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## Stage of lactation affects the milking performance and behaviour of cows in a pasture-based automated milking system

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### ABSTRACT

The successful implementation of automatic milking (AM) technology in pastoral dairy systems is dependent on the regular voluntary passage of cows from the grazing area to the dairy. A herd of 94 cows at the Dexcel Greenfield research farm was observed during a 31-day period to determine the effect of stage of lactation on milking performance and behaviour. Sixty-five cows were spring calved (late lactation, average 266 days in milk) and 29 were autumn calved (early lactation, average 19 days in milk). Cows were grazed as one herd in a rotational grazing management system with a fresh area of pasture available twice daily. Early lactation cows had a shorter average milking interval (14.6 vs 20.4 hours,  $p < 0.001$ ) and a higher average daily production (20.0 vs 7.0 kg milk/cow/day,  $p < 0.001$ ). They visited the selection units (from which they could gain access to water, fresh pasture and the raceway to the dairy housing the AM units) more often than cows late in lactation (2.8 vs 1.8 visits/cow/day,  $p < 0.001$ ) and had a quicker transit time between pasture and the AM units (2.2 vs 2.7 hours/cow/milking,  $p = 0.026$ ). Fewer early lactation cows needed to be manually moved from the grazing area for milking. The data indicates that stage of lactation will be a significant factor to consider when developing management systems for combining grazing with automatic milking.

**Keywords:** automatic milking; grazing; stage of lactation; motivation; dairy.

### INTRODUCTION

The successful implementation of automatic milking (AM) technology in pastoral dairy systems relies on the voluntary attendance of cows to the AM unit which will be located some distance from the grazing area. There is a large number of factors which may influence the behaviour patterns of cows including the location and availability of resources such as feed and water relative to the AM unit, climatic conditions, the cows physiological state (e.g., lactational stage, hunger and thirst) and experience with the AM unit. Identifying the various factors and understanding the effect their interactions have on the motivation of cows to visit the AM unit is important when developing farm systems for automatic milking.

Lactation in the modern dairy cow is a complex physiological process. Lactation is induced by parturition after which follows a period of high energy need, increasing milk production and changing hormonal state (Cowie & Tindal, 1971). The behaviour patterns of cattle change following parturition along with increased feed requirements and frequent feeding of young (Albright & Arave, 1997). Over time the frequency of feeding is reduced until the young are weaned and lactation ceases (Day *et al.*, 1987; Phillips, 1993). The energy requirements of the dairy cow

change throughout a lactation. Given these nutritional, physiological and behavioural changes which occur it is hypothesized that a cows stage of lactation will influence the behaviour of dairy cows' milked by automatic milking systems in which there is a greater freedom of movement than in conventional batch milking systems.

The Greenfield project was established in 2000 to evaluate the practical and economic viability of automatic milking for New Zealand pastoral dairy systems. A prototype farm was established (Jago *et al.*, 2002) then expanded to a small commercial scale operation (Jago *et al.*, 2004). The split-calving (autumn and spring) pattern of the Greenfield herd presented the opportunity to study the milking performance and behaviour of cows at different stages of lactation within the Greenfield milking system.

