Remote automatic selection of cows for milking in a pasture-based automatic milking system

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ABSTRACT

New Zealand pastoral dairy farming presents unique challenges for combining automatic milking systems (AMS), including long walking distances, large herds, year round pasturing and a predominately fresh pasture diet. This paper describes a system designed to minimise walking, maximise the efficiency of AMS utilisation and enable control of individual cow milking frequency by remotely selecting cows for milking up to 400 m from the dairy. Cows report to a selection unit (SU) located in the centre of a block of pasture and linked via raceways to the AMS. Entry is via one-way gates and exit via a computer controlled drafting gate, which directs the cow either to the dairy or the paddock depending on time since last milking. A communication cable connects the SU to the AMS server in the dairy. Cows wear an electronic identification device. Water and pasture access act as incentives for cows to enter the SU. Cows readily learned to use the SU and were observed visiting the unit at every hour over 24 hours. Twenty-seven cows were assigned to either a 6h or 12h minimum milking interval (MMI). On average, cows visited the SU 4.5 and 5.5 times/d for the 6h MMI and 12h MMI groups, respectively, and achieved a milking frequency of 1.9 and 1.4 milkings/d, respectively. Results showed that milking frequency can be controlled via a system for remotely selecting cows for milking and that access to fresh pasture is a strong factor in motivating cow traffic through the SU.

Keywords: automatic milking systems; grazing; dairy cows; behaviour; pre-selection.

INTRODUCTION

New Zealand pastoral dairy farming conditions present unique challenges for combining automatic milking systems (AMS) and grazing. Dairy farms and herd sizes are typically large by world standards (average effective land area is 111 ha, average herd size 285 cows, LIC Dairy Statistics, 2002-203), with cows sometimes required to walk considerable distances (up to 3km) to the dairy. Cows graze year-round and the majority of herds are fed >90% of their diet in fresh pasture. Although automatic milking systems have been in commercial operation in Europe for over a decade, combining grazing with AMS has proven to be less sucessful than with cows housed indoors (Ketelaar-de Lauwere and Ipema, 2000).

A key consideration when developing a farm layout to combine AMS with grazing is the choice and availability of incentives to encourage a time-distributed flow of cows to the dairy. Typically concentrate and roughage feeds along with resting areas have been strategically used as incentives for cows to visit the AMS in housed systems (Prescott, 1995; Thune *et al*., 2002). However for pasture-based farming systems such as in New Zealand these are unlikely to be cost-effective due to current milk prices. An earlier paper described a method for milking cows without the need to manually collect the herd from pasture twice daily and drive them to the dairy (Jago *et al*., 2002). Access to water was used as an incentive for cows to leave the pasture after which they were required to walk to the dairy and through the AMS in order to return to pasture. Similarly, to access new pasture, cows were required to walk to the dairy and pass through the AMS. Although sucessful with a small herd walking a relatively short distance to the dairy this method meant there was a degree of inefficiency in that cows not due for milking, having left the paddock for water or any other reason, were required to walk to the dairy only to be released without milking.

The practicality of incorporating AMS into New Zealand dairying will partly depend on optimising the ratio of cows/AMS. It is likely that a milking frequency less than twice/day will be necessary to achieve this (Woolford *et al*., 2004). To attain maximum efficiency in terms of cow throughput it is desirable that only cows that require milking should present at the AMS (at the dairy). Previous studies have shown that cows will readily walk from pasture to the dairy up to a distance of 800m between 2 and 3 times per day (Ketelaar-de Lauwere *et al*., 2000; Salomonsson & Sporndly, 2000; Jago *et al*., 2002) and that a proportion of cows were rejected for milking due to insufficient duration since their last milking.

This paper describes an improved method for combining automatic milking into a mainly grazing system, which involves selecting cows for milking remote from the dairy.

