 0.69	67.92 ± 0.79	88.34 ± 0.51	102.07 ± 0.52	0.000	0.000	0.000

[1]LP = cows in primiparous with low milk-yield; HP = cows in primiparous with high milk-yield; LM = cows in multiparous with low milk-yield; HM = cows in multiparous with high milk-yield.
[2]Interaction = Interaction between Parity and Milk-yield.

In addition, the differences in meal size between milk yield groups were significant (P <0.001). The daily DMI of multiparous cows increased by 4.21 kg compared to primiparous cows (P<0.001). Cows in HM ate ca. 5 kg DM per day more than cows in LP (23.44 vs. 18.28, P<0.001). The feeding rate of multiparous cows was about 30 g DM/min higher than that of primiparous cows (95.06 vs. 66.09, P<0.001).

The correlations between feeding behaviour characteristics and daily DMI for all cows and cows in each milk yield group are shown in *Table 2*.

Table 2. **The correlation between feeding behaviour characteristics and daily DMI of lactating dairy cows with different parity and milk yield level**

Measure		All cows	LP[1]	Daily DMI (kg/d)		HM
				HP	LM	
n[2]		6930	1287	990	2376	2277
Meal frequency in day	r	-0.089	0.029	0.099	0.124	0.115
	P	0.001	0.297	0.02	0.001	0.001
Meal duration (min/meal)	r	0.239	0.222	0.287	0.205	0.365
	P	0.001	0.001	0.001	0.001	0.001
Daily mealtime (min/d)	r	0.179	0.314	0.361	0.287	0.496
	P	0.001	0.001	0.001	0.001	0.001
Meal size (kg/meal)	r	0.699	0.528	0.638	0.536	0.618
	P	0.001	0.001	0.001	0.001	0.001

[1]LP = cows in primiparous with low milk yield; HP = cows in primiparous with high milk yield; LM = cows in multiparous with low milk yield; HM = cows in multiparous with high milk yield
[2]n = Total number of observations.

The correlations between meal frequency and daily DMI were low. The correlation between meal duration and daily DMI was higher in both higher yielding groups than in LP and LM (r = 0.37 and 0.29 vs. 0.21 and 0.22, respectively). Similar to meal duration, the daily mealtime related significantly with the daily DMI in all milk yield groups (in the range of r = 0.29 to 0.50). The correlation between meal size and daily DMI was also closer in both higher yielding groups than that in LP and LM (r = 0.64 and 0.62 vs. 0.53 and 0.54, respectively).

Feeding behaviour characteristics, feed intake, and milk production parameters for cows with subclinical disorders (SCD) and without subclinical disorders (WSCD) are shown in *Table 3*.

Table 3. **Means of feeding behaviour, feed intake, and milk yield values for cows with sub-clinical metabolic disorders (SCD) and without sub-clinical metabolic disorders (WSCD) during the second and third week of lactation.**

	2nd week				3rd week			
	SCD	WSCD	SEM[1]	P-Value	SCD	WSCD	SEM	P-Value
Cows, no.	8	14			9	14		
Meal frequency	7.39	7.66	0.26	0.31	7.58	7.56	0.24	0.94
Meal duration (min/meal)	26.12	32.07	1.82	0.01	29.51	35.46	2.47	0.01
Daily mealtime (min/d)	190.04	233.63	11.84	0.01	216.99	256.41	14.57	0.000
Meal size (kg/meal)	2.44	2.62	0.092	0.04	2.5	2.93	0.102	0.000
Daily DMI (kg/d)	17.36	19.3	0.47	0.01	18.61	21.44	0.51	0.000
Feeding rate (g/min)	102.88	89.42	4.96	0.01	95.18	95.06	5.77	0.98
ECM[2] (kg/d)	37.29	39.01	1.15	0.14	43.72	42.56	1.10	0.27

