ANALYSIS OF THE NUMBER OF COW VISITS TO THE MILKING ROBOT

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Abstract. Based on data obtained using T4C herd management software from three farms equipped with milking robots, analysis was made of the effect of herd, age of cows, stage of lactation and milk production level on the number of visits to the milking robot and the proportion of different numbers of these visits. GLM and FREQ procedures of the SAS package were used for statistical analysis. The visits ended with 3.0 milkings and 2.6 refusals on average. The number of visits ending with milking decreased with advancing age and lactation, and increased with increasing milk production level. Among primiparous cows, 48% of the cows milked 3 times and 28% of the cows milked 4 times a day. Among multiparas, most cows milked 3 times (39%) and 2 times a day (37%). Most of late lactation cows (56%) milked twice, and in the other groups three times daily milking formed the largest proportion (around 45%). Considerable differences were found in the milking frequency depending on milk production level: among lowest yielding cows ($\leq$ 20 kg milk) as much as 58% milked twice, and among highest yielding cows ($\geq$ 50.1 kg milk) as much as 55% milked four times. The relatively high proportion of 5 refusals among the highest yielding cows (18%) and also among cows until 251 days of lactation (23–33%) should direct breeders' attention to the proper balancing of diets for these cows.

Key words: dairy cows, milking robot, milking frequency, daily milk yield, cow category

INTRODUCTION

For over 20 years, owners of dairy farms around the world have been offered machines that allow complete automation of the milking process [Czarnociński and Lipiński 2005, Winnicki et al. 2010]. In Poland, milking robots were introduced in 2008 [Głowicka-Wołoszyn et al. 2010].

Milking robots (AMS) are often referred to as a voluntary milking system, although the milking is not always voluntary. In some systems, cows have to pass through the milking robot to reach the feeding table [Olechnowicz et al. 2006]. Access to the feed table depends on the traffic system imposed on cows and can be guided, forced, feed-first, or free. In the latter system, cows have unlimited access to the feeding table and milking box and there is no need to invest in additional selection gates, but good herd management is crucial. [Lesiakowski 2012]. Both concentrates supplied in the milking robot and the physiological need to empty the udder encourage cows to visit the milking robot. This system has the advantage of using the cow's natural behaviours, as a result of which rearing conditions are less stressful (this is particularly important for lower ranking cows). Compared to other solutions, in the free traffic system fewer cows wait to be milked and thus have more time to rest, which gives them better conditions to ruminate; together with the free access to the feed table, this encourages them to ingest more Partial Mixed Ration (PMR). Free cow traffic in the robotic milking system ensures high milk production, while greater milking regularity compared to other systems reduces the risk of udder diseases. All of this translates into lower veterinary costs as well as lower expenses on preparation of the facility (fewer gates or travel lanes). This solution is limited by the risk that too many cows may pass through the milking robot without being milked (so-called refusals). On the other hand, in this system it is necessary to stimulate cows to visit the milking unit, which requires extra work and puts these cows at risk of being milked at irregular times. Usually around 10% of cows may be unwilling to visit the milking robot despite being motivated by concentrates. This unwillingness results from the advanced stage of lactation paralleled by a decrease in milk yield [Kowalski 2011].

In automatic milking systems, cows are free to choose their milking times, with a shorter waiting time before milking [Głowicka-Wołoszyn et al. 2010]. The benefits of AMS are increased frequency of milk letdown by the cow to 2.5-3 milkings/day and shorter milk intervals [Meier 1998, Głowicka-Wołoszyn et al. 2010]. When summing up the results of other authors concerning milk production efficiency and the health status of cows depending on milking frequency, Kuczaj et al. [2010] concluded that switching cows from twice daily to thrice daily milking may increase lactational milk yield by 5% to 25% while improving udder health.

The aim of the study was to analyse the effect of some factors on the number and proportion of cow visits to the milking robot.

MATERIAL AND METHODS

Data for the analysis were collected during one day in March 2013 from three farms: A – 54 Polish Holstein-Friesian cows, B – 164 Polish Holstein-Friesian

cows; C – 233 Polish Holstein-Friesian cows. On all three farms, cows were kept in a loose-housing system and fed PMR diets of similar composition. Milking was performed with Lely Astronaut A4 Manager robots and cows were allowed free traffic. The following data were acquired using T4C herd management software:

— lactation number,
— lactation day,
— number of milkings per day,
— number of milking refusals per day,
— average daily milk production.

