Behavioral activity of dairy cows milked in a free traffic automated milking system

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Abstract. The aim of this study was to investigate the behavioral activity of lactating cows kept in an automatic milking system (AMS) with free cow traffic. Thirty-two lactating Holstein dairy cows (13 primiparous and 19 multiparous) with a lactation number of 1.94 ± 0.2 (mean ± SD), days in milk of 152 ± 13.2 d, and a milk yield of 31.0 ± 1.8 kg/d were enrolled in the study. The cows had access to 2 single-box AMS. Durations of individual acts of behavior was determined by visual observations of individual cows over 3 days and was calculated for each day of observation. Cows spent 280.8 ± 11.2 min/d eating. This eating time was dividing into 9.2 ± 0.4 bouts/d, which lasted 30.7 ± 1.0 min. This accounted for 19.5% of total time spent eating. The cows' lying time was 660.9 ± 27.9 min/d, lying bout frequency was 7.4 ± 0.4 bouts/d, and the lying bout duration was 89.2 ± 23.3 min/bout and accounted for 45.9% of the total time spent lying. The rumination activity time of cows was 508.0±3.6 min/d, the rumination activity bout frequency was 11.9±0.4 bouts/d, and the duration of a rumination activity bout was 39.3 ± 1.0 min. This accounted for 36,2% of total time spent rumination activity. The standing time of cows was 779.1 ± 27.9 min/d or 54.1% of the total time, and the walking time of cows was 10.3 ± 0.5 min/d or 0.7% of the total time. The milking time of cows is 20.49 ± 0.92 min/d (or 1.4% of the total time), milking frequency is 3.2 ± 0.1 times per day, milking bout duration is 5.49 ± 0.92 min/times. These results add to body of literature on cow behavioral activity under AMS conditions.

1 Introduction

In the Russia, the use of automatic milking systems (AMS) has shown an increasing trend, although the adoption rates have been slower than in Europe and North America. Conventional parlor milking systems provide a more structured daily routine, whereas AMS allow for more flexibility in eating, lying or milking times for individual cows and impact on daily behavioral activity [1].

The study of behavioral acts is an important factor in determining the welfare of cows [2]. During economic use, cows are exposed to a multitude of management-related changes [3]. These changes, in addition to the traffic situations [4], climatic conditions, and other factors [5], can influence the behavioral activity of cows.

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To our knowledge, no studies to date have assessed the time budget of cows in Russian AMS dairy herds. The objectives of the current study were to investigate the behavior of cows milked in a free traffic AMS kept in the Russia.

2 Materials and methods

2.1 Animals, housing and feeding

Thirty-two lactating Holstein dairy cows (13 primiparous and 19 multiparous) with a lactation number of 1.94 ± 0.2 (mean ± SD), days in milk (DIM) of 152 ± 13.2 d (range 65…312 d), and a milk yield of 31.0 ± 1.8 kg/d (range 14.4…56.3 kg/d) were selection for the study.

All procedures in this study involving animals were carried out in accordance with the rules for conducting work using experimental animals (Ministry of Health USSR, 1977) [6].

The selected animals were housed in a tree-stall barn and an AMS with free cow traffic (i.e., cows were allowed to traffic between the resting area, feeding area and milking area freely), located in the peasant farm "Mukhametshin Z.Z." (Sabinsky district, Republic of Tatarstan, Russia).

The barn divided into 2 slatted floor sections with approximately 115 lactating cows in each section had access to 128 lying stalls, 2 cow brushes, ad libitum water from 3 self-filling troughs at each end of the sections and 1 in the middle. They also had access to 2 single-box AMS (Astronaut A4, Lely, the Netherlands) for 22.5 h/d (in total 1.5 hours was dedicated to cleaning of the system). Cows were granted milking permission after 4.5 h from previous milking, unless a milking failure occurred, in which case cows would be granted permission to be milked again immediately. Cows that had not voluntarily entered the milking box for more than 8 h since the last milking were fetched to be milked.

The concrete lying stalls were covered with mattresses, and the tops of the mattresses were bedded daily with wood sawdust.

The cows were fed a partially mixed ration (PMR) containing 16.8 kg of dry matter (DM) per cow (ME 10.5 MJ, CP 17%, CF 19.2% on a DM basis) and mixed in a mixer-dispenser (ISRK-12 Khozyain, LLC Zapagromash, Belarus). The PMR was formulated according to the NRC (2001) nutrient requirement recommendations for high-producing dairy cows [7]. Fresh PMR was delivered 3 times/d at 5:30, 9:30 and 15:30, and was offered ad libitum. In addition, concentrated pellets were fed in the milking box in the amount of 220-250 g per 1 kg of milk (ME 14.2 MJ, CP 15.2%, CF 6.4% on a DM basis). Feed table were cleaned out daily before addition of fresh PMR, no earlier than 4:45 h.