[1]SEM = the standard error of means
[2]ECM = energy-corrected milk

There was no significant difference in meal frequency per day or in the number of visits per meal in the second and third week of lactation between these cows. The mean of the meal duration for cows with sub-clinical metabolic disorders was about 6 min shorter than that for healthy cows in the second and third week of lactation (26.12 and 29.51 vs. 32.07 and 35.46 min/meal, respectively, P <0.01). The SCD cows spent about 40 min less at daily mealtime than WSCD cows in the second and third wk of lactation (190.04 and 216.99 vs. 233.66 and 256.41, respectively, P <0.01). Healthy cows ate a significantly larger meal size than SCD cows in the second and third wk of lactation (P <0.01). They also ate ca. 2 kg DM per day in the second wk and 3 kg in the third week more than SCD cows (17.36 and 18.61 vs. 19.30 and 21.44, respectively, P <0.01). The feeding rate was significantly different in the second wk (P<0.01), but not in the third wk (P <0.98). We found no significant difference in milk production between SCD and WSCD cows.

Discussion

The hypothesis of this study was that cows have different feeding behaviour characteristics depending on their parities and productivity as well as their state of health.

The means of feeding behaviour characteristics and feed intake parameters obtained in the current study were within the range of results which had been reported by other researchers (*Dado and Allen*, 1994; *Tolkamp et al*., 2000; *DeVries et al*., 2003). However, the results were partly different from those reported by *Miron et al*. (2004) and *Morita et al*. (1996).

Miron et al.(2004) stated an average of 14 meals per day, 15.9 min/meal for meal duration, and 223 min/d for eating duration (daily mealtime); and *Morita et al*. found an average of 18.9 min/meal for meal duration, 4.0 kg/meal for meal size, and 0.249 kg/min for eating speed (feeding rate). Therefore, a possible explanation may be the differences in the definition of meal criteria. *Miron et al.* (2004) used an arbitrary definition of meal, which was defined as a visit to a trough that lasted at least 1 min while eating at least 0.2 kg of food; *Morita et al.* (1996) calculated an average of 13 min as meal criterion. The longer meal criterion used in our recent study compared with these meal criteria translated into a lower meal frequency (*Tolkamp et al*., 2000; *DeVries et al.,* 2003).

To investigate the feeding behaviour and feed intake between primiparous and multiparous cows, *Dado and Allen* (1994) studied 6 primiparous and 6 multiparous cows during early lactation and reported an average of 11.3 and 10.8 eating bouts per day (meal frequency) with a bout length of 25.9 and 31.1 min (meal duration). The meal size was 1.8 and 2.5 kg, and the daily eating time added up to 284 and 314 min with a daily DMI of 20 and 24.8 kg for primiparous and multiparous cows, respectively.

Our results showed also a reduced meal frequency by 10%, a 40% bigger meal size, and a 22% higher daily DMI in multiparous cows compared with primiparous cows.

Only a few studies have examined the variation in feeding behaviour and feed intake among lactating dairy cows depending on their level of milk yield. *Dado and Allen* (1994) found in a multivariate data acquisition system, measuring continuous feed and water intake as well as chewing behaviour, that cows with higher yields achieved greater DMI by increasing meal size while spending less time eating. These findings are in agreement with the results of our study, which showed that cows with a higher milk yield consumed more daily DMI and spent less time eating per day than cows with a lower milk yield. Cows in the HM group spent 20% less time eating than the cows in the LP group. They also ate 53% more per meal and 28% more dry matter per day than the cows in the LP group.

The results showed higher correlations between feeding behaviour characteristics and feed intake (DMI) within milk yields groups than across all cows. These correlations were similar to those reported by *Dado and Allen* (1994) and *Friggens et al.* (1998).

Dado and Allen (1994) found a correlation of r= 0.35 between eating bouts per day and daily DMI, r=0.27 between eating bout length and DMI, r=0.42 between daily eating time and DMI, and r =0.58 between meal size and DMI. We found a stronger correlation between meal duration, daily mealtime, and daily DMI (r= 0.37and 0.50, respectively) in HP than *Dado and Allen* (1994).

Highly positive correlations between meal duration, daily mealtime, and daily DMI indicated that these variables could probably be used to describe the feed intake. The comparison of the variation in meal duration and daily mealtime (35% and 26%, respectively), on the one hand, and the smaller variation of daily DMI (14%), on the other hand, shows that there is a great variation in feeding rates in cows.

