

## **Quarter milking in primiparous and multiparous cows\***

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**Cows in their first lactation usually have lower milking parameters than multiparous cows. The purpose of this study was to determine changes in milking parameters in primiparous and multiparous cows in a quarter milking system. This is preliminary research which at a later stage will indicate whether primiparous cows milked in an automatic milking system (AMS) throughout their first lactation will have better milking parameters as multiparous cows. The data for statistical analysis was collected from three dairy herds in which Lely Astronaut A4 automatic milking systems were used. In total, data from 718 cows were analysed (531 lactations of primiparous cows and 477 of multiparous cows). The data was collected over a period of four years beginning in 2012, when the automatic milking system was implemented. After eliminating visits to the milking robot which ended in refusal, we analysed 352,708 milking sessions from primiparous cows and 488,711 from multiparous cows. Multifactorial analysis of variance of the numerical data was performed using a linear model taking into account the effect of herd, lactation stage, milking year and season, and the interaction of these factors. The statistical procedure showed that all linear model components had a highly significant or significant impact on the milking parameters considered. During initial stage of lactation the duration of the stay in the milking robot in the two groups was very similar—396-398 s. During this stage the milking time was about 268 s for the primiparous cows and 280 for the multiparous cows, and the average milk yield was 8.38 kg for the former and 10.40 kg for the latter. During the final stage of lactation (after 200 days) the milking time was 214 s in the primiparous cows and 241 in the multiparous cows, with yield of 7.93 and 8.77 kg of milk, respectively. Both primiparous and multiparous cows stayed longer in the milking robot and were milked longer in the spring and winter, which can be linked**

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to higher milk yield. In both groups of cows it took longer to milk the rear quarters; these differences amounted to about 25 s in the primiparous group and about 40 s in the multiparous group.

**KEY WORDS:** Automatic milking system / primiparous cows / multiparous cows / milk yield / quarter milking

In the automatic milking system (AMS) produced by Lely a cow can decide on its own when it is milked, which improves its well-being and seems to be a more ethical approach [5, 20]. The use of the AMS in the herd requires the determination of the optimal number of animals per milking robot, to fully exploit its potential and to provide the animals with problem-free access to the machine. When the stocking density is too high the waiting time for milking is prolonged, but when it is too low the use of the system is not economical. Cows waiting a long time to be milked experience stress, which can predispose them to udder diseases [9]. Ketelaar-De Lauwere et al. [10] state that even with optimum stocking density variation is observed between individuals in the time spent in the box (TB). Farmers aim to fully exploit the potential of the milking robot. The profitability of production mainly depends on three milking parameters: milk yield, milking time and the time spent by the cows in the box [7, 13].

The time spent in the box depends on the length of each stage of automatic milking. The sequence of these stages is constant, but specific milking elements can take different amounts of time depending on the circumstances, e.g. due to problems with teat recognition or placement of milking cups, longer milking time due to milk quantity or flow rate, and finally the cow's individual physical or psychological characteristics. Hopster et al. [8] stress that in the case of cows which are lower in the herd hierarchy, including primiparous cows, which due to their physiology produce less milk during milking, improper stocking density can be a very stressful factor which is closely linked to the milking process. At the same time it should be emphasized that primiparous cows milked in the AMS may demonstrate higher yield in subsequent lactations owing to the greater frequency of milking in this system [12, 21].

The objective of this study was to determine changes in cow milking parameters in the quarter milking system in primiparous and multiparous cows. This is preliminary research which at a further stage will show whether primiparous cows that have been milked in the AMS throughout their first lactation will demonstrate better milking parameters in subsequent production periods.

### **Material and methods**

The data used for the statistical analyses were collected in three herds of dairy cattle, located in the Wielkopolskie Voivodeship and equipped with an Astronaut A4 automatic milking system (AMS) by Lely. All facilities were newly built and adapted to the AMS. The animals were fed using the PMR (Partly Mixed Ration) method at

a feed table and additionally received individually (depending on their milk yield) a concentrate in the milking box.

In herd A data collected from a total of 368 cows were analysed, with the primiparous cows accounting on average for 47% of the herd; in herd B the data were collected from 174 animals, of which about 52% were primiparous; and in herd C data from 466 animals were analysed, of which 56% were primiparous. In total, data on 531 lactations of primiparous cows and 477 of multiparous cows were analysed. The data were collected over a period of four years, from the moment the herds were formed in 2012. After discarding visits to the robot that ended in refusal, a final total of 352,708 milking sessions of primiparous cows and 488,711 milking sessions of multiparous cows were analysed.

