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ORIGINAL ARTICLE

Results of robotic milking on selected farms in the Czech Republic

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Abstract
The introduction of robotic milking into farms in the Czech Republic began in 2003. This paper gives the results on 7 farms with robotic milking machines, with regard to breed (Bohemia Spotted cattle, Holstein), company size (number of robots 1 to 8) and type of ownership (private, cooperative). All farms used Lely Astronaut A3 robots. The companies showed statistical differences in average daily milk performance ($P \leq 0.001$) from 21.04 kg of milk/head/day to 40.43 kg of milk/head/day. Small private companies with one robot reached significantly ($P \leq 0.001$) higher milk performance of 28.79 kg of milk/head/day. On average, the daily milk performances of the Holstein cattle were 7.17 kg of milk higher than those of the Bohemia Spotted cattle (29.97 kg and 22.80 kg, respectively). The average number of milkings per head and day in individual companies ranged from 1.97 to 2.67. The average number of rejections per head and day (1.11) was low in companies with one robot and is influenced by the number of cows per one robot. The highest number of cows that had to be accompanied to the robot could be seen in large cooperatives – 20.1%. Bohemia Spotted cattle showed the lowest number of breeding-cows needing to be accompanied to the robot (8.8%).

Key words: robotic milking machine; Holstein; Bohemia Spotted cattle; milk performance

INTRODUCTION

The first attempts at full automation of the milking process were made in the 1970's in several developed countries at the same time. The development was fastest in the Netherlands. The first fully automated milking system (Automatic Milking System-AMS) was put into operation in 1992. Given the ever increasing average milk performance of cattle in the Czech Republic (6,870 l in 2009) and the increasing number of farms with average annual milk performance exceeding 10,000 litres of milk per cow, the country's first robotic milking machine was installed in 2003. By 2009 their number had risen to 102. Single Lely robots were the most frequent type, used on 35 farms (Machálek 2009).

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Rotz et al. (2003) recommend installing milking robots on small family farms where the main motivation is for a flexible arrangement of working time and a better quality of life for farmers, improving working conditions and the independence of a foreign workforce. Rodenburg (2002) recommends robotic milking of herds sized from 60 to 200 cows due to lower costs using robotic milking compared with using milking parlours.

Key factors for a successfully operating system in a dairy farm include breed, nutrition, the environment and human issues. When using AMS the management of dairy farming is transformed into so-called individual management. The flexibility and responsibility of management in controlling and managing, and their ability to use PCs are important parts of the whole management system (Havlík 2007). Robotic milking requires no physical presence of an operator, thereby increasing productivity several times (Fleischmanová 2005). It has been shown that robotic milking leads to savings in physical labour of 30–40% compared with conventional milking.

The milk production of dairy cows increases progressively from the first to the fifth lactation, and their potential can be exploited by increasing the number of milkings using the robotic milking system (Debrecéni et al. 1999). According to Přikryl (1997) and Stelwagen (2001), proper management of the milking process may make it possible to milk cows several times a day using the milking robot, which is particularly important in high-producing animals. Doležal (2000) points to the positive impact of multiple milking of cows with milk performance over 35 kg of milk (an increase of 18.9%) compared to cows with milk performance under 25 kg of milk (1.4% increase). Therefore, the author recommends the use of multiple milkings only when the average herd milk performance exceeds 9.500 liters of milk (Doležal 2002). Kopeček and Machálek (2009) show an increase in milk performance after the introduction of AMS by up to 25%. By contrast, Kvapilík (2005), in estimating the economic efficiency of the introduction of milking robots in the Czech Republic, expects an increase in milk production per cow and year on average by 8% compared with conventional milking in a parlour. Doležal (2002) and Kruip et al. (2002) point to the deterioration of reproductive performance as a result of multiple milking.

For the cattle to voluntarily visit a milking robot several times a day the AMS incentive system must function correctly. As Šťastný (2010) points out, this can be done if the cow, during each well-timed visit, is given a dose of granular grain with higher (10%) energy-content than is the energy content of bulk feed. This makes cows look for the energy deficit in the AMS. Also, according to Weiss et al. (2005), the strongest motivation for the animal to visit the milking robot is the reward in the form of concentrated feed, which is offered during the visit.

