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# THE DAILY DISTRIBUTION OF MILKINGS OF COWS IN FARMS EQUIPPED WITH THE AUTOMATIC MILKING SYSTEM

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**Abstract.** The material of the study consisted of 140 cows of PHF breed, reared in the farm equipped with the automatic milking system (AMS). Cows in different lactations (from 1 to 5) were reared in the period from May 2011 to April 2013. The daily distribution of milkings (12, two-hours periods) was analyzed according to: cows' age (primiparous and multiparous), the average milk production per milking during the whole lactation (<12.5 kg, ≥12.5 kg) and season (spring, summer, autumn, winter). The statistical analysis was conducted with the use of the $\chi^2$ independence test. It was noted that the daily distribution of milkings was statistically conditioned by all analyzed factors. The first peak of the increased milking frequency was obtained during midday hours and the next one during late night hours, i.e. during hours that are generally different from the typical milking hours in farms that do not use AMS. The lowest milking frequency was recorded during milking hours typical for farms that do not use the AMS.

**Key words:** automatic milking system, cattle, milk

## INTRODUCTION

One of the most common reasons why farmers rearing dairy cattle decide to use automatic milking system (AMS) is a desire to reduce an effort put into milking while increasing milking frequency and milk yield [Wagner-Storch, Palmer 2003, Svennersten-Sjaunja, Pettersson 2008].

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Most dairy cows reared in milking parlor are milked twice a day, while in intensive programmes milking frequency increases to three or even six times a day [Stelwagen et al. 2013]. Erdman and Varner [1995], while summarizing the information about the milking frequency, have noted that the increase in the milking frequency positively affects cow's milk performance, irrespective of the level of the animal's production. In turn, limiting the milking number to one per day has an exceptionally adverse effect – it reduces the milk yield by approximately 22%. Such practice may also adversely affect the length of lactation and its course.

One of the AMS advantages is the opportunity to milk cows in times more consistent with the animals natural rhythm, which is possible due to the continuous operation of the milking robot. Cows may visit the AMS with varying frequency throughout the day during the entire lactation, which is especially pronounced among multiparous [Bach, Busto 2005].

The software installed in the AMS enables the full control of cow's access to automatic milking robots while taking into account their daily production level, stage of lactation and the time that passed since the last milking. Technical capabilities of AMS allow to prevent too frequent milkings but also can motivate animals to more frequent visits when it is necessary. One of such mechanisms is the blockade which allows milking only after at least 3 hour after the previous successful milking [Bruckmaier et al. 2001]. At the same time, AMS can monitor animals and inform the farmer if the cow did not use the robot for more than 14 hours [Melin et al. 2006, Nixon et al. 2009].

Moreover, different feed concentrates are used in order to encourage cows to more frequent visits in AMS [Bach et al. 2007, Madsen et al. 2010]. Those feed concentrates are particularly important immediately after changing the milking system to AMS. According to Deming et al. [2013], the increase of the frequency of milkings, which entails an increase in milk yield, may be associated with the reduction of the number of animals per one robot. Such reduction provides easier access to feed and water. André et al. [2010] emphasize that increasing the frequency of milkings and the number of animals may increase the profitability of AMS, however, this strategy is mainly connected to the milk yield. As pointed out by Nixon et al. [2009], after the application of AMS, the intervals between milkings may vary considerably and may, depending on the animal, be very short or very long.

The aim of the present study was to determine the daily distribution of milkings of cows in farms equipped with the automatic milking system according to cows age, average milk quantity per milking and season.