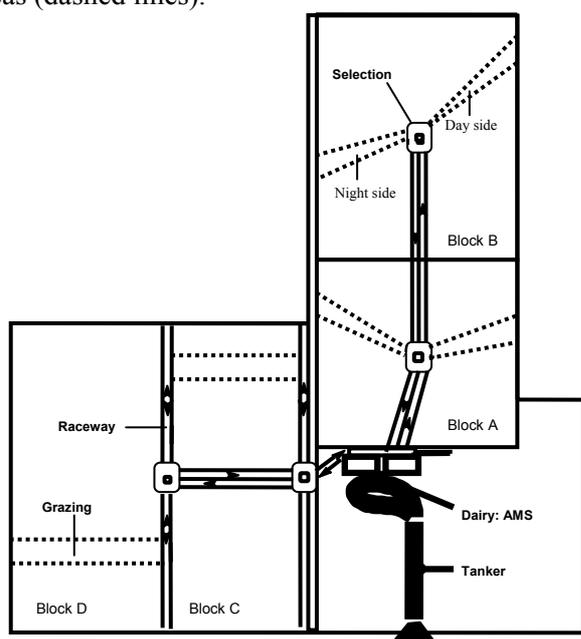
### MATERIALS AND METHODS

#### Farm Layout

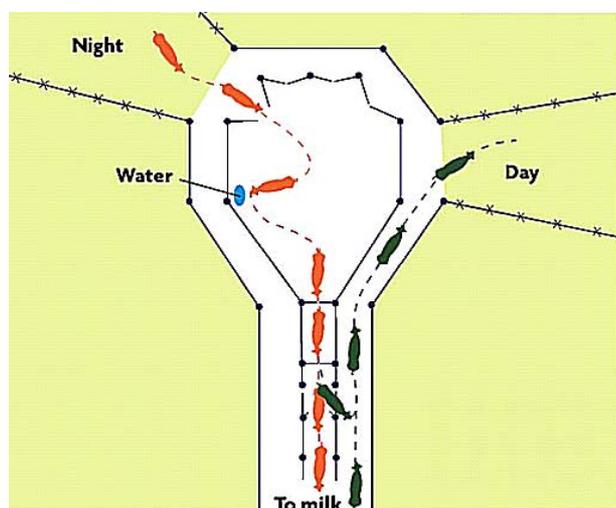
The layout of the 43 (effective) ha Greenfield farm is depicted in Figure 1. The main features of the farm include two automatic milking systems (AMS) and four selection units (SU) used to remotely select cows for milking (Figure 2). A detailed description of the SU was reported by Jago *et al.* (2004). Pasture areas were either radially subdivided leading to a central SU (Blocks A & B)

or divided into strips adjacent to a feeder raceway leading to a SU (Blocks C & D). A race system extended between the SU and a small waiting yard adjoining two Fullwood Merlin<sup>®</sup> AMS. A series of cow-operated one-way gates positioned at the entrance to the SU and waiting yard along with AMS-controlled automatic gates at the exit from the AMS were used to control cow traffic. Water was located in each SU and at the exit from each AMS.

**FIGURE 1:** Greenfield farm layout showing dairy with two AMS units, raceways (multi and single direction), selection units for automatic diversion either to the dairy for milking or to the grazing areas (dashed lines).



**FIGURE 2:** Configuration of remote selection unit showing entry via one-way gates (●—●), water and automatic diversion either to the dairy for milking or to the grazing area.



### Animals and grazing management

Milking performance and behaviour data were collected from a herd of 94 mixed-age (range = 2-13 years old) and mixed-breed (Friesian, Jersey, Friesian x Jersey) cows that had had at least 90 days experience in the Greenfield farm system (either in the current or a previous lactation). Of the 94 cows, 65 were spring calved (late lactation,  $266 \pm 23$  days in milk at the start of the study period) and 29 were autumn calved (early lactation,  $19 \pm 12$  days in milk at start of the study period). Each cow was fitted with a small leg-mounted radio transponder identification device that allowed automatic identification at the SU and in the AMS. Cows received a maximum of 1 kg crushed barley/24 h fed in the AMS during milking. The amount received at each visit was proportionate to the time since last milking visit.

Cows were grazed as one herd in a rotational grazing management system with a fresh area of pasture made available twice a day at 8:00 h and 20:00 h. A grazing system was used in which two areas of pasture, one on the day side and one on the night side of the farm, were grazed at any one time. Cows entered the SUs to move from one pasture area to the other or to gain access to the AMSs. Entry was via cow-operated one-way gates and exit via a computer-controlled pneumatically operated gate. On presentation at the exit gates of the SU a cow was either directed along the raceway to the dairy if due for milking, or released to pasture if not due for milking (Figure 2). Production rate and target yield criteria were used to derive a minimum milking interval of 9 hours (Crystal 0.44, Fullwood Fusion, Holland) and therefore determine if a cow was due for milking. The only exception was if a cow gave less than her expected yield at the previous milking, in which case she was allowed back to the AMS earlier.

