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Dominance effects on the time budget and milking behaviour of cows managed on pasture and milked in an automated milking system

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ABSTRACT

The influence of social hierarchy on the behaviour of a herd of 41 cows milked in an automated milking system (AMS) was studied under conditions of free or no access to water at pasture. In phase 1 (P1) water was available within a central collection area (CCA) in the centre of the farm from which return to pasture was via the AMS. In phase 2 (P2), water was available at pasture in addition to the CCA. The time budget for activity (grazing, standing, lying or walking) and location (paddock, CCA entrance race, exit race or waiting yard) was determined over 2x24h in each of P1 & P2. Dominance values (DV) were calculated and cows classified as high, middle or low ranking. In P1 & P2, DV was positively related to the number of milking visits to the AMS. In P1, 83.4% of all drinking occurred in the CCA compared with 14.2% in P2. Social rank had no effect on time budget in P1, however, in P2, DV influenced waiting times with lower ranking cows spending a greater proportion of time waiting before entering the AMS. The results show that social rank affects the number of visits to the AMS and yard waiting times but has little effect on the activity time budget of cows milked in a AMS.

Keywords: automatic milking systems; grazing; dairy cows; behaviour; social hierarchy; dominance.

INTRODUCTION

Automated milking systems (AMS) rely on cows voluntarily presenting themselves for milking evenly during a 24-h period. The farm is typically designed using the placement of feed, usually concentrate and/or forage, to encourage cows to visit the AMS. The prototype farm combining grazing with AMS and described by Jago *et al.* (2002) used the strategic placement of water, crushed barley and pasture to generate cow flow.

It is well documented that within a herd, cattle develop a social hierarchy (Syme & Syme, 1979). An individual's position in the hierarchy will determine their access to resources such as feed, water and resting places (McPhee *et al.*, 1964; Kabunga, 1992). Dominant animals take priority access to resources, particularly when the contested resource is scarce.

Previous studies have shown that within indoor housing systems, social rank influences attendance at the AMS (Prescott, 1996), timing of visits and waiting times prior to entering the AMS (Ketelaar-de Lauwere *et al.*, 1996). The pasture-based AMS farmlet described in Jago *et al.* (2002) creates a competitive situation at the entrance to the AMS as access to fresh pasture is via the AMS, which can be occupied by only one animal at a time. In addition, water is not freely available at pasture but is available at three watering points: one at a central collection area (CCA) located in the centre of the farm and a second in the waiting yard prior to entering the AMS and the third in the exit race after exiting the AMS. The competitive situation at the entrance to an AMS has the potential to affect cows ability to visit the AMS for milking and, as a consequence, their access to pasture.

This study aimed to evaluate the effect of social rank on the visiting behaviour and time budgets of cows milked in an AMS under conditions of free or no access to water at pasture.

MATERIALS AND METHODS

Animals, farm layout, grazing and feeding management

An established herd of 41 mixed-age (range = 2-11 years) and mixed-breed (31 Friesian, 8 Jersey and 2 Ayrshire) cows which were familiar with the farm layout and AMS, were used in this study. Each cow was fitted with a leg-mounted transponder for automatic identification within the AMS. Cows had access to the AMS for 24h/day, with the exception of three seven-minute periods at 0600, 1130, and 1930 when the unit was automatically washed.

The farm layout is described in full in Jago *et al.* (2002). Briefly, two paddocks were grazed at any one time. Cows walked from one paddock to a yard positioned in the centre of a 10 ha block. A two-way race joined the CCA and waiting yard adjacent to the AMS. On presentation at the AMS, a cow was either milked (if ≥ 6 h since last milking), returned to the waiting yard (if ≥ 5 and < 6 h since last milking) or released to pasture (if < 5 h since last milking) via AMS-controlled gates. Twice daily any cows remaining in the previously grazed paddock were moved to the CCA. Cows received a total of 2kg/24h of crushed barley in the AMS during milking.

Design

The study was carried out in two phases, covering 38 and 35 days respectively, between October 2001 and January 2002. In phase 1 (P1), water was located within the CCA, from which return to pasture was via the AMS, in the waiting yard before entering the AMS, and in the area immediately after exiting the AMS. In phase 2 (P2) water was available at pasture in the two paddocks currently being grazed, in addition to the CCA, waiting yard and exit race.

