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Behavioral Pattern of Dairy Cows Milked in a Two-Stall Automatic Milking System with a Holding Area[1]

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ABSTRACT: Behavioral pattern was investigated in dairy cows milked in an automatic milking system (AMS) in contrast to cows milked in a conventional milking parlor. Forty-eight Holstein cows were allocated to two groups of 24 animals. The two groups were housed in adjacent free stall pens. Both groups were milked twice a day at 0500 and at 1500 for 30 d before commencement of the experiment, one in a two-stall AMS (AMS Group), the other in a 16-stall herringbone parlor (Parlor Group). The respective holding areas were used to encourage cows to enter the milking compartments. All cows consumed total mixed rations ad libitum, provided once a day between 0500 and 0600 in indoor feed bunks. Cows in both groups were allowed daily access to two adjacent outdoor paddocks from 1030 to 1230. Behavioral observations were carried out in the free stall barn from 0400 to 0900 and from 1250 to 1900 for 30 d. The number of cows lying down, standing in the stalls, standing in the passageway, and eating was recorded every 10 min. Analyses of variance were used to compare time serial changes in behavioral states between groups. Although the time serial changes in the behavioral states were not different between groups after returning from paddocks, they became significantly different between groups for all four recorded behavioral states after the onset of milking. Ethograms during the 11-h observation period showed that cows in the AMS group spent less time eating at the feed bunk and standing in the stalls to compensate for the longer time standing in the holding area. The results indicate that AMS milking with a holding area affects social synchronization of cows eating and resting and reduces time spent eating significantly more than parlor milking.

Key Words: Dairy Cattle, Automation, Milking Machines, Milking Parlors, Animal Behavior

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Introduction

Several types of automatic milking systems (**AMS**) have been developed in recent years and some are already in commercial use (Hogeveen, 1994). The AMS is expected to facilitate more frequent daily milking and a corresponding increase in daily milk yields (Hillerton and Winter, 1992; Ipema and Benders, 1992). Studies with the AMS have been conducted mainly in relation to the reliability of teat cup attachment (Hogewerf et al., 1992), economic and labor evaluation (Rossing, 1990; Parsons, 1991), and adaptability of dairy cows to the system (Jagtenberg and Van-Scheppingen, 1994). Posture during milking (Artmann et al., 1992) and voluntary entry and exit to and from the milking stall (Ketelaar-de Lauwere et al., 1992; Devir et al., 1993; Marchal et al., 1994; Winter and Hillerton, 1995) have been also studied. Winter and Hillerton (1995) reported that an increase in the number of daily milkings per cow is associated with a reduction in synchrony for maintenance behaviors. Some studies reported that voluntary movement of cows to and from the AMS was not fully satisfactory in the present systems even if concentrates were provided in the milking compartments (e.g., Metz-Stefanowska et al., 1993; Winter and Hillerton, 1995). For this reason, until a new effective and efficient milking system is established, the usage of a holding area at the entrance to the AMS would be one of the preferred choices in AMS milking arrangements. The objective of this study was to investigate time serial changes and time budgets in behavioral states and the proportion of time spent performing the behavioral states of dairy cows milked either in an AMS or a conventional milking parlor, with special attention to social synchronization of their behavior (Hurnik, 1992).