The direction of cow traffic (to day-side or to night-side) was reversed twice in 24 h at 8:00 h and 20:00 h (change-over). Any cows remaining in the old pasture area were moved to the SU before a new area of pasture was made available to the herd. For example, at 16:00 h any cows remaining in the paddock on the night side were moved into the SU and cows returning from the AMS or diverted “to paddock” when exiting the SU began to enter the new area of pasture on the night side at 20:00 h. Similarly, at 8:00 h, any cows remaining on the day side were moved to the SU and cows returning from the AMS or diverted “to paddock” when exiting the SU began, to enter the new area of pasture on the day side.

All cows in the herd were free to enter the SU closest to their grazing area at any time during a 24-h period, however their access to the dairy and

therefore opportunity for milking, was limited to a minimum of 9 hours between milkings. The same criteria was maintained throughout the data collection period.

### Data collection and analysis

Milking data and cow behaviour data were collected for a total of 31 days in May 2004 and used to determine milking frequency (milkings/cow/day). All data were recorded automatically by a computing system (Crystal 0.44, Fullwood Fusion, Holland) that was linked to the cow identification points at each SU and the two AMS. Milk yield was determined using Afikim ICAR approved milk meters installed on each AMS. Milk harvest rate was determined by dividing milk yield by total milking time (time from entry to exit from AMS, collected by Logview®). The time of exit from the SU was used to determine frequency of visits to the SUs. The difference between time of exit from the SU closest to the paddock currently grazed and the time of exit from the AMS was used to calculate time off pasture for each milking. The number and identification of cows remaining in the paddock was recorded at 08:00 h and 16:00 h.

The effect of stage of lactation (early vs late) on milking performance and behaviour was analysed using ANOVA.

## RESULTS

**TABLE 1:** Milking data (days in milk, total daily yield, harvest rate) and cow behaviour (milking interval, selection unit visits, time off pasture per milking) for cows either in early (n = 29) or late (n = 65) lactation and milked in a pasture-based automatic milking system (Greenfield system) during a 31 day period.

	Stage of Lactation		SED	P value
	Early	Late		
Days in milk (days) <sup>1</sup>	19	266	-	-
Total milk yield (kg/cow/day)	20.0	7.0	0.696	<0.001
Harvest rate (kg/min) <sub>2</sub>	1.57	1.08	0.097	<0.001
Milking interval (h)	14.6	20.4	0.667	<0.001
Daily milkings (number/cow/day)	1.7	1.2	0.052	<0.001
Selection unit visits (visits/cow/day)	2.8	1.8	0.144	<0.001
Time off pasture (h/milking)	2.2	2.7	0.243	0.026

<sup>1</sup> Average days in milk at start of data-collection period

<sup>2</sup> kg milk per milking/harvest time (time of exit from the AMS crate - time of entry into the AMS crate).

Stage of lactation had a clear effect on both milking performance and behaviour of the cows in the Greenfield system. Cows in early lactation had a significantly higher milk yield, shorter milking interval and therefore higher milking frequency and higher harvest rate than the late lactation cows (Table 1). Early lactation cows also made more frequent visits to the selection units and spent less time in transit on the raceways and waiting yard each milking. On average 7 % and 9 % of early lactation cows remained in the “old” pasture area at the morning and afternoon change-over, respectively. This compared to 26 % and 20 % of late lactation cows that remained in the “old” pasture area and had to be moved to the SU at the morning and afternoon change-overs, respectively.

## DISCUSSION

The milking performance and trafficking behaviour of cows within the Greenfield herd, managed under the same grazing and milking regime, clearly differed depending on whether cows were recently calved or nearing the end of their lactation.