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Data collection

Milking data: The time of entry to the AMS, the type of visit (milk or return to pasture without milking), outcome of each milking event (unsuccessful or successful teat cup attachment) and yield were automatically collected by a computing system (Crystal 0.44, Fullwood Fusion, Holland).

Time budget: The time budget for individual cows was determined by a team of observers over 2x24h periods in each of P1 & P2. Individual animals were identified by a combination of ear tags, freeze brands and large numbers painted on their sides. The location (paddock, CCA/entrance race, exit race or waiting yard) and activity (grazing, standing, lying or walking) of each cow was recorded at 10-minute intervals. Cows engaging in mounting, drinking or agonistic behaviour were recorded as standing. All occurrences of drinking behaviour as well as the location of the water trough during each drinking event were recorded using continuous behaviour sampling. A drinking event was defined as a cow dipping her muzzle in the water and drinking. Multiple dips into the water trough were considered a single drinking event. Water intake from each water trough was determined using water meters that were read daily at 0800h. Daily maximum temperature was obtained from the Ruakura Meteorological Station located approximately 5km from the trial site.

Establishment of social hierarchy: The outcomes of agonistic interactions between pairs of cows observed when cows were either in the CCA or waiting yard were recorded over the duration of the study. The observations were carried out during peak visiting times to increase the chance of viewing large numbers of interactions between different pairs of cows. An interaction was recorded when an agonistic behaviour (threat, bunt or push) initiated by one cow displaced another. The cow that caused another cow to be displaced was determined the winner. Using the method described by Sambraus (1975) and Ketelaar-de Lauwere *et al.* (1996) the dominance value (DV) of each cow was calculated by determining the relative number of cows that were subordinate to the cow concerned (D of Cow A = number of cows subordinate to Cow A/number of known

dominance relationships of Cow A). A dominance relationship was considered known when one cow of a pair had displaced the other at least once more than vice versa (Wierenga, 1990). Dominance relationships are persistent over time (Syme & Syme, 1979), therefore dominance was not determined separately for each phase of the study.

Data analyses

Data from 40 cows were used in the analysis as one cow was removed from the herd mid-way through P1 of the study for reasons unrelated to the study. Data from 2 days in P1 and 1 day in P2 were not included in the analysis due to disruptions to the AMS for over 2h. Cows were classified as high (DV>0.60), middle (0.60>DV>0.40) or low (DV>0.40) ranking (Ketelaar-de Lauwere *et al.*, 1996). The time budget for individuals was calculated by summing the number of observations for each behaviour or location and expressing this as a percentage of total observations or proportion of time. Data was subject to an analysis of variance with dominance value as the main effect.

RESULTS

A total of 484 agonistic interactions between pairs of cows were observed from which a DV was calculated for each cow. There were 12, 13 and 15 cows ranked as high, middle or low social rank, respectively. Dominance value affected milking frequency in P1 and P2 with high ranking cows making more milking visits than low ranking cows (Table 1). Cows made very few non-milking visits to the AMS in either phase. Milking visits were distributed over 24h with fewest visits between midnight and 0600h. In P1, high-ranking cows made proportionately fewer visits between 1800h and midnight compared with middle- and low-ranked cows. Cows were in mid to late lactation and averaged 16.3 and 13.3 kg/day, during P1 and P2, respectively. Yield did not differ with DV in either P1 or P2 (Table 1).

There was no significant effect of social rank on total number of drinking bouts in either P1 (mean drinks/cow/24h = 1.8, 2.3 and 2.5 for low-, middle- and high-ranked cows, respectively, sed = 0.38) or P2 (mean drinks/cow/

TABLE 1: Milking and non-milking visits (per 24h) to the automatic milking system, distribution (%) of milking visits according to four 6-hour periods and yield (kg/24h) when water was available in the CCA, waiting yard and exit race (Phase 1) or paddock in addition to the CCA, waiting yard and exit race (Phase 2), for cows of low, middle or high social rank within a herd of 41 cows milked by an AMS and managed on pasture.