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Materials and Methods

Forty-eight Holstein cows were allocated to two groups of 24 animals. The two groups were comparable in milk yield, days in milk, lactation number, and age (Table 1). The two groups were housed in adjacent free stall pens (14 m × 34 m) at the Elora Dairy Cattle Research Centre, University of Guelph. Each pen contained 24 stalls (1.2 m × 2.1 m), a feed bunk (.8 m × 22 m), and slatted concrete floor passageway (width 3.5 m). One group was milked in a two-stall AMS, installed at the side of the free stall barn (AMS Group). The AMS was manufactured by Prolion in The Netherlands. The other group (Parlor Group) was milked in a double-eight (16 stalls) herringbone milking parlor adjoining the free stall barn. The herringbone parlor was manufactured by Westfalia Separator AG in Germany. Milking was conducted twice a day at 0500 and at 1500. The respective holding areas (AMS Group 3.8 m × 9.6 m; Parlor Group 5.4 m × 7.3 m) were used to ensure all cows passed through the milking compartments for milking. All cows were subjected to their respective milking conditions for 30 d before commencement of the experiment. All cows were offered total mixed ration (**TMR**) between 0500 and 0600 for ad libitum consumption. The AMS Group diet was adjusted for the 3.0 kg of grain pellets each cow received in the amount of 1.5 kg/milking. Cows in both groups were allowed daily access to separate outdoor paddocks (16 m × 22 m) from 1030 to 1230.

The duration of the milking period was measured as the time from aggregation of cows in the holding area until the last cow returned to the free stall pen. Behavioral observations were carried out from 0400 to 0900 and from 1250 to 1900 for 30 d. Behavioral states (Hurnik et al., 1995) of the cows were recorded at 10-min intervals, focusing on the number of cows lying down in the stalls, standing in the stalls, standing in the passageway, eating at the feed bunk, standing in the holding area, and milking in the milking compartments. Cows drinking from the water troughs were included with cows standing in the passageway. Proportion of time spent performing the behavioral states during the 11-h observation period was estimated using 10-min interval data (Martin and Bateson, 1993).

Experimental data were statistically analyzed using SAS (1994). The duration of the milking period and proportion of time spent performing the behavioral states were compared between groups using a paired *t*-test. Time serial changes in behavioral states were compared between groups using repeated measures analysis of variance according to GLM procedures of SAS. When Huynh-Feldt epsilon was in the range of 0 to 1, the adjusted *F*-test by Greenhouse-Geisser was used.

Table 1. The variables (mean ± SD) milk yield, days in milk, lactation number, and age of cows allocated to be milked using an automatic (AMS Group) and a parlor (Parlor Group) milking system

Variable[a]	Group	
	AMS	Parlor
Milk yield, kg/d	22.40 ± 7.19	24.05 ± 8.08
Days in milk	247.5 ± 66.5	240.1 ± 94.3
No. of lactation	2.0 ± 1.1	2.0 ± 1.4
Age, mo	38.4 ± 15.6	37.8 ± 18.5

[a]Not significant for all variables between groups.

Results and Discussion

Time serial changes in behavioral states after returning from the paddocks and after the onset of milking are shown in Figure 1. After returning from the paddocks, the time serial changes in the behavioral states were not different between groups for any of the four recorded states. Most cows (75% or more) finished eating within 40 min and lay down within the next 20 min. The results verify the behavioral tendency of cattle as social animals; they prefer to eat, rest, and perform many other activities in a socially synchronized fashion, as discussed by Hurnik (1992).

During milking, the distinct difference in the number of cows admitted into the milking compartments (2 cows in the AMS vs 16 cows in the parlor) caused a large difference in the duration of the milking period. This duration was 130 ± 26 min in the morning and 119 ± 16 min in the evening in the AMS Group, whereas the duration in the Parlor Group was 37 ± 8 min ($P < .001$) and 25 ± 8 min ($P < .001$). As an unavoidable consequence of this discrepancy, significant differences in time serial changes in standing in the holding area ($P < .001$ in the morning; $P < .001$ in the evening) and milking in the milking compartments ($P < .001$ in the morning; $P < .001$ in the evening) occurred between groups. In addition, the time serial changes in other behavioral states became statistically significant between groups during and after milking, especially in the morning (standing in the stalls, $P < .05$; standing in the passageway, $P < .01$). Most cows (75% or more) finished eating within 80 min and lay down within 100 min in the Parlor Group, whereas it took 140 min to finish eating ($P < .001$) and 170 min to lay down ($P < .001$) in the AMS Group. The time serial changes (time budgets) in the behavioral states were also significantly different between groups in the evening (standing in the stalls,