Analysis of variance (GLM procedure of SAS, 2011) was used to estimate the average number of milkings and refusals depending on the following factors:

— herd (A; B; C)
— cow category (primparous; multiparous)
— stage of lactation (0–99; 100–249; $\geq$ 250 days)
— daily milk yield ($\leq$ 20; 20.1–30; 30.1–40; 40.1–50; $\geq$ 50.1 kg)

Significant differences were analysed using the Scheffe test [SAS 2011]. The χ^2 square test of independence [SAS 2011] was used to analyse the frequency of visits to the robot (milkings and refusals), taking into account the effect of the above factors.

RESULTS AND DISCUSSION

The herds differed in stocking density because higher density was accompanied by a greater number of milking stalls; the number of cows per stall was similar in herds and ranged from 54 in herd A to 58 in herd C (Table 1). Lipiński [2004] and Gaworski and Kupczyk [2006] indicated that for the milking robot to be profitable, at least 500,000 kg of milk has to be produced annually. Considering the average daily milk yield of the cows in different herds and the average number of cows per milking stall, it is estimated that only herd B meets the profitability requirement.

Milking frequency is of great practical importance. In most Polish herds, twice daily milking is used. In our study, milking was performed in the automatic milking system and the average number of milkings per cow per day was 3.2 in herds A and C, and 2.7 in herd B (Table 2). The average number of refusals varied more widely, from 1.8 in herd B to 3.6 in herd C. The results of other authors [Klungel et al. 2000, Kruip et al. 2000, Rasmussen et al. 2001, Głowicka-Wołoszyn et al. 2010] show that when robotic milkers are used, daily milking frequency increases but generally does not exceed 3 [Kruip et al. 2000]. When analysing the effect of

cow category on the number of visits to the milking robot, the activity of primiparous cows was found to be significantly greater (P ≤ 0.01) than that of multiparous cows, both for milkings and refusals.

Table 1. Characteristics of the investigated herds

Tabela 1. Charakterystyka badanych stad

Herd Stado	Date of robot launch Data uruchomienia robota	Number of cows per herd Liczba krów w stadzie	Number of milking stalls Liczba stanowisk udojowych	Average number of cows per milking stall Średnia liczba krów przypadająca na jedno stanowisko udojowe	Average daily milk yield of the cows, kg Średnia wydajność dobowa krów, kg
A	24.07.2012	54	1	54.00	27.77
B	12.11.2012	164	3	54.60	34.83
C	11.09.2012	233	4	58.25	25.06

Table 2. Effect of selected factors on the number of visits to the milking robot

Tabela 2. Wpływ wybranych czynników na liczbę wizyt w robocie

Factor Czynnik				Number of visits – Liczba wizyt			
				ending with milkings zakończonych dojem	IR significant istotność	ending with refusals odrzuconych	IR significant istotność
Herd Stado	A	1	54	3.2	1–2[xx]	1.9	1–3[xx]
	B	2	164	2.7	2–3[xx]	1.8	2–3[xx]
	C	3	233	3.2		3.6	
Category of cows Kategoria krów	primaparous pierwiastki	1	258	3.1	1–2[xx]	3.1	1–2[xx]
	multiparous wieloródki	2	193	2.9		2.0	
Phase of lactation, days Faza laktacji, dni	0–99	1	154	3.1	1–3[xx]	2.4	NS
	100–249	2	227	3.1	2–3[xx]	2.8	
	≥ 250	3	70	2.4		2.4	
Daily milk yield, kg Wydajność dobowa, kg	≤ 20	1	64	2.4		2.6	2–4[xx]
	20.1–30	2	212	3.0	1–2,3,4,5[xx]	2.9	
	30.1–40	3	119	3.3	2–3[xx]	2.5	
	40.1–50	4	45	3.1		1.8	
	≥ 50.1	5	11	3.5		2.1	

[xx] Significant at P ≤ 0.01.
[xx] Istotne przy P ≤ 0,01.