Phase		Social Rank			SED	P	
		Low	Middle	High			
1	Milking visits	1.8	2.0	2.1	0.13	0.05	
	Non-milking visits	0.18	0.22	0.30	0.060	NS	
	% of milking visits between:	00.00 – 06.00 h	14.0	13.4	12.9	2.33	NS
		06.00 – 12.00 h	24.8	29.5	29.0	2.68	NS
		12.00 – 18.00 h	32.3	29.1	34.5	2.84	NS
		18.00 – 00.00 h	29.0	28.1	23.6	2.29	< 0.05
Yield (kg/24h)	15.1	16.8	16.9	1.43	NS		
2	Milking visits	1.6	1.9	1.9	0.12	< 0.05	
	Non-milking visits	0.16	0.16	0.22	0.057	NS	
	% of milking visits between:	00.00 – 06.00 h	16.6	16.1	13.6	2.61	NS
		06.00 – 12.00 h	20.7	27.6	26.3	3.56	NS
		12.00 – 18.00 h	29.6	25.8	30.1	2.93	NS
		18.00 – 00.00 h	33.2	30.6	29.9	2.53	NS
Yield (kg/24h)	12.3	13.9	13.8	1.3	NS		

24h = 2.7, 2.7 and 3.3 for low-, middle- and high-ranked cows, respectively, $sed = 0.58$). There was no effect of social rank on the number of drinks at each of the different watering points in either P1 or P2. Cows did not use the various watering points equally. In P1, 83.4 % of all drinking occurred at the CCA and only 16.5 % occurred at the waiting yard while no instances of drinking were observed from the water trough in the exit race. In P2, 14.2% of all drinking occurred in the CCA, 2.4% occurred in the waiting yard, 0.0% from the exit race and 83.3% in the paddocks. Average water intake during P1 and P2 was 20.7 L/cow and 29.5 L/cow, respectively. Average maximum daily temperature was 20.7°C and 22.6°C for P1 and P2, respectively.

In both P1 and P2, cows spent the majority of their time at pasture, followed by the CCA/entrance race, waiting yard and least time in the exit race. In P1, cows spent (mean \pm sem) 18.3 \pm 1.6h of the 24h at pasture, 3.2 \pm 1.5h in the CCA/entrance race, 2.2 \pm 0.50h in the waiting yard and 0.4 \pm 0.3h in the exit race. In P2, the cows spent 20.6 \pm 0.8h at pasture, 1.6 \pm 0.7h in the CCA and entrance race, 1.4 \pm 0.3h in the waiting yard and 0.3 \pm 0.4h on the exit race. Dominance value had no effect on the location time budget of cows in P1, however, in P2, time in the waiting yard decreased with increasing DV (time in waiting yard = 1.9h, 1.3h and 1.1h for low, middle and high ranking cows, $sed = 1.25$, $P < 0.05$, respectively), despite high-ranking cows making more milking visits/day. On average, in P1 and (P2), cows grazed for (mean \pm sem) 8.1 \pm 0.8h (8.9 \pm 0.6h), lay for 9.0 \pm 0.8h (9.1 \pm 0.9h), stood for 3.5 \pm 0.8h (4.1 \pm 1.1h) and walked for 0.6 \pm 0.1h (0.6 \pm 0.2h) per day. The activity time budget of cows was not affected by DV in P1, however, in P2 there was a tendency for lower-ranked cows to graze longer than middle- or higher- ranked cows (time grazing = 9.4h, 8.6h and 8.6h for low, middle and high ranking cows, $sed = 0.42h$, $P = 0.060$).

DISCUSSION

This is the first study to investigate the effect of a cows' place in the herd social hierarchy on behaviour and performance within a *pasture-based* automatic milking system. The results show that social rank influences the frequency of milking and, when water is freely available at pasture, the waiting times prior to entering the AMS. The placement of water but not social rank, influences the cows choice of drinking site.

There was a clear positive relationship between social rank and milking frequency when water was available at pasture as well as when water was available only within the central collection area, yard and exit race. A similar positive relationship between overall visits to the AMS and dominance was reported by Prescott (1995) for was housed indoor and milked with an AMS. However Ketelaar-de Lauwere *et al.* (1996) found no influence of social order on visits to the AMS. It is postulated that in the present study, because of their social status, cows of higher rank could make their way from pasture to the AMS more quickly than lower-ranked cows and gain priority access to the AMS, which could result in a higher milking frequency. Therefore, the lower milking

frequency for low-ranked cows could be due to a behavioural limitation on the cows ability to access the AMS for milking. Certainly, when water was freely available at pasture, this was likely to have been the case as lower-ranked cows waited longer before entering the AMS, suggesting that they were being prevented from accessing the AMS by higher ranked cows. When water was not available at pasture, waiting times were not influenced by social rank suggesting that the lower milking frequency for lower ranked cows was due to factors other than restricted access to the AMS. These factors could include a reduced motivation to make the journey from pasture, through the CCA, entrance race and AMS due to previous negative experiences in these areas, possibly caused by agonistic encounters with higher-ranked cows.