## MATERIAL AND METHODS

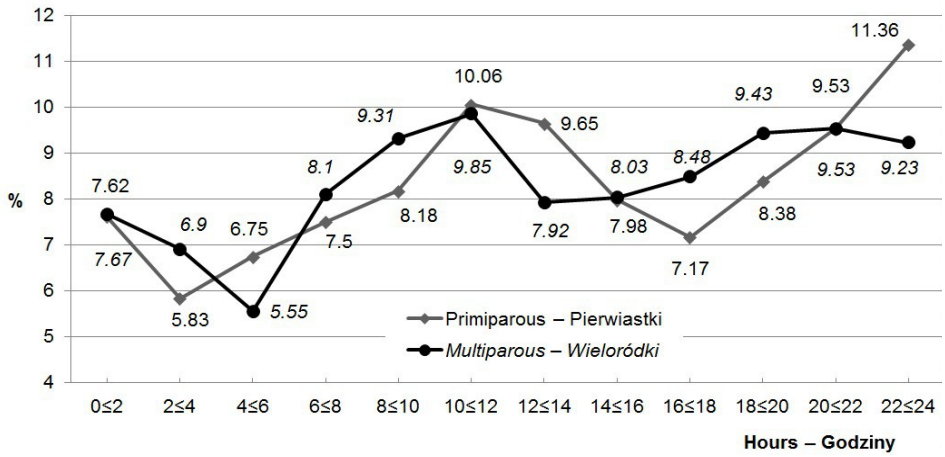
The material of the study consisted of data collected from 140 cows of PHF breed reared in a farm equipped with the automatic milking system (AMS) between May 2011 and April 2013. Cows used in the study were in different lactations (from 1 to 5). The average annual milk yield in the whole population was 9800 kg. Rearing and feeding conditions were the same for all animals throughout the whole period. Cows were kept in free stalls and were fed with the use of the PMR method. All of 161 502 milkings registered by AMS since the introduction of the system (May, 2011) (except for the first month that was considered to be an acclimatization period) were analyzed. During all lactations animals received the same Partly Mixed Ration (PMR) offered ad libitum. The PMR consisted the following feeds: maize silage, sugar beet pulp, haylage, straw, soy extracted meal also vitamin and mineral supplements.

The daily distribution of milkings (12, two-hours periods) was evaluated according to cows' age (primiparous and multiparous), the average milk quantity per one milking (<12.5 kg and $\geq$12.5 kg) and milking season (spring, summer, autumn, winter). The figures and tables provide information about the percentage of milkings carried out in the defined time intervals. The statistical analysis was performed using the $\chi^2$ independence test, with the use of the FREQ procedure included in the SAS 9.4 software (SAS Institute Inc. 2013).

## RESULTS

The $\chi^2$ independence test indicated the statistical ($P \leq 0.001$) dependence between cows' age (primiparous and multiparous) and the time of day when a milking occurred (Fig. 1). It was noted that primiparous preferred the time interval between 10 p.m. and 12 p.m. and then between 10 a.m. and 12 a.m. (Fig. 1). The frequency of milking for multiparous was the highest between 10 and 12 a.m., although it was also high between 8 and 10 p.m. In the case of both groups cows used AMS the least frequent between 2 and 6 a.m. (on average less than 7% of all milkings). What is more, it was found that primiparous less frequently used AMS between 2 and 4 a.m. while multiparous between 4 and 6 a.m. At the same time, the daily frequencies of milkings for both age groups were similar, for primiparous – 2.79 and for multiparous – 2.81 (Table 1).

The average level of milk production per whole lactation was found to have a statistical effect ($P \leq 0.001$) on the time of milking (Fig. 2). It was noted that the daily milking frequency obtained for cows that gave more than 12.5 kg of milk per one milking was 2.63 (Table 1). This frequency was lower than the one obtained for cows producing less that 12.5 kg of milk per one milking (2.89 per day).