In the robot, cows are relieved of milk very gently (Debrecéni et al. 1999); even so, during the adaptation period (about 15 days) after the introduction of the AMS the animals should be treated positively rather than be forced to milking. However, there is a certain percentage of cow-nonconformists which refuse to accept new modes of behaviour. These cows ignore visits to the robot. Therefore, it is necessary for the farmer to reserve some time to accompany such animals to AMS; otherwise they have to be totally excluded from the system. The higher the number of cows per AMS, the higher is the percentage of cows that need to be lead to milking. Some cows may also become accustomed to being guided to the robot. The reason for some cows to be excluded from the system is their aggression or excessive nervousness (e.g. kicking, or dodging the robot). Kic and Nehasilová (1997) also indicate that up to 15% of cows should be excluded for the reasons already mentioned. The animal's behaviour, its calm and well-balanced temperament, is thus becoming one of the criteria of selection in creating specialized herds suitable for AMS.

The aim of the paper was to evaluate the performance of breeding cows kept on farms with robotised milking in relation to the breed, number of milking units and the type of ownership of the company. Another objective was to assess the behaviour of dairy cows while being milked by means of milking robots.

MATERIAL AND METHODS

The monitoring covered seven farms, mostly from South Bohemia, using automated milking technology – the Astronaut A3 model from Dutch manufacturer Lely (AMS). The companies were divided by the number of robots into small (one robot – company No. 1, 2 and 3), medium (two and three robots – company No. 4 and 5) and large (seven and eight robots – company No. 6 and 7). Companies Nos. 1–3 were private, Nos. 4–7 were cooperative companies. The breeds milked included Bohemia Spotted cattle breeding-cows (C-companies 2, 3 and 7) and Holstein breeding-cows (H-companies 1, 6 and 7); both breeds were raised together in companies 4 and 5. The following indicators were monitored in the breeding cows: reproduction indicators (insemination interval, service period and between-calving interval), the average amount of milk per cow and day (in kg), the average number of milkings per cow and day, the average number of rejections of milking per cow and day, and number of problem cows (refusing milking in the robot).

Basic background data were obtained on individual farms from the T4C (Time for Cows) programme, which is the AMS control unit, is used for communication and which allows reverse access to milking data history. The data file was later processed in statistical programme Statistica 8.0 (Statsoft CR s. r. o. 2008). Information used to analyze the problem animals, which had to be accompanied to the robot, was provided directly by their owners. The data were evaluated for the period from 1 January 2009 to 30 November 2009 (334 days).

RESULTS AND DISCUSSION

Table 1 gives an overview of breeds in different companies, including the average number of dairy cows, the average number of cows per robot and selected parameters of reproduction. Holstein cattle were kept in company 1 and 6, company 7 kept both H and C breeds, but separately. Companies 4 and 5 had mixed herds containing both breeds, making it impossible to evaluate the parameters separately. The lowest average number of cows ranged from 51 heads (company 2) to 377 heads (company 6). The number of robots ranged from 1 (companies 1–3) to 8 (company 7). The insemination interval spanned considerably from 59 days (company 4) to 86 days (company 7); the service period ranged from 89 (company 4) to 141 days (firm 1). The length of the between-calving interval ranged from 395 days (companies 3 and 6) to 415 days (company 7). For comparison, Kvapilík et al. (2010) mention national average values of dairy cows in their performance overview for 2009: insemination interval 83.6 days, service period 122.9 days and average between-calving interval 411 days.

Table 1. The selected reproduction parameters of observed herds

Farm number	Breed	Average number dairy cows in herd (heads)	Number of robots in farm	Install AMS (year)	Rest period (days)	Service period (days)	Between-calving interval (days)
1.	H	59	1	2007	76	141	412
2.	C	51	1	2008	62	97	398
3.	C	73	1	2008	85	112	395
4.	H+C (30 : 70%)	97	2	2008	59	89	401
5.	H+C (40 : 60%)	165	3	2006	84	125	405
6.	H	377	7	2007	75	118	395
7.	H	201	4	2006	86	132	415
	C	160	4				

H = Holstein, C = Bohemia Spotted cattle

The average daily milk production achieved in the individual companies is listed in Table 2. Company 1 showed the highest milk performance (40.43 kg). The second highest milk performance (30.16 kg) was reached in company 6. In contrast, the lowest milk performance (21.04 kg) was achieved in company 3, with the highest number of animals per robot (73 heads). Statistically, the differences between the companies were highly significant ($P \leq 0.001$). The results obtained support Doležal (2000) whose premise is that the higher the milk performance, the greater the effect of a higher frequency of milking. Compared with the average daily milk performance of 18.82 kg of milk (Kvapilík et al. 2010) reached in the Czech Republic in 2009, the daily performance of all the monitored companies using robotic milking technology was higher.

