Behavioural pattern of dairy cows in an automatic milking system with a 4-way grazing setup

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Abstract

Automatic milking (AM) has been successfully integrated into pasture-based commercial and research farms in Europe, Australia and New Zealand. A high voluntary cow flow is crucial for the success of AM in a pasture-based system. Previously, it has been shown, that providing three rather than two fresh grass allocations during the day improved the cow flow through the system. In order to achieve a good cow flow with increased cow numbers (> 80 cows per robot), a 4-way grazing system was set up in the present study. To examine the effect of the 4-way system on cow behaviour, 18 cows in a herd of 84 cows were monitored to establish their behavioural patterns. Behavioural monitoring was conducted using the RumiWatchSystem over a period of nine days. Graphical analysis of the daily behavioural pattern was conducted in three-hour summaries. Overall, the cows showed an average grazing time of 468 minutes day^{-1} and an average rumination time of 419 min day^{-1}. Those values align closely with values in the literature from conventional pasture-based milking systems, where cows spend 481 min day^{-1} grazing and 406 min day^{-1} ruminating. These results demonstrated that cows have sufficient time for natural behaviour in a 4-way grazing AM system.

Keywords: time-budget, chronobiology, circadian rhythm, grazing behaviour, milking robot

Introduction

The technology of automatic milking (AM) was first implemented in indoor-systems in the 1990s and has continued to increase in popularity. In addition to implementing AM in indoor housing systems, it has been proven that AM can be combined with pasture-based milk production (Davis *et al.,* 2006). Farms in New Zealand and Australia and parts of Europe have been successful in operating AM on pasture systems. A crucial parameter for the successful implementation of AM on pasture is a high voluntary cow flow to the robot and efficient cow flow around the farm. Diurnal feeding patterns and recommended grass allocations are important parameters influencing cow flow. Lyons *et al.* (2013) showed that a three-way grazing system improved cow flow through the AM system compared to a traditional two-way grazing system. To establish if a milking robot could operate satisfactorily with a higher cow number (> 80 cows per robot), a four-way grazing system was implemented. However, it was necessary to assess the suitability of this system with regard to the natural behavioural pattern of cows. Thus, the objective of this study was to monitor the grazing behaviour and activity of cows in the system using RumiWatch sensors.

Materials and methods

This study was conducted at the research farm of Teagasc Dairygold, Animal and Grassland Research Centre, Moorepark, Kilworth, Co. Cork, Ireland from 8 to 16 May 2017. This farm had a herd of 84 cows milked with an AM system (Lely Astronaut A4, Lely, Maassluis, the Netherlands). A four-way grazing system was in place with gate changing taking place at 04:00, 10:00, 16:00 and 22:00 hrs. Eighteen spring-calving dairy cows were randomly selected from the herd of 84 cows on the AM system. Primiparious cows were excluded due to lack of experience and training to the robot. The experimental cows were equipped with the RumiWatchSystem. The cows had an average of 42 ± 15 days in milk and an average milk yield of 27.7 ± 8.6 kg at the beginning of the experiment. All cows were Holstein-

Friesian and were maintained on a pasture diet (with < 0.5 kg concentrate/milking offered in the robot). The RumiWatchSystem, consisting of a noseband sensor and a pedometer, was previously validated for measuring grazing behaviour and activity by Werner *et al.* (2017a). The sensors were applied to 18 cows and behavioural and activity data were recorded continuously over a period of nine days. The data relating to the first day was excluded from subsequent analysis to allow for cow adaptation to the sensors. Subsequently, raw data were recorded in a 10 Hz resolution. These raw data were then converted by the RumiWatch Converter V.0.7.4.10 into three-hour and daily summaries. Microsoft Excel Version 2010 (Microsoft Corporation, Redmond, USA) was used for analysis of the data. The daily values of all cows were averaged and the standard deviation was calculated. For graphical analysis, the three-hour data were used to represent behavioural patterns during the day. Grazing time was calculated as the sum of EATUP (times when cows were chewing with head position up) and EATDOWNTIME (times when cows were biting/chewing with head position down). Grazing bite frequency was calculated as Number of Grazing bites/EATDOWNTIME.