The following characteristics were monitored during the study: the time spent by the cow in the robot milking box (time in the box), the total and quarter milking time, and the total and quarter milk yield per milking session. The following designations were introduced for the udder quarters: FL – front left, RL – rear left, FR – front right, and RR – rear right.

The variability in these characteristics was determined by the following factors: herd (A, B, C), lactation stage (below 100 days, 100-200 days, 201-305 days), year (2012, 2013, 2014, 2015) and milking season (spring, summer, autumn, winter). The effect of the interaction between the factors was determined as well.

The effect of the factors on the characteristics analysed was tested using multifactorial analysis of variance [15], using the GLM procedure in the SAS package with the following linear model:

$$y_{ijklm} = h_i + l_j + p_k + r_l + hl_{ij} + hp_{ik} + hr_{il} + lp_{jk} + lr_{jl} + pr_{kl} + e_{ijklm}$$

where:

$y_{ijklm}$  –  $ijklm$ -th milking

$h_i$  – fixed effect of the  $i$ -th herd (A, B, C)

$l_j$  – fixed effect of the  $j$ -th lactation stage (below 100 days, 100-200 days, 201-305 days)

$p_k$  – fixed effect of the  $k$ -th year (2012, 2013, 2014, 2015)

$r_l$  – fixed effect of the  $l$ -th milking season (spring, summer, autumn, winter)

$hl_{ij}$ ,  $hp_{ik}$ ,  $hr_{il}$ ,  $lp_{jk}$ ,  $lr_{jl}$ ,  $pr_{kl}$  – interactions

$e_{ijklm}$  – random effect associated with the  $ijklm$ -th observation

In addition, linear correlation coefficients between the milking parameters were calculated [15].

## Results and discussion

The multifactorial analysis of variance indicated a highly significant impact of all factors tested (herd, lactation stage, year and milking season) on all analysed milking characteristics, in both the primiparous cows and the multiparous cows (Table 1). Ta-

**Table 1**  
Value of  $F_{emp}$  and the effect of the factors studied on milking parameters

Factors	Time in box (s)				Milking time (s)				Milk yield (kg)				
	total	FL	RL	RR	total	FL	RL	RR	total	FL	RL	FR	RR
Herd (H)	3359.65*	1668.97*	4759.56*	1521.54*	4580.14*	44117.1*	30566.9*	25375.8*	26068.0*	30527.2*			
Lactation stage (days) (LS)	16267.7*	17170.6*	12402.2*	17559.5*	12057.6*	8614.71*	6592.39*	5230.34*	5322.01*	4405.81*			
Milking year (MY)	317.39*	220.35*	663.15*	139.13*	224.14*	1548.87*	1490.98*	1227.92*	759.12*	1103.47*			
Milking season (MS)	480.44*	494.57*	180.30*	396.01*	428.92*	804.53*	608.79*	446.51*	603.62*	665.66*			
H x LS	181.01*	334.38*	295.86*	184.74*	147.61*	512.23*	599.73*	265.47*	230.74*	307.51*			
H x MY	265.55*	394.95*	269.54*	467.89*	269.47*	1764.47*	1201.40*	1392.23*	863.92*	1078.40*			
H x MS	185.97*	126.72*	206.01*	162.28*	241.31*	441.33*	248.05*	331.06*	293.58*	352.79*			
LS x MY	85.94*	69.68*	99.71*	126.18*	110.66*	316.88*	321.47*	223.02*	188.41*	236.95*			
LS x MS	74.16*	86.28*	32.42*	43.79*	39.18*	15.43*	21.65*	54.07*	24.83*	70.96*			
MY x MS	64.94*	64.29*	77.23*	65.48*	56.61*	386.74*	326.11*	232.80*	233.07*	339.59*			
H	1959.36*	2628.11*	1079.00*	1077.79*	2112.15*	36196.9*	24768.6*	29106.8*	27099.7*	27884.5*			
LS	7593.30*	10236.9*	6704.74*	10122.1*	6654.00*	21500.5*	16431.8*	11655.6*	13694.7*	9877.53*			
MY	1580.68*	1212.76*	1531.19*	1182.15*	1395.76*	793.37*	266.69*	175.76*	689.21*	160.08*			
MS	384.06*	488.77*	282.31*	806.80*	340.88*	915.08*	750.41*	889.22*	578.74*	835.85*			
H x LS	94.33*	131.78*	141.20*	171.88*	167.79*	642.44*	321.83*	496.80*	392.42*	554.34*			
H x MY	1342.90*	1100.01*	1107.99*	931.51*	762.46*	797.89*	331.76*	514.85*	353.35*	532.48*			
H x MS	187.87*	168.18*	315.97*	215.32*	116.76*	696.36*	327.95*	513.30*	260.83*	216.38*			
LS x MY	106.25*	99.67*	66.64*	115.04*	60.16*	148.91*	39.71*	87.15*	68.16*	124.93*			
LS x MS	149.54*	156.43*	134.63*	342.91*	313.64*	71.80*	80.78*	104.00*	90.34*	103.23*			
MY x MS	39.77*	92.31*	62.79*	36.73*	58.48*	203.91*	113.92*	107.00*	136.86*	91.44*			