2.2 Protocol for observation of behavior

Durations of individual acts of behavior was determined by visual observations of individual cows over 3 days and was calculated for each day of observation. Data were then averaged over the 3-d observation period. The 12 h before observation of behavioral, the cows were marked with animal spray paint (Yard Color, LLC PCF AeroKhim, Russia) on the neck, back, rump in the form of transverse stripes and dots in various combinations to improve identification of individual cows. At each change in the act of behavior of the cow, the time (h:min:sec), the act of behavior and the location of the cow were recorded. The act of behavior and location may fall under any of the following categories: eating, rumination activity, lying, standing, walking and milking (Table 1).

2.3 Data collection, handling and statistical analysis

Animals were observed from July 2022 to June 2023. The 12-month data collection period was chosen to cover seasonal variations in ambient temperature and relative humidity in the Eastern European part of the Russia.

The diurnal pattern of rumination activity of cows was recorded using an electronic system in the form of a logger (Qwes HR, Lely, the Netherlands). Data are calculated and summarized in 2-h intervals and stored in the memory of the logger [8].

The behavioral activity of each cow was recorded in an observation protocol and then handling and entered into a Microsoft Excel 2007 spreadsheet (Microsoft Corporation, WA) for statistical analysis.

Descriptive statistics (mean, standard deviation (SD), coefficient of variation (Cv), maximum and minimum values) were used to characterize the behavioral activity of cows.

Table 1. Definitions of acts of behavior and studied variables for time budgets.

Act of behavior	Definition	Variables
Eating	Located at the feed area, touches the feed and chewing the picked feed	Eating time, min/d; eating bout frequency, bouts/d; eating bout duration, min/bout; % of total time spent eating
Rumination activity	Regurgitation, re-masticating and re-swallowing of the food bolus, while standing or lying down in any area of the barn.	Rumination activity time, min/d; rumination activity bout frequency, bouts/d; rumination activity bout duration, min/bout; % of total time spent rumination activity
Lying	Body in contact with floor	Lying time, min/d; lying bout frequency, bouts/d; lying bout duration, min/bout; % of total time spent lying
Standing	Four legs touch the floor in any area of the barn	Stating time, min/d; % of total time spent stating
Walking	Walking in any area of the barn, walking through the milking box	Walking time, min/d; % of total time spent walking
Milking	Stands in a milking box, milking cups are put on the teats of the udder	Milking time, min/d; Milking frequency, no./d; % of total time spent milking

3 Results and Discussion

To better understand the behavioral activity of cows in AMS, we created the following descriptive graphics: percentage of animals engaged in eating and lying behavior during the day (Fig. 1), diurnal pattern of rumination activity (Fig. 2).

From figure 1, eating activity was greater during the day than at night, as evidenced by the eating behavior curve. In fact, between 05:00 and 17:00 h, an average of 37.0 ± 2.4% (Cv = 21.3%, range 25.0…53.1%) of the total number of cows studied were at the feed area, compared with 22.9 ± 3.3% (Cv = 48.0%, range 3.1…40.6%) between 17:00 and 05:00 h.

Our results are consistent with previous studies where selectively forced cow traffic demonstrated by reduced cow passage rate through the preselection gate into the feeding area between 20:00 and 08:00 h [9]. It appears that cows in a free traffic system have a similar diurnal pattern of eating behavior, but this may be largely dependent on the timing of PMR delivery.