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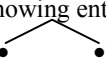
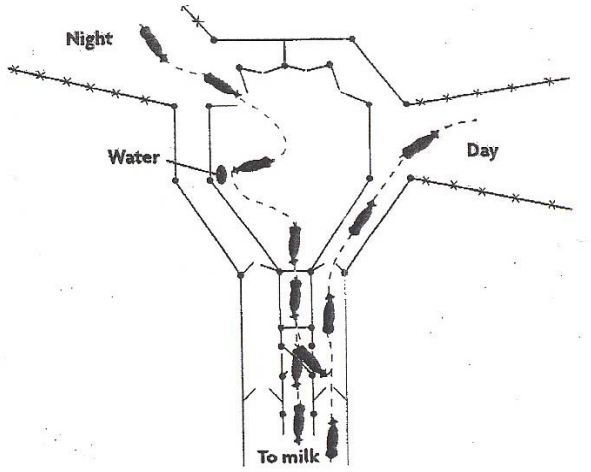
MATERIALS AND METHODS

Remote selection unit design

The system hardware consisted of a selection unit (SU) made of a concrete base and pipe rails, located in the centre of a 10 ha block of pasture and linked via raceways to the Fullwood Merlin AMS positioned on the edge of the land area and 180m from the SU. Cows entered the SU via cow-operated one-way gates and exited via a computer-controlled pneumatically operated gate at which point they were identified and directed either to the dairy or the paddock depending on the time since their last milking (Figure 1). The AMS server was programmed to make this decision and it was relayed to the SU with a communication cable laid above ground in alkathene which connected the SU to the AMS server in the dairy. Compressed air was used to drive the exit gates. Cows were fitted with a leg-mounted radio transponder identification device that allowed automatic identification at the SU and in the AMS. A water trough was located within the SU. No water was available within the pasture.

FIGURE 1: Configuration of remote selection unit showing entry via one-way gates: (•  •), water trough (), and automatic diversion either to the dairy for milking or to the paddock.



Animals and grazing management

A herd of 41 mixed-age (range = 3-12 years old) and mixed-breed cows were trained to enter the SU through the one-way gates and exit via the computer-controlled gates. All cows were experienced at using the AMS for milking. Twenty-seven cows (4 Jersey, 1 Ayrshire, remainder Friesian or FxJ) within the herd of 41 cows were part of a multi-factorial experiment that investigated the effect of feeding crushed barley in the AMS during milking and milking interval on behaviour and milking performance in a pasture-based automatic milking system (Jago et al., 2004). Only data on the effects of minimum milking interval on visiting frequency to the SU and milk yield for these 27 cows are presented in this paper. Data on the visiting pattern to the SU are presented for the herd of 41 cows.

Cows were assigned to either a 6h minimum milking interval (6hMMI; n = 13) or a 12 h minimum milking interval (12h MMI; n = 14) treatment. Each treatment was balanced for calving date (23 cows: 7 – 38 days lactation; 4 cows: 347 – 376 days lactation at start of data collection period) and as much as possible breed. There is a large range in daily visits to the AMS across individuals (Jago *et al.*, 2002) therefore historical data on the frequency of AMS visits was used to ensure the treatment groups were balanced for this factor. Data was collected for each cow for a total of 6 weeks in two blocks of 3 weeks for each cow. The 27 cows were split into three groups, each beginning their first 3-week observation period at least 7 days post-calving to allow them to become re-established in the farm system.

Cows were managed as described in Jago *et al.* (2002). 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. After entering the SU cows were prevented from returning to the paddock from which they had walked by one-way gates. On presentation at the exit gates of the SU a cow was either directed along the race to the AMS if due for milking, or released to pasture if not due for milking, via computer-controlled gates (Figure 1). Production rate and target yield criteria were used to derive the 6h or 12h MMI (Crystal 0.44, Fullwood Fusion, Holland) and therefore determine if a cow was due for milking. For example average production rate x interval required (either 6h or 12h) = target yield. 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 24h at 8:00h and 20:00h. 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 20:00h 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. Similarly, at 8:00h, 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.

