

Effect of extended lactations on cow milk and reproductive performance

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Abstract

Frequency of extended lactations and their effect on milk and reproductive performance of cows from the active population of 11 891 Black and White cows with different proportions of Holstein Friesian inheritance were analysed. It was found that lactations longer than a 305-day standard lactation were quite common in the analysed population of Black-and-White cows improved with the Holstein-Friesian breed. The age of cows, the level of yield in a standard lactation and season of the year had a significant effect on the proportion of extended lactations. Lactation extension had a beneficial effect on milk yield in full lactation but was detrimental to fertility. The efficiency of lactation extension was found to increase with the increasing level of yield in the standard lactation.

Keywords: cow, extended lactations, milk performance, reproductive performance

Zusammenfassung

Der Einfluss verlängerter Laktationsdauer auf Milch- und Fruchtbarkeitsleistungen bei Kühen

Untersucht wurde der Einfluss einer verlängerten Laktationsdauer auf den Milchertrag und die Fruchtbarkeitsleistung an 11 891 Schwarzbuntrindern mit unterschiedlichem Holstein Friesian Genanteil. In den untersuchten Populationen konnte eine durchschnittlich 305-tägige Laktationsdauer ermittelt werden. Das Alter der Kühe, das Durchschnittsniveau einer Standardlaktation und die Kalbezeit hatten einen signifikanten Einfluss auf die Auswirkungen der Laktationsverlängerung. Die Verlängerung erbrachte einen höheren Milchertrag in der Gesamtlaktation aber eine Verminderung bei den Fruchtbarkeitsleistungen.

Schlüsselwörter: Kuh, Verlängerung Laktationsdauer, Milchleistung, Fruchtbarkeitsleistung

Introduction

Intensive breeding over the last 40 years coupled with improvement of environmental conditions resulted in the doubling of the cows' milk yield in many countries. Higher milk production increased changes in cow productivity, including extended lactations and reduced fertility (BIELFELDT *et al.* 2004, GULIŃSKI *et al.* 2004, KRZYŻEWSKI and REKLEWSKI 2003, SAWA *et al.* 2002, HINRICHS *et al.* 2006, SALAMOŃCZYK and GULIŃSKI 2007, SEELAND

and HENZE 2003, SÖLKNER *et al.* 2000). According to GULIŃSKI *et al.* (2004), prolongation of the lactation period by 30, 60, 120, 180 and over 180 days increased fat corrected milk production by 3.3%, 9.6%, 21.4%, 33.8% and 55.5%, respectively. For cows yielding over 9 000 kg of milk, KRZYŻEWSKI *et al.* (2004) showed a beneficial effect of extended lactations not only on milk yield and composition but also on basic reproductive parameters.

The cow's lactation period lasts from calving to drying off. The average length of this period is approximate 10 months (with a standard lactation of 305 days), but in practice the fluctuations are considerable. Lactations shorter than standard ones occur in undernourished, sick or early fertilized cows. Extended lactations most often involve the extension of calving interval and are found in high-yielding cows (BORKOWSKA 2005). The possibility of extending lactations is increasingly considered as individual yields increase. According to SZAREK (1998), the idea of 18-month lactations was conceived at the same time in the USA and Europe. BERTILSSON *et al.* (1998) and KNIGHT *et al.* (1998) suggest that cows with extended lactations may generate larger profits as a result of increased lifetime milk yield, extended length of productive life, and lower cost of herd replacement.

The aim of the present study was to analyse the effect of lactation extension on the yield and fertility of cows and to determine factors affecting extended lactations.

Material and methods

Data used in the study originated from the SYMLEK database and concerned the milk and reproductive performance of 11 891 Black-and-White cows improved with the Holstein-Friesian breed. The cows belonged to the active population of the Kujawsko-Pomorskie province, first calved in 2001 and were used or culled by 2007. The length of 57 883 full lactations was calculated. After preliminary analysis of the data, statistical calculations were limited to 22 432 lactations extending beyond 305 days. Extended lactation length, milk yield in a 305-day lactation and extension period, daily milk yield during the extension period, the proportion of milk obtained during the extension period in relation to 305-day lactation yield, as well as the length of consecutive calving intervals (CI), reproductive rest period (RRP) and number of inseminations after each calving (1, 2, 3, >3) were calculated.