The data shows that cows in early lactation left the grazing area and visited the selection units from which they could gain access to water, fresh pasture or the AM units more often than cows in late lactation. There was also fewer early lactation cows remaining in an “old” grazed area at the two times of the day that the direction of transverse was changed on the farm. Cows have a higher nutritional need after calving compared with cows nearing the end of their lactation (Webster, 1983) and as cows were able to access new pasture via the SUs the higher number of visits may simply reflect a greater motivation to search for feed. As a result of the more frequent visits to the SU the early lactation cows would have had a higher chance of being sent to the dairy for milking which would translate into a higher milking frequency. The quicker transit time from leaving the grazing area to entering the AM unit is indicative of an animal more motivated to visit the AM units and may reflect a greater urgency to access the small amount of feed available in the AM unit, or pasture available after milking or perhaps return to the area where calves were weaned from cows. Individual water intakes were not measured in this study so it is not possible to draw conclusions on the relative incentive-value of the water within the SUs for the early and late-lactation cows. However the much higher daily yield (20L/cow/day) recorded for the recently calved cows would be expected to result in a higher water requirement for those cows.

The higher SU visiting frequency for cows that had recently calved was reflected in a higher milking frequency for these animals. The average milking interval of 14 hours was similar to the 13 hour interval previously reported for spring calved cows in early lactation within the Greenfield system (Jago *et al.*, 2004). The decreasing milking frequency with increasing length of lactation is consistent with the behaviour of cattle suckling their young (Phillips, 1993). It is also consistent with the decline in milking frequency from 2.3 milkings/cow/day to 1.5 milkings/cow/day from early- to late-lactation reported for a small herd of predominantly spring calved cows milked on the Greenfield farm and which had unlimited access to the AM units (Jago *et al.*, 2002).

Previous studies have attempted to determine the effect that stage of lactation has on a cows motivation to be milked. Prescott (1995) suggested that there are three reasons why a dairy cow may choose to be milked. First, discomfort caused by intramammary pressure from a distended udder (Phillips, 1993; Rathore, 1982), second, cows may gain some psychological reward from being milked and third that the process of milk ejection or milk let-down is positively rewarding due to the involvement of the hormone, oxytocin. Subsequent experimental studies showed that although there was some evidence of early lactation cows choosing to be milked more frequently than late lactation cows there was considerable variation between cows. When given the choice of feed or milking, cows always chose the feed (Prescott, 1995). In light of the results of Prescott (1995), the observations in the current study are more likely a result of a higher motivation to access food, rather than to be milked.

This study provides clear evidence for an effect of lactation stage on behaviour of cows in a pastoral automatic milking system. However, it is not possible to interpret the relative importance of the resources (grass, water or milking unit) accessible when the cows were visiting the SUs, and this deserves further investigation. This must be considered along with other factors that have been shown to influence a cows behaviour in automatic milking systems including climatic conditions, pasture length (Ketelaar-de Lauwere & Ipema, 2000; Salomonsson & Spornly, 2000), age as well as position within the herds social hierarchy (Ketelaar-de Lauwere *et al.*, 1996; Jago *et al.*, 2003) and social facilitation of behaviour, whereby the behaviour of one cow is influenced by that of another, or larger groups within the herd (Ketelaar-de Lauwere & Ipema, 2000).

The results have implications for the design of farm layouts and development of

management systems for automatic milking within pastoral dairying systems. Clearly a higher milking frequency will be able to be achieved more easily early in lactation. This is beneficial as most yield will be harvested in the first half of a lactation when a reduced milking frequency will have the most negative impact on overall production. In a seasonal-calving herd it may be more difficult to maintain a desired milking frequency as the cows reach late lactation, however this will depend upon the targeted milking interval. The greater willingness of cows to transit within the farm layout in early lactation has likely positive implications for cow training.

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