Table 2. The average production in individual farms (kg of milk/day)

Number of farm	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
1.	59	334	40.43	1.65	2745.0**
2.	51	334	24.83	1.71	1:2, 3, 4, 5, 6, 7***
3.	73	334	21.04	1.40	2:3, 4, 5, 6, 7***
4.	49	668	22.92	3.00	3:4, 5, 6, 7***
5.	55	1 002	26.75	1.74	4:5, 6, 7***
6.	54	2 338	30.16	2.97	5:6, 7***
7.	45	2 672	24.87	2.97	6:7***

S_x = sample standard deviation, *** = $P \leq 0.001$, ** = $P \leq 0.01$

The classification of companies by size corresponds to the classification by type of ownership (Table 3). The highest daily milk performance was achieved in small privately owned companies with one robot (28.79 kg of milk), albeit within a large margin (s_x = 8.54), and differences of 3.57 and 1.45 kg of milk, respectively, compared to medium and large cooperative companies, were statistically significant ($P \leq 0.001$). The results correspond to the findings of Rotz et al. (2003), who recommend installation of milking robots on small family farms. Rodenburg (2002) states that robotic milking offers a very good opportunity for dairy herds sized 60 to 200 heads, where milking in parlours is too expensive compared to using a milking robot, which turns out to be more economical.

Table 3. The average production by size and ownership of farm (kg of milk/day)

Farm size	Type of ownership	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
Small (1)	private	61	1 002	28.79	8.54	206.2**
Middle (2)	cooperative	53	1 670	25.22	2.99	1:2***
Large (3)	cooperative	49	5 010	27.34	4.00	1:3***
						2:3***

S_x = sample standard deviation, *** = $P \leq 0.001$, ** = $P \leq 0.01$

Table 4 shows the average performance with regard to the breed of cow. The highest milk performance was achieved by H breeding cows (29.97 kg of milk). The difference from C cows was 7.17 kg ($P \leq 0.001$). Herds containing both breeds achieved a roughly average value of the two above-mentioned breeds (25.22 kg of milk). The number of cows per robot was identical in companies with H and both H and C (53 heads) and was lower in C (47 heads).

Table 4. The average production by breeds (kg of milk/day)

Breed	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
Holstein (1)	53	4 008	29.97	4.33	2903.0**
Bohemia Spotted cattle (2)	47	2 004	22.80	2.26	1:2***
The whole breeds	53	1 670	25.22	2.99	1:3***
					2:3***

S_x = sample standard deviation, *** = $P \leq 0.001$, ** = $P \leq 0.01$

The average number of milkings per cow and day is an important indicator in the robotic milking system. Table 5 indicates significant differences between companies ($P\leq0.001$), where the highest number of milkings per cow was reached by a company with a frequency of 2.67; this was a company with a significantly higher milk performance, which corresponds to the findings of authors (Doležal 2000, 2002, Stelwagen 2001) on the positive impact of multiple milking of high-production cows. The lowest number of milkings was found in company 3 (only 1.97). This company had the highest number of breeding cows (73 heads) per robot. Reducing the number of breeding cows per robot by 14 heads resulted in increasing the number of milkings to 2.67. It must be stressed here that both companies kept different breeds of cattle.