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$P < .001$; standing in the passageway, $P < .001$; eating at the feed bunk, $P < .001$). The time serial change in lying in the stalls was also significantly different between groups ($P < .001$); however, the difference seemed to be less pronounced than in the morning, and more than 35% of cows did not lie down even within 170 min in both groups. This was essentially caused by cows in the Parlor Group that were standing in the stalls longer in the evening than in the morning before lying. The longer standing in the evening may be explained by the diurnal pattern of nutritional behavior in cattle. Cows seem to have the longest meal in the evening, and the most intensive period of rumination occurs several hours after dusk (Phillips, 1993). Relatively longer eating times were detected in both groups in the evening, compared with those in the morning (Figure 1; Eating at the feed bunk).

The estimated proportion of time spent performing the behavioral states during the 11-h observation period for cows in both groups is shown in Table 2. Although individual milking in the AMS resulted in a shorter time that cows spent in the milking compartments compared with milking in the parlor ($P < .05$), the limitation of only two compartments in the AMS caused a large difference in time spent standing in the holding area ($P < .001$). Cows in the AMS Group spent approximately the same time lying down as

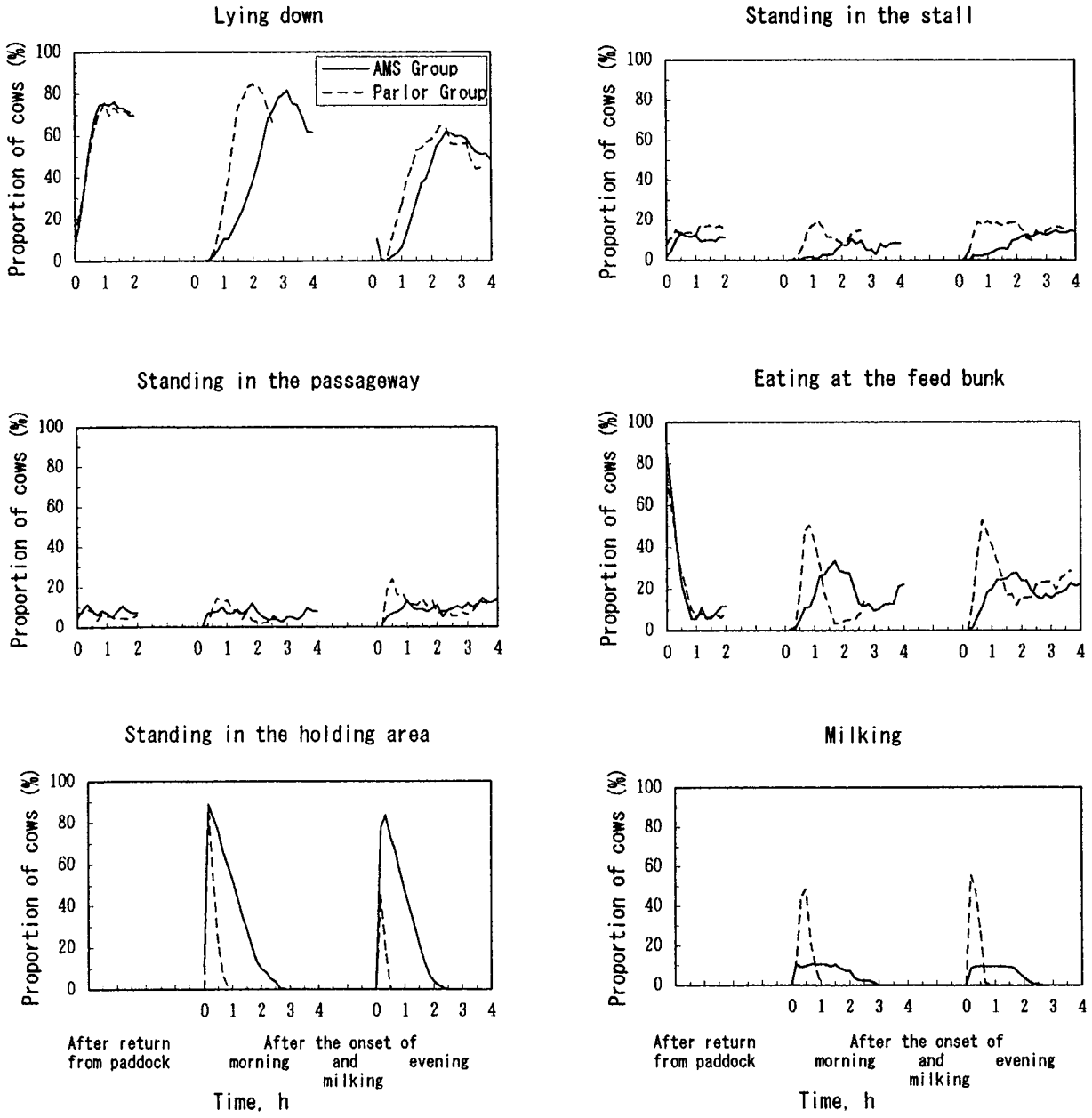

Figure 1. Time serial changes in behavioral states of cows after returning from the paddock and after the onset of morning and evening milking in both groups (automatic milking system [AMS] and Parlor Groups).

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Table 2. Estimated proportion (mean ± SD, %) of time spent performing the behavioral states during the 11-hour observation period for cows allocated to be milked using an automatic (AMS Group) and a parlor (Parlor Group)[a] milking system

	Behavioral state					
Group	Lying down	Standing in the stall	Standing in the passageway	Eating at the feed bunk	Standing in the holding area	Milking
AMS	45.9 ± 3.3	8.4 ± 1.7[e]	8.0 ± 1.7	17.9 ± 3.2[c]	16.4 ± 3.1[e]	3.4 ± .3[a]