\* $P \leq 0.001$ 

N – number of milking sessions

Udder quarter designations: FL – front left; RL – rear left; FR – front right; RR – rear right

**Table 2**  
Analysis of time in box, milking time and milk yield in each quarter depending on the herd and lactation stage (mean values, coefficients of variation under-neath) in the primiparous cow group

Factors	N	Time in box (s)				Milking time (s)								Milk yield (kg)				
		total	FL	RL	FR	RR	total	FL	RL	FR	RR	total	FL	RL	FR	RR		
Herd	A	111 744	364.52	175.29	200.46	176.83	210.27	7.63	1.81	2.12	1.79	2.11						
			31.65	45.96	45.26	46.28	47.96	28.48	33.87	36.99	39.20	35.60						
			237.85	43.92														
B	65 002	366.14	182.57	213.33	183.20	218.97	8.28	1.88	2.34	1.87	2.26							
		30.30	46.57	38.64	47.37	42.90	26.64	33.38	30.82	34.96	31.45							
		244.52	41.54															
C	175 962	357.03	181.50	205.14	188.03	205.86	8.58	2.05	2.36	2.03	2.35							
		31.04	46.91	45.05	48.09	44.25	29.62	37.29	35.58	37.40	37.90							
		238.16	42.46															
Lactation stage (days)	<100	103 888	396.06	201.55	228.98	208.79	233.94	8.38	1.99	2.31	1.97	2.27						
			31.50	46.72	43.32	47.84	45.18	31.19	37.23	36.59	39.60	38.51						
			268.54	42.51														
100-200	133 745	357.82	179.04	203.25	182.46	208.78	8.35	1.97	2.31	1.96	2.29							
		30.23	45.12	42.70	45.76	44.45	27.95	34.29	34.15	36.75	34.89							
		237.38	41.67															
201-305	115 075	333.30	160.65	185.81	162.30	188.76	7.93	1.85	2.21	1.85	2.22							
		28.74	44.44	43.05	44.50	42.84	28.50	37.02	35.69	37.42	36.36							
		214.93	40.49															

N – number of milking sessions  
Udder quarter designations: FL – front left; RL – rear left; FR – front right; RR – rear right

bles 2-5 present mean values and coefficients of variation for time in the box and for milking time and milk yield, both total and for individual quarters, in relation to the research factors. The factors of herd and lactation stage are shown in Tables 2 and 4, and the season and year of milking in Tables 3 and 5. The two first tables present the results for the group of primiparous cows. The highest number of milking sessions was recorded in herd C and the lowest in herd A, which was directly linked to the number of cows in these herds (Table 2). The average time in the box ranged from 4 to 6 minutes. The average total milking time was on average 238 seconds in herds A and C, but over 6 seconds longer in herd B. The shortest milking time was noted in herd A (FL, RL and FR quarters) and the longest in herd B (FL, RL and RR quarters). Longer milking time was observed for the rear quarters, by 17 to 35 seconds. Herd A was characterised by the lowest average milk yield, at 7.63 kg, while herd C had the highest yield, with 0.95 kg more milk obtained per milking session. The same pattern was observed for the quarter milking sessions. In a study by Edwards et al. [6], the average milk yield per milking was similar to that of the group of multiparous cows (10 kg; Tab. 4), while the average milking time in the study cited was longer, at 360 seconds.

