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# Comparison of energy expenditure, eating pattern and physical activity of grazing and zero-grazing dairy cows at different time points during lactation

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ABSTRACT

An experiment was conducted to determine the effect of grazing versus zero-grazing on energy expenditure (EE), feeding behaviour and physical activity in dairy cows at different stages of lactation. Fourteen Holstein cows were subjected to two treatments in a repeated crossover design with three experimental series (S1, S2, and S3) reflecting increased days in milk (DIM). At the beginning of each series, cows were on average at 38, 94 and 171 (standard deviation (SD) 10.8) DIM, respectively. Each series consisted of two periods containing a 7-d adaptation and a 7-d collection period each. Cows either grazed on pasture for 16–18.5 h per day or were kept in a freestall barn and had ad libitum access to herbage harvested from the same paddock. Herbage intake was estimated using the double alkane technique. On each day of the collection period, EE of one cow in the barn and of one cow on pasture was determined for 6 h by using the $^{13}$C bicarbonate dilution technique, with blood sample collection done either manually in the barn or using an automatic sampling system on pasture. Furthermore, during each collection period physical activity and feeding behaviour of cows were recorded over 3 d using pedometers and behaviour recorders. Milk yield decreased with increasing DIM ($P<0.001$) but was similar with both treatments. Herbage intake was lower ($P<0.01$) for grazing cows (16.8 kg dry matter (DM)/d) compared to zero-grazing cows (18.9 kg DM/d). The lowest ($P<0.001$) intake was observed in S1 and similar intakes were observed in S2 and S3. Within the 6-h measurement period, grazing cows expended 19% more ($P<0.001$) energy (319 versus 269 kJ/kg metabolic body size ($BW^{0.75}$)) than zero-grazing cows and differences in EE did not change with increasing DIM. Grazing cows spent proportionally more ($P<0.001$) time walking and less time standing ($P<0.001$) and lying ($P<0.05$) than zero-grazing cows. The proportion of time spent eating was greater ($P<0.001$) and that of time spent ruminating was lower ($P<0.05$) for grazing cows compared to zero-grazing cows. In conclusion, lower feed intake along with the unchanged milk production indicates that grazing cows mobilized body reserves to cover additional energy requirements which were at least partly caused by more physical activity. However, changes in cows' behaviour between the considered time points during lactation were too small so that differences in EE remained similar between treatments with increasing DIM.



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## 1. Introduction

In temperate regions with plentiful regular herbage growth such as Ireland, New Zealand or Switzerland grazing systems for dairy cows have gained increased interest for different reasons. From an economic point of view these production systems are interesting because herbage from pasture is the most cost efficient nutrient source for dairy cows (Taweel et al., 2006). Furthermore, in many developed countries, consumers are becoming increasingly aware of the conditions under which food producing animals are kept. Compared to cubicle housing systems, grazing systems offer greater opportunities to dairy cows to display their natural behaviour (Van den Pol-Van Dasselaar et al., 2008). Moreover, grazing potentially has positive effects on cows' health. Hernandez-Mendo et al. (2007) found indications that lame cows recover from hoof and leg injuries when they had spent time on pasture and Van den Pol-Van Dasselaar et al. (2008) suggested a reduced risk of mastitis in grazing cows. However, a herbage dominated diet may have limitations with respect to the energy density (Kolver and Muller, 1998) and nutrient imbalances (Bruinenberg et al., 2002) that could compromise milk production and impair health and welfare, especially during early lactation when the cow's metabolism is additionally challenged. Mobilization of body fat reserves indicates that herbage-fed, high producing cows require supplemental energy to express their genetic potential for milk production (Kolver and Muller, 1998). These requirements may be even more pronounced in grazing compared to zero-grazing cows. At the same dry matter (DM) intake, cows on pasture spend more time eating than cows fed herbage in the barn (Oshita et al., 2008) indicating a greater physical activity. Based on results obtained in respiration chambers or by measuring heart rate, eating and walking cost more energy than ruminating and lying (Rometsch et al., 1997; Susenbeth et al., 1998, 2004). Furthermore, the energetic costs for grazing are greater than for standing (Aharoni et al., 2009). Thus, one can conclude that grazing cows expend more energy than cows fed herbage in the barn. This was already confirmed by a recent study (Kaufmann et al., 2011) where the $^{13}C$ bicarbonate dilution technique in combination with an automatic blood sampling system was used for the first time to collect data from cows in early lactation on pasture. However, to assess the energy requirements of grazing cows during the whole lactation, a greater data set about their energy expenditure (EE) is required.