Parlor	46.4 ± 3.1	14.4 ± 1.6[f]	9.7 ± 3.2	21.8 ± 1.8[d]	3.6 ± 1.9[f]	4.1 ± .7[b]

[a,b]Means within a column lacking a common superscript differ ($P < .05$).
[c,d]Means within a column lacking a common superscript differ ($P < .01$).
[e,f]Means within a column lacking a common superscript differ ($P < .001$).

those in the Parlor Group. The cows in the AMS Group spent less time eating from the feed bunk ($P < .01$) and standing in the stalls ($P < .001$) to compensate for the longer time standing in the holding area. In contrast to our results, Winter and Hillerton (1995) reported identical time spent eating and a decrease in lying time. Recording the duration of various behaviors in a free stall barn for each of the 5 d of voluntary milking with an AMS, they found that overall daily eating time was not different between the days, occupying approximately 25% of 18 h, whereas lying time decreased for the final 3 d from approximately 44 to 35%. Possible explanations for the different results could be the introduction of a holding area, use of concentrates during AMS milking, and a TMR provided for ad libitum consumption in this experiment. A long time standing in the holding area and free access to the feed bunk could cause resting desires of cows to be relatively stronger than their appetite after returning from the milking compartments.

The results of this study indicate that AMS milking with a holding area affects social synchronization of cows eating and resting and reduces time spent eating significantly more than parlor milking. To harmonize the systems with the psychological and social tendencies of dairy cows, the designers of AMS should consider increasing the number of milking compartments to accommodate more cows simultaneously.

Implications

The results of this study show that milking in a two-stall automatic milking system with a holding area affects social synchronization of cows eating and resting and reduces time spent eating more than does a 16-stall herringbone parlor milking. We conclude that behavioral tendencies of cows should be considered when new management systems are designed for the automatic milking system.

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