The next factor analysed was the stage of lactation. The longest time in the box, longest milking time and highest milk yield (except for the RR quarter) were noted in the period up to 100 days of lactation. In subsequent lactation stages a decrease was observed in the time in the box, milking time and milk yield. The differences in yield between the rear and front quarters oscillated between 0.31 and 0.46 kg of milk, depending on the lactation stage. A similar number of milking sessions was observed between 2012 and 2014, while in 2015 this number was three times lower (Tab. 3). Wright et al. [21] report that increased milking frequency in primiparous cows has no negative impact on udder health and improves yield in successive stages of lactation.

The shortest milking time was observed in 2012 and the lowest yield in 2015. The highest yield and also the longest milking time were recorded in 2014. In 2012 and 2013 the RL quarter was milked 27 seconds longer and the RR quarter 31 seconds longer than the front quarters. In the next two-year period these differences were 23 and 19 seconds, respectively. The smallest differences in yield (0.28 and 0.29 kg) between the front and the rear quarters were noted in 2012, and the largest (0.42) in 2013. A study by Tančin et al. [18] found that the rear quarters are usually larger than the front ones, which results in higher milk yield and a longer milking time. On the other hand, a study by Berglund et al. [4] found no significant differences in milk yield and milk composition between front and rear udder quarters.

Analysis of the effect of the season revealed that the highest number of milking sessions was observed in spring, while the shortest milking sessions took place in summer. The lowest number of milking sessions was noted in autumn, and these were also characterised by the lowest milk yield. The longest and most productive milking sessions were observed in winter. The differences between the yield of the front and rear quarters varied depending on the season, ranging from 0.32 to 0.36 kg. Bagnato et al. [3] report that cows in their first lactation show increasing milk production capacity as the lactation

progresses, while older cows exhibit a reverse trend, i.e. decreasing milk yield and lactation persistency. Spolders et al. [17] observed higher milking frequency in primiparous cows, which did not, however, result in higher milk yield.

Tables 4 and 5 present the characteristics analysed divided on the basis of the research factors in the multiparous cows. The highest number of milking sessions was recorded in herd C, as in the case of the primiparous cows, while the fewest were observed in herd B (Table 4). The time spent by the cows in the box ranged from 367 seconds in herd A to 403 seconds in herd B. Herd A was characterised by the shortest milking time and the lowest milk yield. The highest average milk yields per milking session were observed in herd B, in which the milking time was the longest. Longer milking time (by 33-50 seconds) and higher yield (by 0.44-0.64 kg of milk) were observed for the rear quarters. Edwards et al. [6] also indicate that both milk yield and the milking time increase with age.

Analysis of the factor of lactation stage revealed similar dependencies as in the case of primiparous cows. The longest milking time and the highest milk yield were noted in the cows up to the hundredth day of lactation, and the time in the box decreased with subsequent stages, together with the milking time and the milk yield. Yield differences between the front and rear quarters varied between 0.52 and 0.57 kg of milk, depending on the lactation stage (Tab. 4). Sandrucci et al. [14] and Tančin et al. [18] demonstrated that cows in the initial stage of lactation gave more milk than during the other stages. In a study by André et al. [1], both milk yield and milking time in different stages of lactation were similar to the values obtained in the present study.

The lowest number of milking sessions was recorded in 2015 and the highest in 2013 and 2014. The shortest time in the box was noted in 2013, and the longest in 2014. The lowest milking yield was noted in 2012 and was accompanied by the shortest milking time, while the highest milking yield was observed in 2014, and the longest milking time in 2015. The differences in milking time and milk yield between the front and the rear udder quarters in 2012 and 2015 were 24-53 seconds and 0.49-0.61 kg of milk (Tab. 5).

Examination of the dependencies between the season and milking parameters showed that the minimum and maximum values were assigned to the same seasons as in the case of primiparous cows. The most milking sessions took place in spring. The time spent by the cows in the milking box was shortest in summer. The lowest milk yield per milking session was observed in autumn. Milking sessions in winter were longest and produced the highest milk yield. In a previous study by the authors [16], conducted on other herds, the lowest milk yields were observed in autumn and winter. In the present study the differences between the yield from the front and the rear quarters varied depending on the milking season, ranging from 0.48 to 0.57 kg (Tab. 5).