Results and discussion

Behavioural characteristics of cows in a four-way grazing system are presented in Table 1. The data indicates that cows spent average times of 468 ± 166 min day^{-1} and 419 ± 93 min day^{-1} grazing and ruminating, respectively. Further, cows spent an average of 93 ± 42 min day^{-1} walking while taking 2,719 ± 1,240 strides day^{-1}. Kennedy *et al.* (2011) reported average rumination times of 406 min day^{-1} and Werner *et al.* (2017b) reported a walking time of 85 min day^{-1} in conventional milking systems. However, a study by O'Driscoll *et al.* (2010) reported that cows in a conventional milking system with a once-a-day or twice-a-day milking regime had longer lying times compared to the current study (620 ± 15 and 627 ± 14 min day^{-1}, respectively compared to 504 ± 218 min day^{-1}). This might be explained by the different stage of lactation or treatment.

The daily pattern of rumination and grazing time in a three-hour interval is displayed in Figure 1. There were two distinguishable periods of grazing 06:00 to 09:00 and 18:00 to 21:00, which were followed by intense rumination periods. These results show that the previously observed pattern of cows having two main feeding periods around dawn and dusk, a likely natural behaviour, is not impacted in a four-way grazing system. This study confirms that cows can express natural behaviour in a four-way grazing system. The study also provides initial results about cows' behaviour in a four-way grazing system. Further studies will report on cow location and behavioural data extended over a full lactation period.

Table 1. Mean values for different measured parameters with standard deviation (SD).

	MEAN	SD
Grazing time (min day^{-1})	468	116
Grazing bites (n day^{-1})	25,575	7,840
Grazing bites frequency (n min^{-1})	68	6
Grazing bouts (n day^{-1})	7	2
Rumination time (min day^{-1})	419	93
Ruminate chews (n day^{-1})	26,075	6,534
Rumination chews per bolus (n bolus^{-1})	53	7
Rumination bouts (n day^{-1})	14	3
Lying time (min day^{-1})	504	218
Standing time (min day^{-1})	843	196
Walking time (min day^{-1})	93	42
Strides (n day^{-1})	2,719	1,240

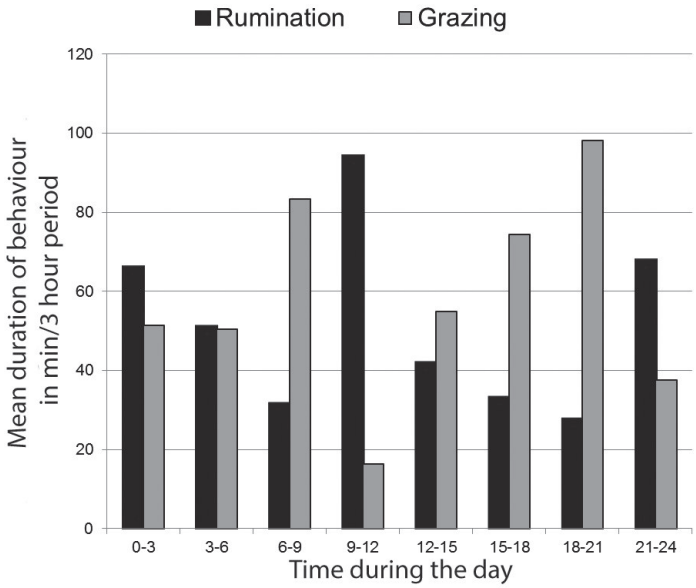

Figure 1. Mean values for grazing and rumination times per three hour-period over 24 hours.

Conclusion

To date, there are limited techniques to continuously monitor cow behaviour, consequently, little data has been generated up until now. Additionally, the four-way grazing system is a novel approach to allow more cows to be milked per robot in a pasture-based system. To the authors' knowledge, this is the first study to record such data. It may be concluded that cows on a four-way grazing system can maintain similar grazing and rumination times compared to cows in conventional pasture-based milking systems. The results also show that the studied cows followed a natural pattern of two large feeding bouts at dawn and dusk followed by two intensive rumination periods.

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