Statistical analysis was performed by means of two-way analysis of variance using the following linear model (SAS 2004):

$$Y = \mu + a_i + b_j + (ab)_{ij} + e_{ijk} \quad (1)$$

where μ is the overall mean, a_i the effect of i -th extension of lactation (≤ 30 , 31-60, 61-90, 91-120, 121-150, 151-180, >180 days), b_j the effect of j -th age of cows (lactation 1, 2, 3 >3) or j -th level of yield in a 305-day lactation ($\leq 5\ 000$ kg, 5 001-7 000, >7 000) or j -th season of calving (III-V, VI-VIII, IX-XI, XII-II), $(ab)_{ij}$ the interaction between lactation extension \times age of cow (or level of yield in a 305-day lactation or season of calving) and e_{ijk} the random error of observation.

Significant differences were checked using the Scheffe test.

The χ^2 independence test (SAS 2004) was used to analyse the frequency of extended lactations according to age of cow, level of yield in a 305-day lactation and season of calving. In addition, the CORR PEARSON procedure (SAS 2004) was used to calculate correlation coefficients between lactation extension length and individual performance traits of the cows.

Results

Full lactation yield (7 204 kg milk) is considered high (Table 1). Lactation extension length averaged 84 days. During this period, an average of 1 064 kg milk was obtained per cow, which accounted for approx. 17% of the yield in a 305-day lactation. Fertility parameters are evidence of reproductive abnormalities.

Table 1
Performance traits of cows in the population studied
Leistungsmerkmale der Kühe in den untersuchten Populationen

Item	Value of trait
Length of lactation extension, days	84
kg milk in 305-day lactation	6 140
kg milk during lactation extension	1 064
kg milk in full lactation	7 204
kg milk/day during lactation extension	12.8
Proportion of milk during lactation extension as related to 305-day lactation, %	17.3
Calving interval, days	439
Reproductive rest period, days	96
Number of inseminations	2.25

Table 2
Frequency of extended lactations
Frequenzen der Laktationsverlängerung

Item	Number of lactations	Percentage of lactation extended by days						
		≤30	31-60	61-90	91-120	121-150	151-180	>180
In general	22 432	29.12	21.36	15.21	10.67	7.42	5.10	11.12
Age (lactation) $\chi^2=284^{**}$								
1	8 477	26.64	19.58	14.99	11.43	7.84	5.60	13.91
2	6 200	28.66	21.82	15.34	10.60	7.44	5.37	10.77
3	4 414	29.66	22.27	15.61	9.86	7.45	4.53	10.63
>3	3 440	35.57	23.83	14.97	9.94	6.26	4.07	5.36
Level of yield per 305-day lactation $\chi^2=166^{**}$								
≤5 000	6 290	33.94	21.67	14.21	9.73	6.34	4.52	9.59
5 001-7 000	10 059	28.77	21.26	15.44	11.02	7.40	5.17	10.94
>7 000	6 083	24.72	21.21	15.85	11.05	8.56	5.59	13.02
Calving season $\chi^2=29^*$								
III-V	5 933	30.46	20.75	14.31	10.37	7.43	5.09	11.06
VI-VIII	5 213	28.45	21.29	15.85	10.59	7.98	5.68	10.17
IX-XI	5 269	28.54	22.17	15.39	10.99	6.98	4.86	11.06
XII-II	6 017	28.90	21.32	15.37	10.75	7.30	4.82	11.53

* $P \leq 0.05$, ** $P \leq 0.01$

Out of 57 883 full lactations, 22 432 lactations (39%) were longer than 305 days. It was shown that 29% lactations were extended by up to 30 days, 21% by 31-60 days, 15% by 61-90 days, 11% by 61-120 days, 7% by 121-150 days, 5% by 151-180 days and 11% by over 180 days (Table 2).

The results of the χ^2 test show significant ($P \leq 0.01$) differences in the frequency of extended lactations according to all factors analysed in the experiment. The proportion of extended lactations was most differentiated by the age of cows (lactation number). As the number of calvings increased, the proportion of lactations extended up to 60 days increased and the proportion of lactations extended by over 90 days (especially by over 180 days) decreased 2.6-fold. As the level of yield per standard lactation increased, the proportion of lactations extended up to 30 days decreased (from 34 to 25%) and the proportion of lactations extended beyond 60 days increased (from 9.6 to 13%), with the greatest differences observed for extensions beyond 180 days. These tendencies seem desirable considering the increased efficiency of using high-yielding cows as their lactations became more extended. Most cows calved in winter and spring. The proportion of extended lactations within particular calving seasons remained constant.