Data collection

The time of exit of each cow from the SU was recorded automatically by a computing system (Crystal 0.44, Fullwood Fusion, Holland). Due to a problem with the electronic collection of this data the number of visits, time of exit and destination (to milking or to paddock) for each cow was checked by observation for six 24h periods between 20th August and 14th October 2002. The data from these six periods have been used in the analysis. The

electronic recordings were validated by observation using a camera positioned above the SU and recording the time she exited the SU. The time of entry to the AMS and milk yield were automatically collected by a computing system throughout the data collection period.

Data analyses

One cow was removed from the analysis due to consistent difficulties with cup attachment. Data on the effects of minimum milking interval on the number of visits to the SU and destination on exiting the SU as well as yield and milking frequency were analysed using residual maximum likelihood (REML). Exact P values are given. The distribution of visits to the SU and the destination on exiting was averaged over the six 24h observations for the entire herd (41 cows) and presented as an average number of visits per hour.

RESULTS

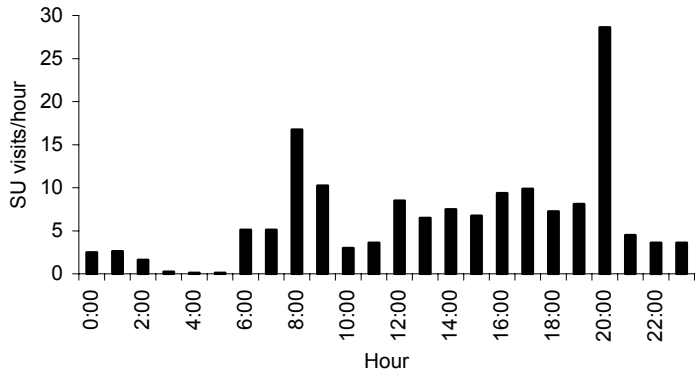
All cows readily learned to use both the one-way entry gates and computer-controled exit gates at the SU. Table 1 shows that there was a tendency ($p < 0.1$) for cows on the 12h MMI treatment to visit the SU more often than the 6h MMI treatment. Minimum milking interval significantly influenced the destination when exiting the SU with 12hMMI cows making more "to paddock" visits and fewer "to milking" visits than 6hMMI treatment cows. Daily milking frequency was higher for the 6hMMI cows. Although yield per milking was lower for the 6hMMI group, there was no significant effect of minimum milking interval on total daily milk yield/cow.

TABLE 1:. Average visits to selection unit (SU) per cow per day, destination when leaving selection unit (visits/cow/day) and milking data for a sample of 27 cows on either a 6h (n = 12) or 12h (n = 14) minimum interval between milkings.

	Minimum milking interval			
	6h	12h	SED	P value
SU visits (visits/cow/day)	4.54	5.52	0.527	0.071
Destination when leaving SU				
To paddock	2.58	4.05	0.440	0.003
To milking	1.96	1.47	0.187	0.019
Total milkings/cow/day	1.91	1.42	0.146	0.002
Yield/milking (kg/cow)	11.96	16.40	1.208	0.001
Total milk yield (kg/cow)	22.78	23.27	2.770	0.860
% times a cow remained in paddock at a changeover*	0.53	2.10	0.968	0.117

* number of times cow was remaining in paddock/total number of opportunities for cow to be in paddock at a changeover.

FIGURE 2: Distribution of visits over a 24h period to the remote selection unit (SU) by a herd (n = 41) grazing pasture and milked through an automatic milking system.



Cows visited the SU at all hours of the 24h period, however there were fewest visits between 03:00h and 06:00h (Figure 2). Visiting peaks occurred between 08:00h and 09:00h and between 20:00h and 21:00h, coinciding with the movement of any cows remaining from the previously grazed pasture to the SU and a new section of pasture being made available.

DISCUSSION

The data showed that it is possible to remotely select cows for milking when combining grazing with automated milking thus saving the need for cows to walk to the dairy for selection. As a result, individual milking frequency can be more effectively controlled within a herd. The SU allowed cows to access water, yet prevented unnecessary walking and time on races while maximising grazing opportunity.