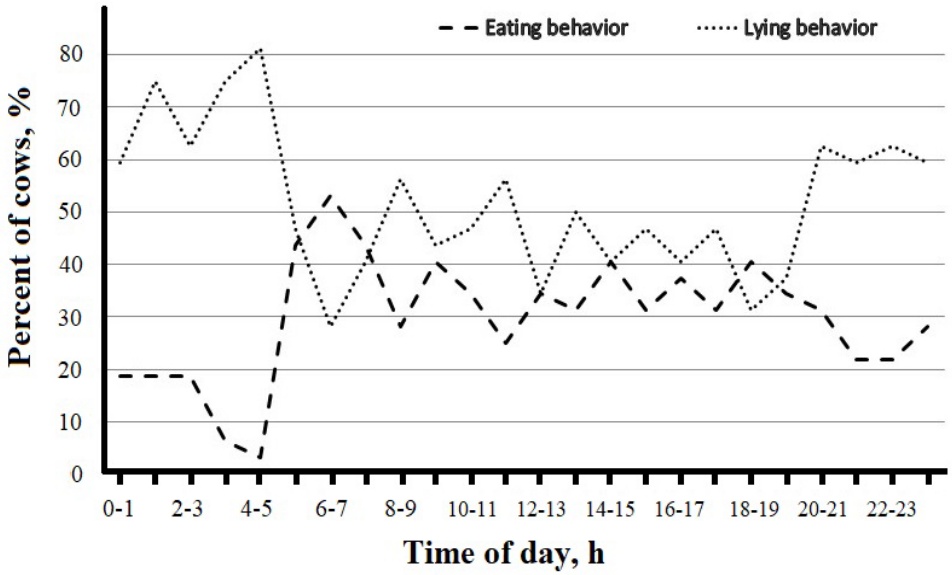

Fig. 1. Percentage of cows engaged in eating and lying behavior during the day.

The highest percentages of cows for eating behavior were observed at 05:00-06:00, 06:00-07:00, 07:00-08:00, 09:00-10:00, 14:00-15:00, 16:00-17:00 and 18:00-19:00 hours (43.8, 53.1, 43.8, 40.6, 40.6, 37.5 and 40.6%, respectively). Activity in the feed area increased after fresh PMR is delivered and is consistent with other studies [10].

Cows spent 280.8 ± 11.2 min/d (Cv = 22.1%, range 190.2…426.3 min/d) eating. This eating time was dividing into 9.2 ± 0.4 bouts/d (Cv = 23.1%, range 4…13 bouts/d), which lasted 30.7 ± 1.0 min (Cv = 53.8%, range 6.5…115.0 min). These data differ from those obtained in studies on cows with a free traffic scheme (168 min/d, 10.1 bouts/d, 15.7 min, respectively) [11]. There is a shortage of data on the average duration of eating bout and bout frequencies of dairy cows in AMS herds.

In the current study, the greatest percentage of cows spent lying down was observed at night (Fig. 1). Our results are consistent with data in AMS by other authors [1, 12, 13].

Cows spent more time lying at night, between 20:00 and 05:00 h, than during the day, between 05:00 and 20:00 h. Between 20:00 and 05:00 h, an average of 59.4±4.5% (Cv = 25.0%, range 31.3…81.3%) of cows were in the lying stall, compared to 44.3±2.5% (Cv = 18.6%, range 28.1…56.3%) between 05:00 and 20:00 h. The greatest percentage of cows spent lying was observed at 01:00-02:00 h (75.0% of cows), 03:00-04:00 h (75.0%) and 04:00-05:00 h (81.3%).

The lowest percentage of cows (28.1%) in lying behavior was recorded at 06:00-07:00 h and coincides with the high activity of cows in the feed area, after the first delivered of fresh PMR. This demonstrates that the timing and frequency of the delivery of fresh feed influence the behavior activity of dairy cows.

The cows' lying time was 660.9 ± 27.9 min/d (11.0 h/d; Cv = 23.5%, range 417…980.5 min), lying bout frequency was 7.4 ± 0.4 bouts/d (Cv = 28.3 %, range 4…13 bouts/d), and the lying bout duration was 89.2 ± 23.3 min/bout (Cv = 55.9 %, range 14.3…292.6 min/bout). These values were very similar to those reported in other studies (11.2 h/d, 8.0 bouts/d, 94.1 min/bout, respectively) [1]. Previous studies have shown lying time (10.8 h/d) similar to what we observed, although the lying bout frequency (9.3 bouts/d) was higher and the lying bout

duration (78.1 min/bout) was shorter [14]. However, other studies have shown longer lying time (11.4-11.5 h/d) with increasing lying bout frequency (9.3-9.5 bouts/day) and decreasing bout duration (71.0-76.0 min/bout) [15, 16].

In the current study, rumination activity was greater during the daytime than at night, as evidenced by the diurnal pattern of rumination activity (Fig. 2). Moreover, rumination activity increased after the first delivered of fresh PMR. Thus, between 06:00 and 18:00 h, rumination activity averaged 513.5 ± 4.7 min/d (Cv = 11.9%, range 351…647 min/d), compared with 502.1 ± 5.4 min/d (Cv = 13.3%, range 347…651 min/d) between 18:00 and 06:00 h.