The results concerning the effect of cow age and lactation extension on milk and reproductive performance are shown in Table 3. Regardless of cow's age, the extension of lactation beyond standard was paralleled by higher yield during 305-day lactation, with differences ranging from 458 kg milk for first calvers to 962 kg milk for third calvers. As lactations became longer, milk yield during the extension period increased (especially in third calvers) to 3 609 kg in lactations extended beyond 180 days. As lactation increased, the proportion of milk obtained during the extension period increased in relation to the yield obtained per 305-day lactation. The proportion of milk obtained from first calvers during lactation extended by over 180 days accounted for as much as 62% of their yield during a 305-day lactation. The proportion of milk yield during the longest extension periods in relation to 305-day yield was approx. 50% in second- and third-lactation cows and approx. 44% in older cows. Extending the lactation by 31-60 days caused a decrease in daily milk yield during the extension period in relation to daily yield of the cows, which prolonged their lactations to 30 days (the highest in the second lactation – by 3.4 kg, the lowest in the third and next lactations – by 1.1 kg). Further extension of lactations did not have a negative effect on daily milk yield during the extension period. There was a tendency towards increased daily milk yield as the lactation period became longer. This tendency was most pronounced during the third lactation, when milk yield increased by 2 kg. As lactations extended, fertility was found to deteriorate, especially in first calvers. The significant relationship found in the experiment between the length of lactation extension and the length of calving interval (CI) is considered obvious ($r=0.917^{***}$) (Table 6). CI extension was caused not so much by longer RRP as by unsuccessful inseminations in consecutive cycles (number of inseminations was approx. 4 for lactations extended by over 180 days) (Table 3).

Milk yield during the extension period increased with the increasing level of yield in a 305-day lactation and with lactation extension (Table 4). As a result, milk yield during the extension period ranged from 136 kg for extension shorter than 30 days and standard lactation level of $\leq 5\,000$ kg to as much as 4 337 kg for extension longer than 180 days

Table 3
Productivity of cows as related to their number of lactation and length of lactation extension
Leistungen der Kühe in Abhängigkeit von Laktationsnummer und Laktationsverlängerung