Typically farms combining grazing with AMS have water located either at the dairy or in the paddock. The decision as to whether a cow should be milked is made either just prior to entering the AMS or once in the AMS. A 2001 survey of 66 Dutch farmers revealed that 38 supplied water in the paddock and 28 provided water only in the barn. Results from the survey showed that the number of animals that had to be fetched from the paddock increased by approximately 30% when water was available in the paddock indicating that water was an important reason that cows were voluntarily leaving the paddock (Van Dooren *et al*., 2002).

This is the first demonstration of a pasture-based AMS in which water was freely available to cows near to where they were grazing but at the same time was used as an incentive for cows to leave the paddock. The remote selection capitalises on the concept of utilising water as an incentive for cows to leave the paddock for purposes of pre-selection (Jago *et al*., 2002) and avoids cows unecessarily walking to the dairy if they are not due for milking. The SU is designed such that cows can enter and drink at any time but when exiting are identified and directed via a computer-controlled gate either to the milker if a calculated predetermined time since last milking has elapsed, or released to either a new area of pasture or where they had previously been grazing before entering the SU (depending on time of day).

The average number of times per day that cows left the pasture and entered the SU (4.5 – 5.5 visits/d) was considerably higher than the 2.7 visits to the dairy per day reported by Jago *et al*. (2002) for a similar sized herd at the same time of the year on the same land area where there was a compulsary walk to the dairy. This figure is also higher than the 2.7 visits/day to the barn reported by Ketelaar-de Lauwere *et al*. (2000) and Solomonsson and Sporndly (2000). One reason for the increased visiting frequency may be that cows learned they could enter the SU and drink without then being required to walk to the dairy and therefore were more inclined to visit the SU. Data are not available on the drinking frequency for this trial however it would be expected that cows would drink between one and four times per day (Albright and Arave, 1997). The higher number of visits by 12hMMI cows suggests that these cows were attempting to visit the milker more often than allowed and made more regular visits to the SU in an attempt to gain access to the AMS. The majority of cows in the study were early lactation and it is known that recently calved cows will milk more frequently than late lactation cows, given free choice (Prescott, 1995).

Another reason for the higher visiting frequency to the SU may be that cows learned they could gain access to the new pasture when visiting the SU at certain times of the day. This is evident in Figure 2 which shows the distribution of visits to the SU over 24h. The highest peaks of activity were recorded between 08:00 and 09:00 and 20:00 and 21:00, which coincided with the times at which a fresh section of pasture was made available. It was also the time any cows remaining in the old section of pasture were moved to the SU, however given the very low number of times cows had to be moved (Table 1) the high number of visits at these times was not entirely due to to enforced movement of cows.

Automated milking systems require that cows report for milking as individuals or small groups distributed over 24h and not in large groups or as a herd. One of the concerns of systems in which cows must walk to the dairy to get access to fresh pasture is that cows last to leave the old pasture and therefore last to arrive on the previously new pasture must then walk back to the dairy in order to gain access to the newest pasture break when it becomes available. One advantage of the remote pre-selection for milking is that cows arriving last onto the previously fresh pasture (up to 12 hours since the first cow gained access) have the opportunity to access the new pasture when it is available via the SU without having to first walk back to the dairy. This system should ensure that there is a more even access to fresh pasture.

In this study the number of cows milked by one AMS was far below the theoretical capacity of 150 milkings/day (Woolford and Jago, 2002). The study has demonstrated the potential for remote selection to limit walking and potentially improve the efficiency of AMS utilisation by ensuring that only cows needing to be milked present at the dairy. It has shown that the selection unit can be programmed (via the AMS computer system) to increase or decrease milking frequency as desired by the farm manager, consequenctly milking frequency can be controlled at pasture and not at the AMS. In addition, the remote SU ensures cows have ready access to water but without it being in the paddock and without it being a considerable walk from the paddock.

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