Table 3. Effect of herd on the frequency of visits to the robot ending with milkings and refusals

Tabela 3. Wpływ stada na krotność wizyt w robocie zakończonych dojem i odrzuconych

Type of visit Rodzaj wizyty	Number of visits per day Liczba wizyt w ciągu doby	Number of cows Liczba krów		Proportion of cows in the herd, % Udział krów w stadzie, %		
		n	%	A	B	C
Ending with milkings Zakończona dojem $\chi^2 = 36.6^{xx}$	1	5	1.11	1.85	2.44	0.00
	2	125	27.72	22.22	37.20	22.32
	3	198	43.90	42.59	46.34	42.49
	4	108	23.95	24.07	13.41	31.33
	≥ 5	15	3.33	9.26	0.61	3.86
Ending with refusals Odrzucona $\chi^2 = 99.9^{xx}$	1	189	41.91	55.56	65.24	22.32
	2	65	14.91	16.67	12.20	15.45
	3	48	10.64	14.81	9.15	10.73
	4	26	5.76	3.70	4.27	7.30
	≥ 5	123	27.27	9.26	9.15	44.21

[xx] Significant at $P \leq 0.01$.

[xx] Istotne przy $P \leq 0.01$.

According to Speroni et al. [2006], milking frequency in an automatic milking system was considerably higher in primiparous (2.8 ±0.03) than multiparous cows (2.5 ±0.04). Stage of lactation caused significant ($P \leq 0.01$) differences in the number of milkings but had no statically significant effect on the number of refusals. Cows in advanced lactation (≤ 250 days) were milked 2.4 times, which is much less frequently compared to other cows (3.1 times). Laurs et al. [2009] observed an even more marked tendency for milking frequency in AMS to decrease with advancing lactation, showing that cows were milked 3.7 times on average during the first 100 days of lactation, 3.0 times during the second 100 days, and 2.1 times per days during the third 100 days of lactation.

Our results also show a significant ($P \leq 0.01$) effect of daily production level on the number of visits to the milking robot, with greater differences found for milkings than for refusals. As expected, the greatest differences occurred between the lowest-yielding group (≤ 20 kg milk) and the others, in particular the group with the highest yield (≥ 50.1 kg milk).

Results of the χ^2 test point to significant ($P \leq 0.01$) differences in the frequency of milkings depending on all experimental factors, whereas the frequency of refusals was significantly ($P \leq 0.01$) influenced by factors such as herd, cow category and daily production level. When analysing the frequency of visits to the milking robot in different herds (Table 3) it was found that most cows (over 40%) were milked 3 times daily, in herds A and C more cows were milked 4 times than

twice daily, and in herd B the proportion of cows milked twice daily was almost 3 times that of those milked 4 times daily. Once daily milking averaged 1.11%, ranging from 0% in herd C to 2% in herd B, which is in agreement with Głowicka-Wołoszyn et al. [2010], who found that once a day milking formed a small proportion of 1.8% to 5.1%. Compared to the findings of Głowicka-Wołoszyn et al. [2010], in which four times daily milking was relatively infrequent (3.7%-3.8%) and five times daily milking sporadic, our results appear to be high because four times daily milking averaged 24% and five times daily milking averaged 3%.

According to Lely's specifications, there should be at least one refusal daily per cow (a cow entered the robot but minimum time after the last visit has not elapsed). Over 50% of the cows had one refusal per day in herds A and B, and over 22% in herd C. In the latter herd, as much as 44.21% of the cows entered the robot more than 4 times before the appropriate milking time.

Table 4. Effect of cows category on the number of visits to the robot ending with milkings and refusals

Tabela 4. Wpływ kategorii krów na krotność wizyt w robocie zakończonych dojem i odrzuconych

Type of visit Rodzaj wizyty	Number of visits per day Liczba wizyt w ciągu doby	Number of cows Liczba krów		Proportion of cows in the herd, % Udział krów w stadzie, %	
		n	%	primaparous pierwiastki	multiparous wieloródki
Ending with milkings Zakończona dojem $\chi^2 = 19.2^{xx}$	1	5	1.11	0.78	1.55
	2	125	27.72	20.54	37.31
	3	198	43.90	47.67	38.86
	4	108	23.95	28.29	18.13
	≥ 5	15	3.33	2.71	4.15
Ending with refusals Odrzucona $\chi^2 = 57.9^{xx}$	1	189	41.91	30.23	57.51
	2	65	14.41	16.28	11.92
	3	48	10.64	8.14	13.99
	4	26	5.76	5.81	5.70
	≥ 5	123	27.27	39.53	10.88

[xx] Significant at $P \leq 0.01$.
[xx] Istotne przy $P \leq 0,01$.