Productive traits of cows	L	Productivity as related to length of lactation extension, days							Significance
		≤30	31-60	61-90	91-120	121-150	151-180	>180	
		1	2	3	4	5	6	7	
kg milk in 305-day lactation	1	5 293	5 496	5 485	5 562	5 635	5 644	5 751	1:2,4,5,6,7** ³ , 2:3,7** ³ , 3:7**
	2	5 940	6 093	6 372	6 358	6 434	6 514	6 629	1:3,4,5,6,7** ² , 2:6 ⁷ , 7**
	3	6 273	6 520	6 782	6 806	7 084	6 955	7 235	1:3,4,5,6,7** ² , 2:5,7** ³ , 3:7*
	>3	6 736	6 886	7 011	7 021	7 294	7 051	7 340	1:4,7**
kg milk during lactation extension	1	185	545	905	1 315	1 715	2 116	3 493	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	2	187	511	889	1 221	1 646	2 023	3 373	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	3	175	537	923	1 319	1 804	2 184	3 609	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	>3	184	539	950	1 349	1 818	2 117	3 174	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
kg milk/day during lactation extension	1	14.0	12.2	12.1	12.5	12.7	12.8	13.0	1:2,3,4** ⁵ , 5 ² , 2:3**
	2	14.8	11.4	11.9	11.7	12.2	12.3	12.9	1:2,3,4,5,6** ⁷ , 2:7** ⁴ , 4:7*
	3	13.0	11.9	12.3	12.6	13.4	13.3	13.9	1:7** ² , 2:5 ⁷ , 7** ³ , 3:7** ⁴ , 4:7*
	>3	13.2	12.1	12.7	13.0	13.6	12.8	13.4	
Proportion of milk during lactation extension as related to 305-day lactation, %	1	3.5	9.9	16.5	23.7	30.5	37.8	61.8	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	2	3.2	8.5	14.1	19.5	26.0	31.6	51.7	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	3	2.8	8.3	13.8	19.5	25.8	32.0	50.9	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	>3	2.7	7.9	13.6	19.4	25.3	30.5	44.3	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
Calving interval, days	1	371	401	431	465	495	526	624	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	2	375	405	440	472	506	536	620	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	3	376	408	442	471	501	536	607	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
	>3	374	405	441	465	492	534	596	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5,6,7** ³ , 5:6,7** ³ , 6:7** ³
Reproductive rest period, days	1	75	88	98	101	107	115	120	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:5 ⁶ , 6,7** ³ , 4:6 ⁷ , 7** ³ , 5:7** ³ , 5:7** ³
	2	78	90	102	106	119	120	131	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:5,6,7** ³ , 4:6 ⁷ , 7** ³ , 5:6*
	3	81	95	104	115	116	125	132	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:6,7** ³ , 4:7** ³ , 5:7*
	>3	80	91	94	110	111	101	135	1:2,3,4,5,7** ² , 2:4,7** ³ , 3:7** ³
Number of inseminations	1	1.54	1.90	2.22	2.73	2.98	3.28	4.10	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5 ⁶ , 6,7** ³ , 5:6 ⁷ , 7** ³ , 6:7** ³
	2	1.50	1.90	2.27	2.73	2.83	3.16	3.87	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:6,7** ³ , 5:7** ³ , 5:7** ³ , 6:7** ³
	3	1.46	1.88	2.34	2.52	2.82	2.98	3.83	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:4,5,6,7** ³ , 4:5 ⁶ , 7** ³ , 5:7** ³ , 5:7** ³ , 6:7** ³
	>3	1.45	1.84	2.53	2.69	2.91	3.24	4.07	1:2,3,4,5,6,7** ² , 2:3,4,5,6,7** ³ , 3:7** ³ , 4:7** ³ , 5:7** ³

L Lactation, *P≤0.05, **P≤0.01

Table 4
Productivity of cows as related to their standard lactation yield and length of lactation extension
Leistung der Kühe in Abhängigkeit vom Milchtrag ihrer Standardlaktation und der Laktationsverlängerung

Productive traits of cows	Level of yield, kg	Productivity as related to length of lactation extension, days							Significance
		1	2	3	4	5	6	7	
kg milk in 305-day lactation	≤5 000	4 165	4 183	4 203	4 217	4 241	4 195	4 198	-
	5 000-7 000	5 914	5 941	5 954	5 951	5 953	5 957	5 986	-
	>7 000	8 454	8 409	8 512	8 449	8 536	8 561	8 587	-
kg milk during lactation extension	≤5 000	136	386	662	961	1 270	1 552	2 654	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
	5 000-7 000	183	530	874	1 257	1 644	2 032	3 270	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
	>7 000	251	691	1 199	1 660	2 195	2 665	4 337	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
kg milk/day during lactation extension	≤5 000	11.1	8.7	8.9	9.1	9.4	9.5	9.9	1:2,3,4**
	5 000-7 000	13.8	11.8	11.7	12.0	12.2	12.3	12.6	1:2,3,4,5,7***, 5*
	>7 000	17.9	15.5	16.0	15.8	16.3	16.1	16.6	1:2,3,4***, 5*
Proportion of milk during lactation extension as related to 305-day lactation, %	≤5 000	3.26	9.26	15.8	22.9	30.1	37.3	64.0	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
	5 000-7 000	3.10	8.95	14.7	21.2	27.7	34.2	54.8	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
	>7 000	3.00	8.2	14.2	19.7	25.8	31.2	50.9	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
Calving interval, days	≤5 000	374	404	436	469	499	532	627	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
	5 000-7 000	373	404	434	466	498	528	614	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
	>7 000	374	405	439	472	504	534	626	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:5,6,7***, 5:6,7***, 6:7***
Reproductive rest period, days	≤5 000	77	91	105	108	116	127	138	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:6,7**, 4:6,7***
	5 000-7 000	77	92	99	104	113	113	122	1:2,3,4,5,6,7***, 2:4,5,6,7***, 3:5,7** 4:7***
	>7 000	80	87	97	104	107	115	118	1:2,3,4,5,6,7***, 2:4,5,6,7***, 3:7**, 5:7***
Number of inseminations	≤5 000	1.48	1.86	2.09	2.46	2.65	2.81	3.33	1:2,3,4,5,6,7***, 2:4,5,6,7***, 3:5,6,7***, 4:6,7***
	5 000-7 000	1.52	1.83	2.24	2.69	2.2	3.29	3.93	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:6,7***, 5:7***, 6:7***
	>7 000	1.52	2.04	2.51	2.97	3.26	3.44	4.73	1:2,3,4,5,6,7***, 2:3,4,5,6,7***, 3:4,5,6,7***, 4:7***, 5:7***, 6:7***