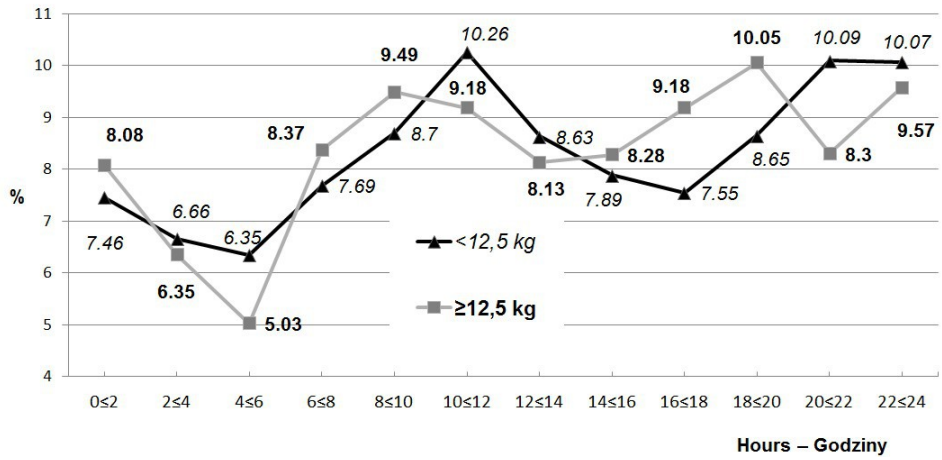

Test $\chi^2$: value – wartość: 615.63; P< 0.0001

Fig. 1. The daily distribution of the number of milkings according to cows' age

Rys. 1. Dobowy rozkład liczby dojów w zależności od wieku krów

Moreover, it was proven that animals producing less than 12.5 kg of milk per one milking most frequently visited the AMS between 10 and 12 a.m. (12.06%) and between 8 and 12 p.m. (in total – 20.16% of all visits) (Fig. 2). For cows producing more than 12.5 kg of milk per one milking most milkings were recorded between 6 and 2 p.m. (more than 10%). Cows, irrespectively of the milk production level, visited AMS the least frequently between 2 and 6 a.m. (Fig. 2).

The $\chi^2$ independence test indicated the statistical ($P \leq 0.001$) relationship between milking season and the time of milking (Table 2). The differences between seasons in respect of the milking frequency in various two-hours time periods ranged from 0.11 to 1.77 percentage points (Table 2). The greatest variation between seasons i.e. more than 1.3 percentage points, was observed between 4 and 10 a.m. The percentage of milkings recorded between 4 and 6 a.m. during the spring, summer and autumn seasons fluctuated in a fairly narrow range (5.54–5.59), while, the share of milkings registered between 4 and 6 a.m. during winter was significantly higher – 6.86%. It was noted that in the subsequent two-hours period cows visited AMS more often during summer (8.61% of all milkings) than during other seasons (7.25–7.99%). It was found that between 8 and 10 a.m. animals visited AMS the most frequently during summer and autumn (approximately 9.2%), and the least frequently during winter (8.22%) and spring (8.66%). The average number of milkings, in respect of the milking season, was as follows: for spring – 2.80, summer – 2.74, autumn – 2.81, winter – 2.86 (Table 1).




Test $\chi^2$: value – wartość: 543.32; P< 0.0001

Fig. 2. The daily distribution of the number of milkings according to the level of milk performance

Rys. 2. Dobowy rozkład liczby dojów w zależności od poziomu wydajności w laktacji

Table 1. The average number of milkings and the milk yield, depending on the selected factors

Tabela 1. Przeciętna liczba dojów oraz uzysk mleka w zależności od wybranych czynników

| Factors<br>Czynniki | Level<br>Poziom | Number of milkings<br>Liczba dojów | Milkings per day<br>Liczba dojów na dobę | | Milk yield, kg<br>Wydajność mleka, kg | |
|---|---|---|---|---|---|---|
| | | n | $\overline{x}$ | CV | $\overline{x}$ | CV |
| Lactation<br>Laktacja | 1 | 51576 | 2.79 | 30.47 | 11.15 | 32.19 |
| | 2 | 40941 | 2.91 | 29.87 | 11.65 | 34.98 |
| | 3 | 21949 | 2.80 | 31.36 | 12.11 | 36.45 |
| | 4 | 28023 | 2.72 | 31.42 | 11.86 | 37.53 |
| | 5 | 19013 | 2.75 | 33.99 | 12.75 | 36.36 |
| Milk yield, kg<br>Wydajność mleka, kg | <12.5 | 110365 | 2.89 | 31.44 | 10.58 | 32.42 |
| | ≥ 12.5 | 51137 | 2.63 | 28.99 | 14.18 | 31.58 |
| Season<br>Pora roku | Spring<br>Wiosna | 43417 | 2.80 | 33.24 | 11.82 | 35.64 |
| | Summer<br>Lato | 35614 | 2.74 | 30.00 | 11.74 | 35.63 |
| | Autumn<br>Jesień | 39467 | 2.81 | 29.65 | 11.65 | 34.62 |
| | Winter<br>Zima | 43004 | 2.86 | 30.90 | 11.66 | 35.57 |
| | Total<br>Łącznie | 161502 | 2.81 | 31.10 | 11.72 | 35.38 |