Table 5. The average number of milkings per 1 dairy cows and day in individual farms

Number of farm	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
1.	59	334	2.67	0.18	344.9**
2.	51	334	2.60	0.18	1:2, 3, 4, 5, 6, 7***
3.	73	334	1.97	0.16	2:3, 4, 5, 6, 7***
4.	49	668	2.53	0.25	3:4, 5, 6, 7***
5.	55	1 002	2.44	0.14	4:5, 6, 7***
6.	54	2 338	2.44	0.24	5:7***
7.	45	2 672	2.41	0.21	6:7***

S_x = sample standard deviation, *** = $P\leq0.001$, ** = $P\leq0.01$

Significant differences ($P\leq0.001$) depending on size and type of ownership of companies were also found in the number of milkings per head and day (Table 6), although the values were not as different. The highest number of milkings was demonstrated by medium and large companies (2.47 and 2.43, respectively). After merging, small companies showed a significant averaging to 2.34. Identical conclusions can be made with regard to ownership.

Table 6. The average number of milkings per 1 dairy cows and day by size and ownership of farm

Farm size	Type of ownership	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
Small (1)	private	61	1 002	2.34	0.33	96.9**
Middle (2)	cooperative	53	1 670	2.47	0.20	2:3***
Large (3)	cooperative	49	5 010	2.43	0.24	1:3***
						2:3***

S_x = sample standard deviation, *** = $P\leq0.001$, ** = $P\leq0.01$

Taking into account the breeds in relation to the number of milkings per head and day, (Table 7) significant differences between breeds were demonstrated. The lowest number of milkings per day was achieved by combined-utility type (C) breeding cows – 2.32 times compared with milking-utility type (H) breeding cows, which were milked 2.45 times ($P\leq0.001$) on average. There is an obvious link with the achieved performance of particular breeds.

If a cow comes into the robot before it is time for her to be milked, the robot will not milk it and releases it – that is the number of rejections. Ideally, this value is around 1.5 per day, ie. there is one rejection per two milkings (Šťastný 2010). In determining the number of rejections per cow and day, statistically significant differences were found ($P\leq0.001$) between the companies (Table 8). The significantly highest number of rejections (3.66) was found in company 4, and the second highest value (2.63) was detected in company 7. Both companies had the lowest number of animals in the group per robot (49 and 45, respectively). Significantly low values were found in company 2 (0.72) and company 3 (0.88).

Table 7. The average number of milkings per 1 dairy cows and day by breeds

Breed	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
Holstein (1)	53	4 008	2.45	0.23	245.2**
Bohemia Spotted cattle (2)	47	2 004	2.32	0.26	1:2***
The whole breeds	53	1 670	2.47	0.20	1:3**
					2:3***

S_x = sample standard deviation, *** = $P≤0.001$, ** = $P≤0.01$

Table 8. The average number of non-acceptance per 1 dairy cows and day in individual farms

Number of farm	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
1.	59	334	1.74	0.51	524.1**
2.	51	334	0.72	0.27	1:2, 3, 4, 5, 7***
3.	73	334	0.88	0.28	2:3, 4, 5, 6, 7***
4.	49	668	3.66	2.07	3:4, 5, 6, 7***
5.	55	1 002	1.20	0.32	4:5, 6, 7***
6.	54	2 338	1.93	1.15	5:6, 7***
7.	45	2 672	2.63	1.31	6:7***
					1:6**

S_x = = sample standard deviation, *** = $P≤0.001$, ** = $P≤0.01$

The average number of rejections by size and ownership is indicated in Table 9. Small privately-owned companies with one robot showed a low number of rejections (1.11) compared to medium and large cooperative companies (2.18 and 2.30, respectively). Small private farms seem to prefer the workload reduction provided by the AMS, rather than milk production. Statistically, the differences were highly significant between 1 and 2 and 1 and 3 at $P≤0.001$. In small private companies milking robots are used more as the number of cows per robot in these companies is higher (61) than in cooperative companies with multiple robots (53 and 49 heads/robot, respectively).

Table 9. The average number per 1 dairy cows and day by size and ownership of farm

Farm size	Type of ownership	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
Small (1)	private	61	1 002	1.11	0.58	231.1**
Middle (2)	cooperative	53	1 670	2.18	1.80	1:2***
Large (3)	cooperative	49	5 010	2.30	1.28	1:3***
						$2:3^{ns}$

S_x = sample standard deviation, *** = $P≤0.001$, ** = $P≤0.01$, ns = nonsignificant

Table 10 shows that, on average, the Bohemia Spotted cattle breeding cows were rejected by the robot 2.55 times/day while Holstein cattle only 1.88 times/day. Statistically, the differences were highly significant ($P≤0.001$). In companies keeping both breeds together, the number of rejections was 2.18.