* $P \leq 0.05$, ** $P \leq 0.01$

Table 5
Productivity of cows as related to calving season and length of lactation extension
Leistungen der Kühe in Abhängigkeit vom Kalbemonat und Laktationsverlängerung

Productive traits of cows	Calving season	Productivity as related to length of lactation extension, days							Significance
		≤30	31-60	61-90	91-120	121-150	151-180	>180	
		1	2	3	4	5	5	7	
kg milk in 305-day lactation	III-V	5727	5923	6035	6086	6224	6218	6206	-
	VI-VIII	5715	5945	5989	6083	6115	6293	6091	-
	IX-XI	6129	6285	6412	6299	6540	6122	6627	1:7**
kg milk during lactation extension	XII-II	6141	6257	6420	6354	6545	6524	6564	-
	III-V	172	508	891	1310	1767	2179	3520	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	VI-VIII	193	584	955	1367	1810	2104	3498	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
kg milk/day during lactation extension	IX-XI	194	540	920	1263	1679	2013	3397	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	XII-II	178	505	882	1246	1648	2095	3423	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	III-V	13.5	11.4	11.9	12.5	13.1	12.8	13.3	1:2**, 3*, 2:7*
Proportion of milk during lactation extension as related to 305-day lactation, %	VI-VIII	14.3	13.0	12.8	13.1	13.5	13.2	13.3	-
	IX-XI	14.3	12.0	12.3	12.1	12.4	12.2	13.1	1:2,3,4**
	XII-II	13.5	11.3	11.8	11.9	12.2	12.7	13.1	1:2,3**, 2:7*
Calving interval, days	III-V	3.0	8.6	15.0	21.8	28.8	34.8	57.8	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	VI-VIII	3.4	10.0	16.2	23.0	30.2	35.4	59.5	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	IX-XI	3.2	8.7	14.5	20.2	25.7	33.5	52.6	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
Reproductive rest period, days	XII-II	2.9	8.1	13.8	19.9	25.7	32.6	53.6	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	III-V	373	404	436	467	498	531	626	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	VI-VIII	372	402	437	466	498	530	619	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
Number of inseminations	IX-XI	374	405	436	472	498	526	617	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	XII-II	375	404	436	468	504	535	618	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
	III-V	78	94	103	104	115	119	132	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:4,5,6,7**, 4:5,6,7**, 5:6,7**, 6:7**
Significance	VI-VIII	75	89	97	108	115	111	120	1:2,3,4,5,6,7**, 2:3,4,7**
	IX-XI	80	90	101	104	111	123	125	1:3,4,5,6,7**, 2:5*, 6:7**, 3:7** 4:7*
	XII-II	76	89	99	105	109	117	123	1:3,4,5,6,7**, 2:4*, 5:6,7**, 3:7**
Number of inseminations	III-V	1.47	1.82	2.22	2.79	2.97	3.26	4.07	1:2*, 3:4,5,6,7**, 2:4,5,6,7**, 3:4,5,6,7**, 4:7**, 5:7**, 6:7**
	VI-VIII	1.58	1.94	2.29	2.59	2.74	3.35	3.89	1:2*, 3:4,5,6,7**, 2:4,5,6,7**, 3:6,7**, 4:7**, 5:7**
	IX-XI	1.45	1.91	2.29	2.69	2.93	2.94	3.76	1:2,3,4,5,6,7**, 2:4,5,6,7**, 3:5*, 6:7**, 4:7** 5:7**, 6:7**
Significance	XII-II	1.52	1.89	2.29	2.70	2.96	3.19	4.18	1:2,3,4,5,6,7**, 2:3,4,5,6,7**, 3:5,6,7**, 4:7**, 5:7**, 6:7**