Table 2. The daily distribution of the number of milkings according to milking season

Tabela 2. Dobowy rozkład liczby dojów w zależności od pory roku

| Hours Godziny | Spring – Wiosna | | Summer – Lato | | Autumn – Jesień | | Winter – Zima | |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % |
| 0≤2 | 3395 | 7.82 | 2781 | 7.81 | 3091 | 7.83 | 3097 | 7.20 |
| 2≤4 | 2822 | 6.50 | 2199 | 6.17 | 2624 | 6.65 | 2950 | 6.86 |
| 4≤6 | 2421 | 5.58 | 1991 | 5.59 | 2185 | 5.54 | 2979 | 6.93 |
| 6≤8 | 3470 | 7.99 | 3065 | 8.61 | 2862 | 7.25 | 3371 | 7.84 |
| 8≤10 | 3762 | 8.66 | 3522 | 9.89 | 3635 | 9.21 | 3536 | 8.22 |
| 10≤12 | 4190 | 9.65 | 3619 | 10.16 | 4151 | 10.52 | 4060 | 9.44 |
| 12≤14 | 3850 | 8.87 | 2758 | 7.74 | 3284 | 8.32 | 3787 | 8.81 |
| 14≤16 | 3585 | 8.26 | 2658 | 7.46 | 3176 | 8.05 | 3527 | 8.20 |
| 16≤18 | 3517 | 8.10 | 2844 | 7.99 | 3182 | 8.06 | 3481 | 8.09 |
| 18≤20 | 3868 | 8.91 | 3868 | 8.91 | 3598 | 9.12 | 3781 | 8.79 |
| 20≤22 | 4209 | 9.69 | 4209 | 9.69 | 3671 | 9.30 | 4120 | 9.58 |
| 22≤24 | 4328 | 9.97 | 4328 | 9.97 | 4008 | 10.16 | 4315 | 10.03 |

Test $\chi^2$: value – wartość: 359.74; $P < 0.0001$

## DISCUSSION

In the whole tested population, cows used AMS approximately 2.78 times a day. Similar study was carried out by Laurs and Priekulis [2011] who tested 62 cows. They noted that only 13–21% of cows used AMS four times a day, 31–52% three times a day and 33–48% twice a day. The results of the present study are in accordance with the findings of Castro et al. [2012] (cows used the AMS 2.7 $\pm$ 0.3 a day), as well as with Kozłowska et al. [2013] (depending on the herd, 2.7–3.2 milkings per day). Castro et al. [2012] reported that the optimal number of milkings per day ranges from 2.4 to 2.6 – these values are slightly higher than those reported in the present study. Higher frequency of milkings than in the present study was reported by Deming et al. [2013] (2.8 $\pm$ 0.4 times a day) and by Madsen et al. [2010] (even 3 times a day). On the other hand, Gygax et al. [2007], Wagner- Storch and Palmer [2003] and Bach et al. [2009] reported less milkings per day (2.2–2.5). In the study of Hogeveen et. al. [2001], the average interval between milkings was 9.2 hours and the milking frequency was 2.6 times a day, while in the study of Mačuhová et. al. [2003] the interval was 11.3 $\pm$ 0,5 hours and the frequency was only 2.1 times a day.

In the present study the highest frequency of milkings (9.5%) was obtained between 10 a.m. and 12 a.m., and between 8 p.m. and 12 p.m. The least visits in AMS (5.93–6.56%) were recorded between 2 a.m. and 6 a.m. In turn, Bach et. al. [2007] studied 115 individuals of Spanish Holstein cattle, that were divided into two feeding groups. They found that the highest number of milkings took

place between 2 and 4 p.m. and between 8 and 9 p.m. In the study of Winter and Hillerton [1995] milking robot was available for cows only between 6 a.m. and 12 p.m. The authors noted that in most cases cows used AMS three times a day, especially during morning hours i.e. 6–7 a.m., around noon (11 a.m.–1 p.m.) and in the afternoon (around 5 p.m.). Winnicki et al. [2010] showed that the time of day in which milkings occur depend on the frequency of milkings. They observed that cows that used AMS twice a day visited the robots mainly in the morning (8–9 a.m.) and in the afternoon (5–7 p.m.), while animals that were milked more times a day preferred to use AMS between 11 a.m. and 3 p.m. and between 11 and 12 p.m. Moreover, Winnicki et al. [2010] noted that cows milked twice a day used AMS least frequently at night (10 p.m.–2 a.m.) and in the morning (5–6 a.m.) while cows milked three times a day used AMS least frequently at 6 o'clock and between 4 and 6 p.m.