The time spent by the animals in the milking robot was 361 and 383 seconds for primiparous and multiparous cows, respectively, and the average milking time accounted for over 66% of this time in the primiparous cows and nearly 70% in the multiparous cows. The differences between milking time for the front and rear udder quarters were smaller in the primiparous cows than in the multiparous cows. The rear udder quarters of primiparous cows were milked 25 seconds longer than the front quarters, while in the case of multiparous cows the difference was on average 40 seconds. Comparison of the milking time of the

**Table 3**  
Analysis of time in box, milking time and milk yield in each quarter depending on the year and season of milking (mean values, coefficients of variation underneath) in the primiparous cow group

Factors	N	Time in box (s)				Milk time (s)				Milk yield (kg)						
		total	FL	RL	FR	RR	total	FL	RL	FR	RR	total	FL	RL	FR	RR
Milking year	2012	354.62	171.16	198.79	176.31	207.03	8.12	1.94	2.22	1.92	2.21	232.53	171.16	198.79	176.31	207.03
		30.94	45.69	43.50	49.83	45.42	29.08	37.66	35.12	39.30	35.76	43.12	45.69	43.50	49.83	45.42
2013	105155	361.45	179.27	206.87	181.14	213.08	8.23	1.90	2.32	1.89	2.31	240.74	179.27	206.87	181.14	213.08
		32.60	49.57	44.91	48.23	47.25	30.05	36.88	35.25	37.90	34.93	45.14	49.57	44.91	48.23	47.25
2014	108772	367.64	187.82	209.87	192.39	210.98	8.43	2.01	2.33	2.00	2.29	244.44	187.82	209.87	192.39	210.98
		29.90	45.06	43.17	45.56	43.21	29.04	34.52	36.33	37.74	39.00	40.53	45.06	43.17	45.56	43.21
2015	37501	358.40	180.70	203.94	185.17	203.66	7.88	1.85	2.20	1.83	2.17	238.02	180.70	203.94	185.17	203.66
		30.61	43.54	44.16	44.23	44.52	27.15	34.24	32.96	33.48	34.18	40.97	43.54	44.16	44.23	44.52
Milking season	Spring	365.09	184.27	210.17	189.82	214.54	8.31	1.96	2.30	1.96	2.28	245.19	184.27	210.17	189.82	214.54
		30.83	45.71	43.62	45.85	44.66	28.46	34.98	34.66	36.75	35.63	41.74	45.71	43.62	45.85	44.66
Summer	87539	348.43	170.60	195.36	172.54	199.94	8.10	1.90	2.26	1.90	2.22	226.68	170.60	195.36	172.54	199.94
		30.13	45.11	43.25	46.52	45.00	28.51	35.89	34.28	37.81	37.37	42.32	45.11	43.25	46.52	45.00
Autumn	67712	355.69	175.34	200.60	178.58	203.60	7.91	1.86	2.21	1.84	2.17	233.56	175.34	200.60	178.58	203.60
		31.60	47.88	44.24	48.60	44.85	29.90	37.55	37.18	38.90	38.21	43.44	47.88	44.24	48.60	44.85
Winter	90778	372.60	186.44	212.33	190.66	217.84	8.48	2.01	2.33	1.98	2.34	248.57	186.44	212.33	190.66	217.84
		31.52	47.30	44.17	48.68	45.83	29.94	36.50	35.99	38.48	35.14	43.15	47.30	44.17	48.68	45.83

N – number of milking sessions

Udder quarter designations: FL – front left; RL – rear left; FR – front right; RR – rear right



**Table 4**  
Analysis of time in box, milking time and milk yield in each quarter depending on the herd and lactation stage (mean values, coefficients of variation underneath) in the multiparous cow group