Social rank is known to influence a cow's ability to access feeding stations (Wierenga & Hopster, 1991). Cows were rewarded for visiting the AMS with up to 2kg of crushed barley, therefore, the AMS was effectively a feeding station within the farm layout. In addition, access to pasture was via the AMS, further focusing the AMS as a pivotal resource for the cows. Higher-ranked cows typically have priority access to feed resources and this may be reflected in the higher milking frequency.

The timing of visits to the AMS seemed to differ according to social rank, however, the trends were weak and not consistent between P1 and P2. In general, proportionately more low-ranking-cow visits occurred later in the day and evening (between 1800h and midnight) and more middle- and high-ranking-cow visits occurred early in the day (between 0600h and midday). In contrast, Ketelaar-de Lauwere *et al.* (1996) reported that lower-ranking cows made more visits between 0.00 and 0600h and cows of higher rank made more visits to the AMS during the day time (between 12.00 and 18.00h). This study was carried out in indoor-housed cattle fed a different diet to those cattle in the current study. Both these factors are likely to have an impact on cow behaviour patterns making a meaningful comparison difficult.

The time budgets for grazing and lying times were consistent with cows managed in pasture-based systems with twice-daily batch milking (Hancock & McMeekan, 1950; Thorne *et al.*, 2003). Dominance value did not affect the time budget of cows when water was available only within the CCA, waiting yard and exit race, indicating that although cows spent considerable time off pasture in the CCA and entrance race they still spent sufficient time at pasture to achieve expected grazing times. The tendency for lower-ranked cows to spend longer grazing in P2 when water was available at pasture, is may be a consequence of the longer waiting times in the yard before entering the AMS. The lower-ranked cows likely entered the fresh break of grass later than the rest of the herd and had to graze longer to achieve similar intakes (Hancock, 1953).

Cows spent considerable time in the CCA and entrance race, particularly when water was not available at pasture. Cows were observed standing or lying in the entrance race even when the waiting yard was empty. In these instances there was no obvious explanation for cows not

to walk directly to the waiting yard and the reason for this pattern of behaviour is unclear. Long periods of time spent on raceways, while not appearing to negatively affect grazing times in this study, have the potential to impact negatively on cow health, particularly if the cows lie down in faeces, thereby increasing the risk of environmentally transferred mastitis pathogens entering the udder (Lacy-Hulbert *et al.*, 2002).

Cows spent very little time in the exit races. This may be explained by the prospect of fresh pasture after exiting the AMS and the unrestricted raceway allowing a clear passageway back to pasture.

The total number of drinks per cow per day reported in this study is consistent with previous studies (Albright & Arave, 1997). The frequency of drinking is known to be dependent upon temperature, condition of feed, stage of lactation and availability of water (Arave & Kilgour, 1982; Murphy, 1992). Earlier studies of a herd of lactating cows found that during a similar time of the year and stage of lactation, cows drank on average 2.3 times per day (Jago, unpublished data). Cows clearly preferred to drink in the CCA when water was not available at pasture, as opposed to in the waiting yard or exit race. When water was available at pasture, cows preferred this source to the CCA. Social rank could be expected to affect a cow's ability to access water. Simply comparing drinking bouts may be misleading, however, as cows could compensate for limited access by consuming a greater quantity during a single bout. It was not possible to measure individual intakes in this study. If social status was preventing lower-order cows from accessing water in the CCA (when none was available at pasture) it could have been expected that lower-order cows may have used the trough in the waiting yard or after they left the AMS. However, this did not occur, indicating that social order appears to have had no negative impact on drinking behaviour. The higher daily intake during P2 could be partly due to easier access to water but also due to the higher daily air temperature during this period.

The theoretical capacity of the AMS system is approximately 150 milkings/day. In this study, the herd size of 41 and an average of approximately 80 milkings/day meant the system was below capacity. As herd size increases, the effects of the social dynamics of the herd would expect to be exaggerated, as there is increasing competition for resources. Waiting times for lower-ranked cows would likely increase, as would disparity in frequency of milking between lowly and highly ranked cows. Automated milking systems, while allowing a degree of choice in timing of daily activities for cows, may, under certain circumstances, disadvantage cows of low social rank. Careful attention must be paid to farm layout and in particular the positioning of key resources to minimise the negative impact of social behaviour among cows managed within farms utilizing an automatic milking system.

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