In the present study it was noted that the frequencies of milkings for primiparous and multiparous were similar. However, some differences between daily distribution of milkings were observed between both groups. In particular this concerned the activity of cows in the evening and at night. Compared to milkings of multiparous, the highest number of milkings observed for primiparous took place 2 hours later i.e. between 10 p.m. and midnight. The results of the present study are in accordance with those reported by Carlström et al. [2013] who also described the daily frequency of milkings. They reported that both primiparous and multiparous visited AMS a similar number of times (2.48 and 2.45 a day, respectively). Bach et al. [2009], however, noted the differences between the average number of visits of cows in the AMS depending on their age. In these studies, primiparous used the milking robot more often than multiparous (2.2 and 1.8 a day, respectively).

In the present study the analysis of the daily distribution of the number of milkings in respect of the milk yield was conducted. It was noted that cows producing less than 12.5 kg of milk per one milking visited AMS more often that cows producing at least 12.5 kg of milk. Those results are in contrast to other studies, where the increase in the milking frequency after the introduction of the automatic milking system led to the increase in the milk yield [Wagner-Storch, Palmer 2003, Madsen et al. 2010]. What is interesting, for animals with a higher milk yield, the afternoon and night peaks of increased milking frequencies took place 2 hours earlier than in the group of cows with lower yield. It should be noted that the hours of the increased milking frequency were generally different from the typical milking hours in farms that do not use AMS.

In the present study the frequency of milkings was the lowest during summer. This is partly consistent with the work of Bava et al. [2012] and Speroni et al. [2006] who reported that in farms that use AMS the milking frequency and milk

yield decreased in spring and summer. According to Czerniawska-Piątkowska et al. [2012], the daily milk performance was higher for cows that were milked four times a day during winter, spring and summer. The present research showed that the influence of the milking season on the daily distribution of milkings was the highest between 4 a.m. and 2 p.m. During other parts of day the differences did not exceed 1 percentage point.

## CONCLUSIONS

On the basis of the present study it was noted that the daily distribution of milkings was statistically conditioned by cows' age, average milk production in one milking and milking season. The first peak of the increased milking frequency was recorded during midday hours and the next one during late night hours, i.e. during hours that are generally different from the typical milking hours in farms that do not use AMS. The lowest milking frequency was recorded during milking hours typical for farms that do not use the automatic milking system. The results of the present study may be found helpful while determining milking time in farms deprived of the AMS.

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## DOBOWY ROZKŁAD DOJÓW KRÓW W GOSPODARSTWIE WYPOSAŻONYM W AUTOMATYCZNY SYSTEMEM DOJU

**Streszczenie.** Badaniami objęto grupę 140 krów będących w laktacjach od 1 do 5, rasy PHF, utrzymywanych w gospodarstwie wyposażonym w automatyczny system doju. Dobowy rozkład dojów (12 dwugodzinnych okresów) analizowano w zależności od: wieku zwierząt (pierwiastki i wieloródki), przeciętnej ilości oddawanego mleka w doju w czasie całej laktacji (<12,5 kg, $\geq$12,5 kg) i pory roku (wiosna, lato, jesień, zima). Statystyczną analizę danych przeprowadzono za pomocą testu niezależności $\chi^2$. Stwierdzono, że dobowy rozkład dojów warunkowany był statystycznie wpływem wszystkich analizowanych czynników. Pierwszy szczyt wzmożonej częstotliwości oddawania mleka przypadał na godziny południowe, zaś kolejny na późnowieczorne, tj. na godziny na ogół odmienne od typowych godziny doju w gospodarstwach niekorzystających z automatycznego systemu doju. Najmniejszą aktywność krów w zakresie częstotliwości doju rejestrowano w typowych godzinach doju gospodarstw, które nie korzystają z automatycznego systemu doju.

**Słowa kluczowe:** automatyczny system doju, bydło, mleko

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