*P≤0.05 **P≤0.01

and standard lactation level of >7 000 kg. During the extension period (regardless of its length), cows whose yield for a 305-day lactation exceeded 7 000 kg milk produced almost twice as much milk as their contemporaries, whose level of yield per standard lactation did not exceed 5 000 kg. Cows which produced over 7 000 kg milk in a standard lactation achieved the highest daily yield also during the extension period (by approx. 6.8 kg regardless of the extension length). The proportion of milk obtained during the extension ranged from approx. 3% when lactation was extended by up to 30 days to 51-60% when lactation was extended beyond 180 days, with higher values obtained for cows with a low level of yield in a standard lactation. Analysis of reproductive parameters showed that they were differentiated less by the level of yield in a standard lactation than by lactation extension. The results obtained demonstrate that the efficiency of lactation extension increases with the increasing level of yield in a standard lactation.

Of the factors analysed, calving season had the smallest effect on the differences in cow performance. Cows whose standard lactation yield was higher milked longer during full lactation, and it was shown that the 305-day lactation yield of autumn- and winter-calved cows was higher than that of spring- and summer-calved cows (differences up to 431 kg) (Table 5). During lactations extended up to 90 days slightly more milk was obtained from summer- and autumn-calved cows, and during lactations extended beyond 90 days more milk was obtained from spring- and summer-calved cows. The highest daily yield during the extended lactation period was achieved by spring-calved cows but their superiority over winter-calved contemporaries did not exceed 1.7 kg milk/day. Cow fertility deteriorated with lactation extension, and the fertility parameters did not vary within calving seasons.

The positive coefficients of correlation (Table 6) between lactation extension length and milk yield during the extension period ($r=0.906^{**}$) and between lactation extension length and proportion of milk during the extension period in relation to a standard 305-day lactation ($r=0.937^{**}$) fully confirm the results presented in Tables 3, 4 and 5 that cow yields increased steadily as lactations became longer. Analysis of the effect of lactation extension length on daily milk yield during the extension period showed a slight relationship between these traits. The correlation coefficients between lactation extension length and cow fertility were positive and statistically significant.

Table 6
Coefficients of correlation between length of lactation extension and productive traits
Korrelationskoeffizienten zwischen Laktationsdauer und Leistungsmerkmalen

Trait	Coefficients of correlation
Milk yield during full lactation, kg	0.496**
Milk yield during 305-day lactation, kg	0.070**
Milk yield during extension period, kg	0.906**
kg milk/day during lactation extension	-0.021**
Proportion of milk during lactation extension as related to 305-day lactation, %	0.937**
Calving interval, days	0.917**
Reproductive rest period, days	0.330**
Number of inseminations	0.536**

** $P \leq 0.01$

Discussion

The previous strategy for management of dairy herds was to obtain one calf per year as it was believed that the quicker the cow would be mated after calving, the more profitable it would be to produce milk (KRZYŻEWSKI and REKLEWSKI 2003). For this reason, a 305-day lactation was considered optimal (BORKOWSKA 2005). The present findings show that 39% of lactations were longer than standard 305 days. Studies by SALAMOŃCZYK and GULIŃSKI (2007) in the Sokołów region demonstrated that 55% of lactations exceeded 305 days. CZAPLICKA *et al.* (2003) reported extended lactations in approx. 70% of cows (slightly more in Black-and-White than Holstein-Friesian cows). GULIŃSKI *et al.* (2004) reported that 531 out of 693 cows (76% of all animals) extended their lactations. According to KHAN *et al.* (2007) 40,2% cows had longer lactation than 308 days of duration.