Factors	N	Time in box (s)				Milking time (s)				Milk yield (kg)			
		total	FL	RL	FR	total	FL	RL	FR	total	FL	RL	FR
Herd	A	190 102	366.94	248.10	177.06	217.93	178.02	213.04	8.88	2.08	2.52	2.12	2.57
			31.34	43.09	45.22	47.55	46.15	44.29	28.59	36.27	36.86	40.97	35.92
			403.07	284.32	195.32	245.09	209.30	251.81	10.91	2.47	3.06	2.50	3.11
B	93 133		31.37	42.00	45.66	44.17	48.61	44.47	32.12	41.43	39.13	38.90	37.19
			388.66	273.83	190.65	235.04	196.85	229.56	10.21	2.37	3.01	2.38	2.98
			29.93	39.95	46.41	45.01	46.64	44.93	33.91	44.29	44.23	45.11	44.13
C	205 476		397.80	280.26	198.79	243.46	205.64	239.27	10.40	2.42	2.98	2.44	2.97
			30.86	41.20	45.41	44.83	46.65	44.32	32.82	41.28	41.11	41.35	40.38
			384.03	267.30	185.81	231.31	193.60	229.12	9.95	2.30	2.87	2.34	2.89
Lactation stage (days)	<100		30.72	41.61	45.38	45.79	46.51	44.82	31.34	40.58	41.53	42.50	39.86
			358.55	241.49	166.95	208.87	168.50	207.29	8.77	2.02	2.54	2.04	2.59
			30.28	41.65	45.63	46.54	47.01	45.31	32.66	42.03	42.46	44.38	41.93

N – number of milking sessions  
Udder quarter designations: FL – front left; RL – rear left; FR – front right; RR – rear right

**Table 5**  
Analysis of time in box, milking time and milk yield in each quarter depending on the year and season of milking (mean values, coefficients of variation under-neath) in the multiparous cow group

Factors	N	Time in box (s)				Milking time (s)				Milk yield (kg)							
		total	FL	RL	FR	RR	total	FL	RL	FR	RR	total	FL	RL	FR	RR	
Milking year	2012	115078	381.81	176.14	228.78	181.01	215.90	9.16	2.11	2.67	2.12	2.64	2.11	2.67	2.12	2.64	
		30.14	45.29	47.30	46.64	46.00	31.98	42.15	42.69	42.23	40.55	31.98	42.15	42.69	42.23	40.55	
		264.45	187.21	227.93	191.55	228.47	9.91	2.31	2.80	2.35	2.84	9.91	2.31	2.80	2.35	2.84	
2013	153987	30.69	41.53	45.74	46.18	43.90	32.58	40.51	41.39	42.80	39.00	32.58	40.51	41.39	42.80	39.00	
		267.38	189.28	230.91	192.24	231.53	10.17	2.34	2.95	2.36	2.97	10.17	2.34	2.95	2.36	2.97	
		42.81	46.65	47.07	48.48	46.48	33.48	42.23	42.85	43.50	41.48	33.48	42.23	42.85	43.50	41.48	
2015	61205	393.36	195.25	238.63	213.10	236.71	9.97	2.36	2.89	2.36	2.92	9.97	2.36	2.89	2.36	2.92	
		30.41	45.38	42.29	46.96	42.09	32.46	41.96	39.19	41.70	42.73	32.46	41.96	39.19	41.70	42.73	
		269.48	189.15	233.69	195.98	230.89	9.96	2.31	2.86	2.33	2.90	9.96	2.31	2.86	2.33	2.90	
Milking season	Spring	145977	29.69	45.48	43.89	46.08	42.63	32.83	41.61	41.74	42.57	40.22	32.83	41.61	41.74	42.57	40.22
		252.31	175.48	220.29	180.35	217.53	9.64	2.21	2.78	2.24	2.79	9.64	2.21	2.78	2.24	2.79	
		42.85	46.02	46.88	48.25	46.14	33.81	42.23	42.76	42.70	42.56	33.81	42.23	42.76	42.70	42.56	
Autumn	103062	378.73	185.35	225.61	186.68	224.24	9.40	2.19	2.72	2.22	2.70	9.40	2.19	2.72	2.22	2.70	
		32.18	46.46	47.80	48.70	47.51	33.53	42.39	42.54	44.87	42.30	33.53	42.39	42.54	44.87	42.30	
		261.78	185.35	225.61	186.68	224.24	9.40	2.19	2.72	2.22	2.70	9.40	2.19	2.72	2.22	2.70	
Winter	132711	394.57	192.45	238.79	201.02	234.35	10.16	2.36	2.92	2.39	2.93	10.16	2.36	2.92	2.39	2.93	
		30.96	41.74	45.86	45.82	44.90	31.77	41.10	41.35	42.10	39.14	31.77	41.10	41.35	42.10	39.14	
		275.82	192.45	238.79	201.02	234.35	10.16	2.36	2.92	2.39	2.93	10.16	2.36	2.92	2.39	2.93	