Table 10. The average number of non-acceptance per 1 dairy cows and day by breeds

Breed	Cows number per 1 robot	Number	$\bar{x}$	s_x	F test
Holstein (1)	53	4 008	1.88	1.01	154.5**
Bohemia Spotted cattle (2)	47	2 004	2.55	1.59	1:2***
The whole breeds	53	1 670	2.18	1.80	1:3**
					2:3***

S_x = sample standard deviation, *** = P≤0.001, ** = P≤0.01

Graphs 1–3 give percentages of the problem cows which had to be accompanied to the robot for a necessary period of time. The lowest percentage was found in company 3 (8.2%), the highest in companies 7 (25.2%) and 6 (15.1%). In other companies, the percentage of problem cows was about 10% (graph 1). In focusing on companies by size or ownership (graph 2) a high percentage of problem cows (20.1%) was shown in large companies, in contrast to medium (and cooperative) and small ones, where the percentage of cows was just over 9%. In determining the differences between breeds (graph 3), Bohemia Spotted cattle had less problem cows (8.8%) compared to the Holstein cattle (14.4%). Veselovský (2005) explains that it is characteristic for classical conditioning that an initially neutral stimulus (visiting a robot) in conjunction with a reward in the form of food becomes a trigger for certain behaviour (milking). What is important is the creation of an association or connection between certain actions and rewards. Šťastný (2010) indicates 5–10% as being the normal percentage of cows needing to be accompanied to the robot. Tančin and Tančinová (2008) pays great attention to the quality of the human – keeper, because the animal is very sensitive in terms of recognizing an evil and violent person, the presence of whom results in a change in behaviour and a reduction in milk performance of up to 10% caused by stress. Based on their own research, Weis et al. (2005) found an excellent ability to learn in cows, as during three days the vast majority of the cows were able to enter the robot without any physical assistance by the keepers.

Based on the results from 7 dairy farms where the milking robot Lely A3 has been identically applied, it can be stated that the differences in milk production are influenced by the number of robots on farms, the form of farm ownership, the breed used, the number of milkings per day and the number of cows per robot.

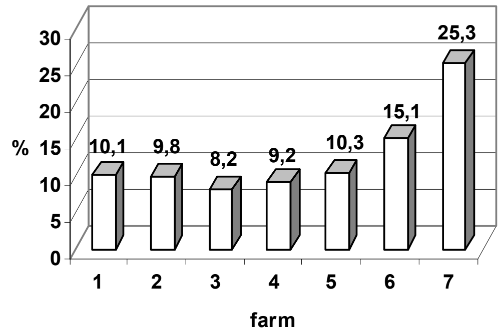


Fig. 1 Number of dairy cows escorted to milking robot in individual farms (%)

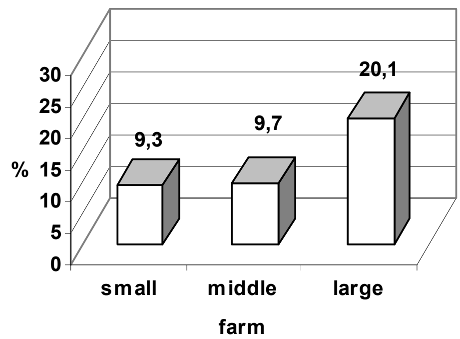
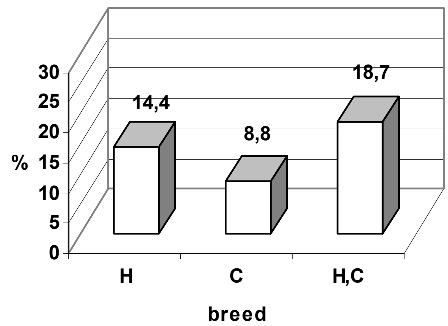


Fig. 2 Number of dairy cows escorted to the milking robot by farm size (%)



H = Holstein, C = Bohemia Spotted cattle

Fig. 3 Number of dairy cows escorted to the milking robot by breed (%)

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