Cow's age (lactation number) was shown to differentiate the proportion of extended lactations the most (Table 2). With each successive calving, the proportion of lactations extended up to 60 days increased and the proportion of lactations extended beyond 90 days decreased. Especially large differences (approx. 10%) concerned the lactations extended up to 30 days and beyond 180 days. Longer lactations in first calvers compared to primiparas were reported by DYMNICKI *et al.* (2003), GULIŃSKI *et al.* (2004) and KRZYŻEWSKI *et al.* (2004). Studies by CZAPLICKA *et al.* (2003) and PIECH and TARKOWSKI (2001) showed that lactations became longer as cows became older. KRZYŻEWSKI and REKLEWSKI (2003) hold the view that lactation extension is particularly beneficial for first calvers, which are naturally characterized by greater lactation persistency. This enables young animals to reach full maturity at an earlier date and appropriate body condition before calving. SZAREK (1998) attributes the greater lactation persistency of first calvers compared to multiparas to the fact that first calvers grow intensively during the first lactation, as do their mammary glands.

Compared to primiparas, first calvers achieved lower yield per 305-day lactation and had lower daily yield during extended lactation (especially during the third lactation), but the proportion of milk during the lactation extension period in relation to a 305-day lactation was in their case the greatest regardless of extension period length. These results are in agreement with the findings of GULIŃSKI *et al.* (2004) and SALAMOŃCZYK and GULIŃSKI (2007).

Extended lactation is most often associated with extended CI (SZAREK 1998). Likewise, the present study showed that as lactation became longer, fertility deteriorated, especially in first calvers (Table 3).

According to KRZYŻEWSKI and REKLEWSKI (2003), the idea to retain standard 305-day lactations and year-long calving intervals is right only when the level of production is not very high. This is confirmed by our findings, which indicate that milk yield during extended lactation increased with lactation length and level of yield obtained by cows in a standard lactation, but the yield of cows that produced over 7 000 kg milk in a standard lactation was, regardless of the extension period, almost twice that of cows which did not exceed 5000 kg in a standard lactation. It is also worth noting the high daily yield of high-yielding cows, which exceeded 16 kg/day even during lactations extended beyond 180 days. Likewise, CZAPLICKA *et al.* (2003) reported that extended lactations in heavy

milking cows did not reduce the yield per day of lactation. HIBNER *et al.* (1999) also found persistently high daily yield of cows during the final period of extended lactation. This phenomenon is believed to be characteristic of Holstein-Friesian cows or crossbreds with high HF inheritance, kept under very good production conditions.

The increase in the amount of milk obtained during extended lactation, found in the present study together with the increased level of yield is consistent with the findings of GULIŃSKI *et al.* (2004) and SALAMOŃCZYK and GULIŃSKI (2007). However, the percentage of milk produced during extended lactation in relation to the amount of milk obtained in a 305-day lactation decreased with the increased level of yield in a standard lactation. This tendency was also prevalent in other studies (GULIŃSKI *et al.* 2004, SALAMOŃCZYK and GULIŃSKI 2007).

Analysis of the relationships between the utilization of cows for milk and reproduction gains special importance because the current strategy for cattle husbandry development foresees that milk yield should be increased on a regular basis. SZAREK (1998) and GULIŃSKI *et al.* (2004) as well as the authors they quote believe that lactation length is largely dependent on CI length. This thesis is fully confirmed by the results of the present study, in which the correlation between lactation extension length and CI length was 0.917** (Table 6). The results obtained for the effect of extended lactations on fertility are in agreement with the results of other authors, who showed that the slightly less beneficial reproductive parameters of the cows in groups with extended CI and longer lactations are compensated by higher milk yield (KRZYŻEWSKI *et al.* 2004, STRZAŁKOWSKA *et al.* 2004).

The average number of inseminations per pregnancy increased with the increasing level of standard lactation, especially with lactation extension. For cows producing up to 5000 kg milk per standard lactation, the insemination index increased with extended lactation from 1.48 to 3.33, and for high-yielding cows (over 7 000 kg milk per 305-day lactation) the insemination index increased with extended lactation from 1.52 to as much as 4.73. This shows, among others, that despite external signs of oestrus, the cow's body was not ready for fetal implantation in the reproductive tract. According to SWANSON (1989), mammary gland function has priority over the reproductive system in high-yielding cows.

One of the factors that affect the milk yield of cows is calving season. Analysis of the means characterizing the effect of calving season on milk yield in a standard lactation showed that it was approx. 400 kg higher in the autumn-winter season than in the spring-summer season. This difference was much lower than for the effect of the other factors. Also other productive traits were much less differentiated by the effect of calving season than by the effect of lactation number or level of yield in a standard lactation.

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