N – number of milking sessions

Udder quarter designations: FL – front left; RL – rear left; FR – front right; RR – rear right

**Table 6**  
Pearson's correlation coefficients between milking parameters

	Milking time (s)					Milk yield (kg)				
	total	FL	RL	FR	RR	total	FL	RL	FR	RR
Time in box (s)	0.9378 <.0001	0.7342 <.0001	0.7950 <.0001	0.7645 <.0001	0.8054 <.0001	0.3077 <.0001	0.2351 <.0001	0.2503 <.0001	0.2355 <.0001	0.2343 <.0001
total		0.7694 <.0001	0.8652 <.0001	0.8012 <.0001	0.8692 <.0001	0.3615 <.0001	0.2761 <.0001	0.3121 <.0001	0.2714 <.0001	0.2905 <.0001
FL			0.6395 <.0001	0.7332 <.0001	0.6286 <.0001	0.3243 <.0001	0.3874 <.0001	0.2041 <.0001	0.2806 <.0001	0.1849 <.0001
RL				0.6464 <.0001	0.7432 <.0001	0.3721 <.0001	0.2375 <.0001	0.4228 <.0001	0.2331 <.0001	0.2850 <.0001
FR					0.6855 <.0001	0.3479 <.0001	0.3085 <.0001	0.2337 <.0001	0.3814 <.0001	0.2275 <.0001
RR						0.3430 <.0001	0.2277 <.0001	0.2690 <.0001	0.2353 <.0001	0.3745 <.0001
Milk yield (kg)							0.7475 <.0001	0.7841 <.0001	0.7629 <.0001	0.7858 <.0001
total								0.4789 <.0001	0.6505 <.0001	0.4538 <.0001
FL									0.4845 <.0001	0.6055 <.0001
RL										0.5079 <.0001
FR										

N – number of milking sessions  
Udder quarter designations: FL – front left; RL – rear left; FR – front right; RR – rear right

front and rear udder quarters in relation to lactation number showed that the milking time of the front quarters was 8 seconds shorter in primiparous cows than in older cows, and the milking time of the rear quarters was 22 seconds shorter.

The milking time of the front quarters was 47% of the total milking time in the primiparous cows and 45% of the total milking time in the multiparous cows, which was directly linked to the quantity of milk obtained from these cows (8.22 kg in the case of primiparous cows and 9.82 kg for multiparous cows per milking session). Bach and Busto [2] as well as Berglund et al. [4] reported that the milk yield of rear quarters is up to twenty percent higher than the yield of the front quarters, which is due to the morphology of the different quarters [11, 18, 19].

Pearson's linear correlations between the characteristics studied were positive and statistically confirmed (Table 6). Pearson's correlation coefficients indicated a high positive correlation between the time spent by the cow in the box and its milking time (0.937) ( $P \leq 0.001$ ). On the other hand, the correlation between milking time and milk yield was quite low, at 0.361, despite the dependency observed in the results for milk yield and milking time. This correlation was intermediate between the value obtained by Sandrucci et al. [14], i.e.  $r=0.47$  ( $P < 0.001$ ), and the value of 0.27 demonstrated by Edwards et al. [6].

The research demonstrated a highly significant impact of the herd, lactation stage, season and year, as well as the interaction between these factors, on the milking parameters analysed, i.e. the time in the box, milking time, milk yield, and milking time and milk yield for individual udder quarters, in primiparous and multiparous cows.

Multiparous cows from herd B spent the most time in the box (over 400 seconds) and the primiparous cows from herd C spent the shortest time in the box (about 350 seconds). During the first stage of lactation the time in the box for both groups was at a very similar level of 396-397 seconds. During this stage the milking time averaged about 268 seconds for primiparous cows and about 280 seconds for multiparous cows. The average milk yield at this time was 8.38 kg of milk in the case of primiparous cows and 10.40 kg in multiparous cows. In the final stage of lactation, after 200 days, the milking time of primiparous cows was 214 seconds and that of multiparous cows was 241 seconds, while the milk yield was 7.93 and 8.77 kg, respectively. Both primiparous and multiparous cows spent more time in the robot and were milked longer in the spring and winter, which can be linked to higher milk yield. The rear udder quarters were milked longer in both primiparous cows and multiparous cows; the difference was about 25 seconds in the case of the former and about 40 seconds in the case of the latter.

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