Table 4 provides results concerning the effect of cow category on frequency of visits to the milking robot per day. Regardless of age, most cows (47.67% primiparous and 38.86% multiparous cows) gave milk 3 times a day. Among primiparous cows, the proportion of those milked 4 times a day was slightly higher than the proportion of cows milked twice daily. A reverse tendency with much greater differences was observed for multiparous cows. The proportion of once daily and five daily milkings was higher for multiparas than for primiparas. Winnicki et al.

[2012] observed that the effect of age on milking frequency was variable because in some barns primiparas were milked less frequently than multiparas, but in other barns the situation was the opposite. Around 70% of primiparas and over 42% of multiparas had more than one refusal. It seems that primiparous cows adapted more quickly to the automatic milking system. It is also worthy of note that two weeks prior to calving, all the cows are trained to join the group of lactating cows, are allowed to use the robot and receive adequate amounts of feed during visits, but they are not milked.

Table 5. Effect of stage of lactation on the number of visits to the robot ending with milkings and refusals

Tabela 5. Wpływ fazy laktacji na krotność wizyt w robocie zakończonych dojem i odrzuconych

Type of visit Rodzaj wizyty	Number of visits per day Liczba wizyt w ciągu doby	Number of cows Liczba krów		Proportion of cows in phase of lactation, % Udział krów w fazie laktacji, %		
		n	%	0–99 days dni	100–249 days dni	≥ 250 days dni
Ending with milkings Zakończona dojem $\chi^2 = 48.9^{xx}$	1	5	1.11	1.95	0.00	2.86
	2	125	27.72	22.43	23.35	55.71
	3	198	43.90	44.16	45.37	38.57
	4	108	23.95	27.27	28.19	2.86
	≥ 5	15	3.33	5.19	3.08	0,00
Ending with refusals Odrzucona $\chi^2 = 13.5^{xx}$	1	189	41.91	45.45	37.00	50.00
	2	65	14.41	15.58	15.42	8.57
	3	48	10.64	10.39	8.81	17.14
	4	26	5.76	5.84	6.17	4.29
	≥ 5	123	27.27	22.73	32.60	20.00

xx Significant at P ≤ 0.01.
xx Istotne przy P ≤ 0,01.

A statistically significant (P ≤ 0.01) effect of the stage of lactation on the proportion of milkings was found (Table 5). Among cows in the first and second lactation period, the proportion of those milked at a given frequency was similar, especially considering three times and four times daily milking (around 45% and 28%, respectively). Among late lactation cows, over 55% of the cows were milked twice daily. The greatest proportion of cows milked 5 times and more than 5 times daily (5.19%) was noted in the group entering lactation, and the lowest (0%) in the group of late lactation cows. Our results confirm the physiological needs of the cows related to milking frequency. Also Winnicki et al. [2012] noted that more frequent milking was characteristic of cows in the first 100 days of lactation. As reported by Kowalski [2011], in the current traffic systems involving milking

robots, cows have greater opportunity to express natural behaviours, which helps to reduce stress and improve welfare.

The results concerning the effect of milk production level on frequency of robot visits indicate that cows with low daily milk yields (0–20 kg) were most often milked twice daily (57.8%), while their proportion in the group milked once and four times daily was small (around 1.6%) (Table 6). Three times daily milking dominated among cows producing 20.1–30.0 and 30.1–40 kg milk per day (50% and 40%, respectively). High-producing cows (> 50 kg milk/day) preferred to be milked four (55%) and three times daily (36%). It can be stated that the milking robot has the advantage of allowing high-producing cows to be milked more frequently and without stress. Głowacka-Wołoszyn et al. [2010] observed that daily milk yield increased with an increase in milking frequency. Likewise, Meier [1998] found that higher producing cows were milked more frequently. In our study we found no once daily milkings among high-producing cows (40.1–50 kg and ≤ 50.1 kg). A few isolated cases of such cows in medium-yielding groups (20.1–30 kg and 30.1–40 kg) may result from the fact that a 24-hour period was investigated. Still, it seems necessary to give particular attention to the cows that have little interest in robotic milkers to be able to milk them more frequently.