Therefore, the objective of the current study was to compare, at three different time points during lactation, EE of grazing and zero-grazing cows fed herbage of similar quality. We hypothesized that not only grazing cows expend more energy and are more active than cows in the barn but also differences in EE changed with increasing days in milk (DIM) because physical activity has been shown to change as well throughout the lactation period (Bewley et al., 2010).

## 2. Materials and methods

### 2.1. Experimental design, animals and treatments

Fourteen multiparous Holstein cows were subjected randomly to two sequences with two alternating treatments (feeding systems; i.e. grazing, zero-grazing) in a repeated $2 \times 2$ crossover design with three experimental series (S1, S2, and S3). Each series consisted of two consecutive 14-d experimental periods which in turn comprised a 7-d adaptation period and a 7-d data and sample collection period. The experimental series were carried out from wk 18 to 21, from wk 26 to 29 and from wk 37 to 40 of 2008. At the beginning of S1, cows were on average 38 (SD 10.8) DIM, had a body weight (BW) of 660 (SD 65.0) kg and produced 44 (SD 2.7) kg/d of milk. In S2, cows were 94 (SD 10.8) DIM, had a BW of 665 (SD 58.2) kg and produced 37.0 (SD 4.1) kg/d of milk. In S3, cows were 171 (SD 10.8) DIM, had a BW of 671 (SD 59.1) kg and produced 32.1 (SD 2.3) kg/d of milk. In the treatment 'grazing' cows grazed from 07:30 to 14:30 h and from 17:00 to 04:30 h. The herbage for cows in the 'zero-grazing' treatment was harvested from the same paddock and was offered ad libitum targeting 10% refusals, during the same time when grazing cows were on pasture. Zero-grazing cows were kept in a freestall barn with access to an outdoor exercise lot. All cows were supplemented with a cereal-based concentrate including a mineral mix to meet their predicted nutrient requirements (ALP, 2008). Concentrate supplementation was adjusted for each cow before the start of each experimental series and remained stable during each series. The concentrate for S1 contained (g/kg): barley, 540; wheat, 310; rumen protected fat, 50; molasses, 40; $CaCO_3$, 20; NaCl, 15; $CaHPO_4$, 15, MgO, 8; and a trace elements-vitamin mix, 2. In S2 and S3 the proportion of wheat was increased by 30 g/kg at the expense of molasses (10 g/kg), $CaCO_3$, (10 g/kg), $CaHPO_4$ (3 g/kg) and MgO (7 g/kg). The concentrate was offered in two equal meals at 06:30 and 16:30 h after milking in the freestall barn using automatic weighing troughs (Insentec B.V., Marknesse, The Netherlands). Fresh drinking water was available continuously to all cows. In S2, the morning grazing just lasted until 12:00 h in order to avoid heat stress. From then on until concentrate feeding, cows in both treatments had no access to herbage. Between the individual experimental series cows of both treatment groups grazed together and were supplemented with the type of concentrate of the following series. The supplementation was adjusted after each experimental series and remained stable until the start of the next experimental series.

### 2.2. Grazing management and climatic conditions

The experimental pastures were long-term established leys with mixed swards. The average botanical composition, as determined once weekly during the experimental series by hand sorting was characterized by high proportions of grasses (57%; dominated by *Lolium perenne* 43%), 19% herbs (dominated by *Taraxacum officinale* 16%) and 24% white clover (*Trifolium repens*). Each pasture paddock was divided into two plots. One was used for grazing, the other to provide herbage for zero-grazing cows. Between the experimental series, all paddocks were once cut for a harvest of conserved forage, to reduce the influence of pasture management over the season. The herbage for bunk feeding was cut daily between 07:00 and 08:00 h at a height of 5 cm. The entire harvested herbage was weighed. This weight was used to calculate yield per hectare and based on this, to estimate pasture allowance for the grazing cows which was on