Very interesting is the influence of suclinical metabolic-related production deseases on feeding behaviour. *Urton et al*. (2005) and *Huzzey et al*. (2007) stated that reduced feeding time can be used to identify dairy cows at risk for metritis. We also concluded that feeding behaviour characteristics, especially daily mealtime, can be used to identify sub-clinical metabolic disorders in dairy cattle.

References

Chase, L.E., (1993): Developing nutrition programs for high producing dairy herds. J. Dairy Sci., 76. 3278-3290.

Dado, R.G., and M.S. Allen. (1994): Variation in and relationships among feeding, chewing, and drinking variables for lactating dairy cows. J. Dairy Sci., 77. 132-144

DeVries, T. early J., M.A.G. von Keyserlink, D.M. Weary, and K.A. Beauchemin. (2003): Measuring the feeding behavior of lactating dairy cows in to peak lactation. J. Dairy Sci., 86. 3354-3361**.**

Forbes, J.M. (1985): The importance of meals in the regulation of food intake. Proc. Nutr. Soc. Aust., 10. 14-24.

Forbes, J.M. (1995): Feeding behaviour. Pages 11-31 in Voluntary food intake and diet Selection in farm animals. J. M. Forbes, ed. CAB International, Wallingford, UK.

Friggens, N.C., B.L. Nielsen, I. Kyriazakis, B.J. Tolkamp, and G.C. Emmans (1998): Effects of feed composition and stage of lactation on the short-term feeding behavior of dairy cows. J. Dairy Sci., 81. 2368-3277.

Grand, R.J. and J.L. Albright. (2000): Feeding behavior. Pages 365-382 in farm animal metabolism and nutrition. J: P. F. DMello, ed. CABI Publihing, Wallingford, Oxon, UK (2001)

Huzzey, J.M., D.M. Veira, D.M. Weary, and M.A.G. von Keyserlingk (2007): Prepartum behavior and dry matter intake identify dairy cows at risk for metritis, J. Dairy Sci., 90. 3220-3233

Kaufmann, O., O. Azizi, and L., Hasselmann (2007): Untersuchungen zum Fressverhalten hochleistender Milchkuehen in der Fruehlaktation. Züchtungskunde, 79. 3. 219-230.

Kertz, A.F., L.F. Reutzel, and G.M. Thomson (1991): Dry matter intake fro parturition to midlactation. J. Dairy Sci., 74. 2290-2295.

Kononoff, P.J., S.K. Ivan, W. Matzke, R.J. Grant, R.A. Stock and T.J. Klopfenstein (2006): Milk production of dairy cows fed wet corn Gluten feed during dry period and lactation. J. Dairy Sci., 89. 2608-2617.

Miron, J.E. Yosef, M. Nikbachat, A. Zenou, and E. Maltz (2004): Feeding behaviour and performance of dairy cows fed pelleted nonroughage fiber byproducts. J. Dairy Sci., 87. 1372-1379.

Morita, S., S. Devir, C. Ketelaar-DE Lauwere, A. C. Smits, H. Hogeveen, and J. H. M. Metz. (1996): Effects of concentrate intake on subsequent roughage intake and eating behavior of cows in an automatic milking system. J. Dairy Sci., 79. 1572-1580.

Nielsen, B.L. (1999): On the interpretation of feeding behavior measures and use of feeding rate as an indicator of social constraint. Appl. Anim. Behav. Sci., 63. 79-91.

SAS Institute. (2003): User's Guide: statistics. Version 9 Edition. INC., Cary, NC.

Shabi, Z., M.R. Murphy, and U. Moallem (2005): Within-day feeding behavior of lactating dairy cows measured using a real-time control system. J. Dairy Sci., 88. 1848-1854.

Tolkamp, B.J., D.J. Allcroft, E.J. Austin, B.L. Nielsen, and I. Kyriazakis (1998): Satiety splits feeding behavior into bouts. J. Theor. Biol., 194. 235-250.

Tolkamp, B.J., D.P.N. Schweitzer, and I. Kyriazakis (2000): The biologically relevant unit for the analysis of short-term feeding behavior of dairy cows. J. Dairy Sci., 83. 2057-2068.

Urton, G., M.A.G. von Keyserlingk, and D.M. Weary (2005): Feeding behavior identifies dairy cows at risk for metritis. J. Dairy Sci., 88. 2843-2849.