Table 6. Effect of daily milking production level on the number of visits to the robot ending with milkings and refusals

Tabela 6. Wpływ poziomu wydajności dobowej mleka na krotność wizyt w robocie zakończonych dojem i odrzuconych

Type of visit Rodzaj wizyty	Number of visits per day Liczba wizyt w ciągu doby	Number of cows Liczba krów		Proportion (%) of cows of daily milk yield Udział (%) krów o dobowej wydajności mleka				
		n	%	≤ 20 kg	20.1–30 kg	30.1–40 kg	40.1–50 kg	≥ 50.1 kg
Ending with milkings Zakończona dojem $\chi^2 = 69.7^{xx}$	1	5	1.11	1.56	0.94	1.68	0.00	0.00
	2	125	27.72	57.81	26.42	15.13	28.89	9.09
	3	198	43.90	39.06	49.53	39.50	37.78	36.36
	4	108	23.95	1.56	21.23	36.97	26.67	54.55
	≥ 5	15	3.33	0.00	1.89	6.72	6.67	0.00
Ending with refusals Odrzucona $\chi^2 = 29.3^{xx}$	1	189	41.91	39.06	35.38	45.38	66.67	45.45
	2	65	14.41	15.63	14.15	14.29	8.89	36.36
	3	48	10.64	14.06	10.38	10.92	8.89	0.00
	4	26	5.76	4.69	5.19	7.56	6.67	0.00
	≥ 5	123	27.27	26.56	34.91	21.85	8.89	18.18

xx Significant at P ≤ 0.01.
xx Istotne przy P ≤ 0,01.

CONCLUSIONS

The number of milking visits averaged 3.0 and the number of non-milking visits averaged 2.6. Both the number of milking visits and the proportion of different milking frequencies were significantly (P ≤ 0.01) dependent on all the experimental factors. The number of milking visits decreased with advancing age and lactation of the cows, and increased with an increase in milk production level. Most of primiparous cows were milked three (48%) and four times daily (28%), and most of multiparous cows were milked three times (39%) and twice daily (37%). Most cows (56%) in advanced lactation were milked twice daily, while the other groups had the largest proportion (around 45%) of three times daily milking. Considerable differences were noted in milking frequency depending on milk production level: as much as 58% of the lowest-yielding cows (≤ 20 kg milk) were milked twice daily and as much as 55% of the cows yielding ≥ 50.1 kg milk were milked four times a day.

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ANALIZA KROTNOŚCI WIZYT KRÓW W ROBOCIE UDOJOWYM

Streszczenie. Na podstawie danych z programu zarządzania stadem T4C z trzech gospodarstw korzystających z robotów udojowych analizowano wpływ stada, wieku krów, fazy laktacji i poziomu wydajności mlecznej na liczbę wizyt w robocie udojowym oraz na udział poszczególnych krotności tych wizyt. W opracowaniu statystycznym wykorzystano procedury GLM i FREQ z pakietu SAS. Stwierdzono, że liczba wizyt zakończonych dojem wynosiła średnio 3,0, natomiast wizyt odrzuconych 2,6. Wykazano zmniejszanie się liczby wizyt zakończonych dojem wraz z wiekiem krów i zaawansowaniem laktacji, natomiast wzrost wraz ze zwiększeniem się poziomu wydajności. Wśród pierwiastek największy był udział dojących się trzy razy (48%) i cztery razy (28%), wśród wieloródek dojących się trzy razy (39%) i dwa razy (37%). Większość krów (56%) w zaawansowanej laktacji doiła się dwukrotnie, natomiast w pozostałych grupach stwierdzono największy udział (około 45%) dojów trzykrotnych. Stwierdzono znaczne różnice w krotności doju w zależności od poziomu wydajności mleka: wśród krów o najniższej wydajności ($\leq$ 20 kg mleka na dobę) aż 58% doiło się dwukrotnie, wśród krów o wydajności $\geq$ 50,1 kg mleka aż 55% doiło się czterokrotnie. Stosunkowo duży udział odrzuconych wizyt (5) wśród krów o najwyższej wydajności (18%), a także wśród krów do 251. dnia laktacji (23–33%) powinien zwrócić uwagę hodowców na zbilansowanie dawek pokarmowych tych krów.

Słowa kluczowe: kategoria krów, krotność doju, krowy mleczne, robot udojowy,
                            wydajność dobowa mleka