The highest rumination time was observed at 06:00-08:00, 08:00-10:00, 10:00-12:00 and 12:00-14:00 h (512.8, 519.0, 518.0 and 512.4 min/d, respectively). The lowest rumination time was recorded at 18:00-20:00, 20:00-22:00, 22:00-24:00 and 02:00-04:00 h (501.7, 501.8, 501.6 and 499.6 min/d, respectively).

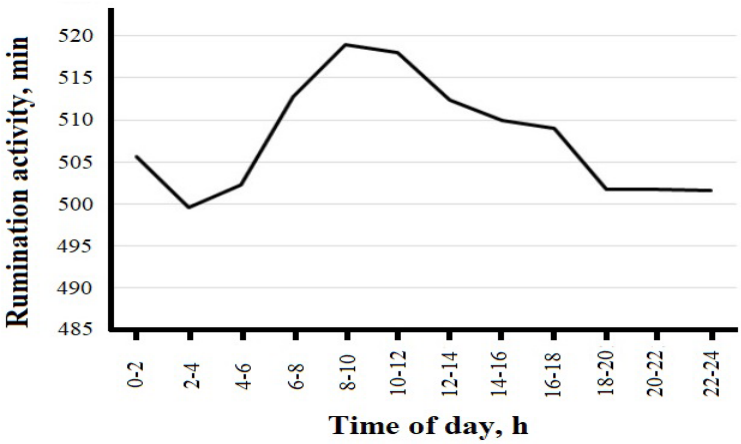

Fig. 2. Diurnal pattern of rumination activity of the cows studied.

The average rumination activity time of cows was 508.0±3.6 min/d (Cv = 12.6%, range 347...651 min/d), the rumination activity bout frequency was 11.9±0.4 bouts/d (Cv = 16.9%, range 8...16 bouts/d), and the duration of a rumination activity bout was 39.3 ± 1.0 min (Cv = 50.0%, range 4.7...128.9 min/bout). The average rumination activity time was very similar to those reported in AMS in previous studies [17]. Other studies have shown higher rumination activity values [18].

In our studies, the standing time of cows was 779.1 ± 27.9 min/d (Cv = 19.7%, range 459.5...1023.0 min/d), and the walking time of cows was 10.3 ± 0.5 min/d (Cv = 26.1%, range 6.5...18.0 min/d). There is a shortage of data on the diurnal standing and walking time of dairy cows in AMS herds.

The milking time (milking time was calculated as the sum of the times of all successful milkings) of cows is 20.49 ± 0.92 min/d, milking frequency is 3.2 ± 0.1 times per day, milking bout duration is 5.49 ± 0.92 min/times. Similar milking frequency of cows was observed in AMS herds with forced traffic [19]. Lower milking frequencies, in the range of 2.6 to 3.0 milkings per day, was documented in AMS herds using free cow traffic [20-21].

Figure 3 depicts the percentage of time cows spent on the behavioral activity of interest over a 24-h period.

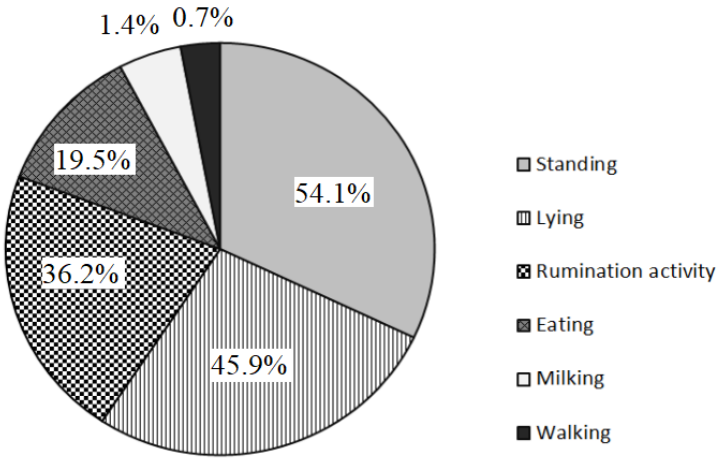

Fig. 3. Percentage of time spent by cows on behavioral activity in AMS.

4 Conclusion

Thus, these results add to body of literature on cow behavioral activity under AMS conditions. Time budget characteristics can be suggested as supplementary indicators to selection indices in the development and implementation of breeding programs.

Monitoring individual acts of cow behavior under AMS conditions can be useful in developing design and technological solutions for the construction of new, modern or reconstruction of old dairy farms.

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