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LENGTH OF LIFE AND MILK PRODUCTION EFFICIENCY IN COWS WITH VARYING LACTATION PERSISTENCY*

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Abstract

A total of 2,484 lactations in 760 Polish Holstein-Friesian cows were analysed. Calculations were made of length of life, length of productive life, total number of days in milk, number of calvings, ratio of days in milk to length of productive life, lifetime milk yield (kg), daily yield at the peak of lactation (kg) and lactation persistency as the percentage difference between daily milk production in the 2nd and 10th month in milk. The cows were divided into three groups according to lactation persistency (decrease in production): group I – up to 30%, group II – 30.1–50% and group III – over 50%. Lactation persistency significantly influenced (P≤0.01) length of life and efficiency of milk production in the analysed cow population. Cows with yield over 30 kg at the peak of lactation followed by a moderate decrease (40%) lived longest (over 6 years) and produced the most milk (nearly 28,000 kg). Yield of primiparous cows at the peak of lactation and its course were found to have a significant effect on length of life and lifetime milk production. The long period of high peak yield (over 30 kg of milk) in the primiparous cows in group I (with the best lactation persistency) in the long term proved to be detrimental, as these cows had the shortest productive life (2.3 lactations on average) and lifetime milk yield about 4,000 kg lower than in the cows in groups II and III (with the poorer lactation persistency).

Key words: dairy production, lactation persistency, length of cows' life, lifetime milk yield

The length of life and productive life of cows should be considered in terms of three aspects: profitability of milk production, the reproductive potential of the herd, and genetic gain. Elimination of young cows from the herd is costly not only economically, but in terms of breeding. In this case more heifers are needed to rebuild the herd, so it is not possible to choose them from the best mothers (Archer et al., 2014; Do et al., 2013; Martens and Bange, 2013).

According to Novaković et al. (2014), lifetime milk yield should be treated as an

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indicator of dairy herd efficiency that directly translates to economic performance and breeding results. The problem of the length of productive life of cows has also been emphasized by Brickell and Wathes (2011), who showed that 43% of cows are culled before their third calving. When we add to this the 11% of heifers (selected for rebuilding of the herd) that do not live to their first calving, the problem of herd reproduction is further exacerbated. These results are confirmed by Rocha et al. (2010), who state that only 15% of Portuguese Holstein-Friesians reach their fourth lactation.

The daily milk yield of a cow changes during shorter or longer periods of lactation, determining what is known as the lactation curve. From the point of view of the dairy farmer, maximum yield should be achieved rapidly (optimally in the second month after calving) and then persist for a long period, followed by a gradual decrease until the dry period. However, the time it takes for the cow to reach peak yield and the shape of the lactation curve are determined by numerous factors, such as breed, nutrition, principles of use for reproduction, calving season, farming system, genetic predispositions of individual animals, mammary gland diseases, frequency of milking, and length of the previous dry period (Bouallegue et al., 2014; Heins et al., 2012; Mohd Nor et al., 2013; Sawa et al., 2015). According to various authors (Albarrán-Portillo and Pollott, 2013; Ahlman et al., 2011; Do et al., 2013; Kheirabadi and Alijani, 2014; Khorshidie et al., 2012; Otwinowska-Mindur and Ptak, 2015; Yamazaki et al., 2014) heritability of lactation persistency ranges from 0.01 to 0.24, depending on how it is defined, e.g. the rate of the decrease in peak yield, the ratio of yield in the second 100 days in milk to the yield in the first 100 days, etc. The many factors affecting this problem are discussed by Rekik and Ben Gara (2004), who showed that as many as 25% of lactations in modern dairy cows have an atypical course. In Poland this was also confirmed by Gołębiewski et al. (2015), who found that 28% of lactations in Polish Holstein-Friesians and 21% in Montbéliarde cows had an atypical course. They also report that lactations in cows raised in an intensive (free-stall) system were characterized by a faster increase in yield in the initial phase of lactation and a sharper decline in the final phase in comparison with cows housed and fed in a traditional manner. Hurley (2009) states that in primiparous cows yield decreases by about 0.2% a day over successive months, and in multiparous cows by 0.3%. In the study of Salomończyk and Guliński (2011) in Polish Holstein Friesian population mean monthly decrease in milk production after the peak of lactation was 3.52%, and lactation persistency index – 31.7%.

Analysis of lactation persistency in individual cows can be a valuable tool for determining feed rations, monitoring the contribution of a given individual to the total productivity of the herd, managing the herd in production groups, or diagnosing mastitis and ketosis (Litwińczuk et al., 2015; Perz and Sobek, 1999). It also has economic significance, because it is closely linked to fertility and health and affects feeding costs (Appuhamy et al., 2009; Dhakal et al., 2015; Tekerli et al., 2000; Yamazaki et al., 2014).

The aim of the study was to determine the relationships, if any, between lactation persistency and the length of life and efficiency of dairy production in cows.

Material and methods

The analysis included 760 Polish Holstein-Friesian cows (2,484 lactations) calving at the turn of 20th and 21st centuries, raised on 91 private herds in Lublin region. The material for the study consisted of source data from the SYMLEK database of the Polish Federation of Cattle Breeders and Dairy Farmers covering the entire productive life of the cow, from its date of birth to its elimination from the herd. The study did not take into account cows exploited for one incomplete lactation.

For each cow, data were collected on date of birth and culling, dates of each calving, and milk performance in each lactation, and these were used to calculate length of life (days), length of productive life (days), total number of days in milk (days), number of calvings, ratio of length of productive life to length of life (%), ratio of number of days in milk to length of productive life (%), lifetime milk yield (kg), daily milk yield at peak lactation (kg), and lactation persistency (%).

Lactation persistency was calculated as the percentage difference between milk production in the second and tenth months of lactation, according to the following formula:

$$LPI = \frac{M2 - M10}{M2} \times 100\%$$

where:

LPI – lactation persistency index (%);
M2 – daily milk yield (kg) in 2nd month of lactation;
M10 – daily milk yield (kg) in 10th month of lactation.

The cows were divided into three groups according to their mean lactation persistency (decrease in production) over their entire productive life:

– up to 30%
– 30.1 – 50%
– over 50%

The results obtained were analysed taking into account daily milk yield at peak lactation. The following subgroups were distinguished:

– up to 20 kg
– 20.1 – 30 kg
– over 30 kg

The numerical data obtained were analysed statistically by the ANOVA procedure for factorial designs (two-way analysis of variance with interactions).

Significance of differences between factors was verified by Duncan's test in Statistica ver. 9.0.

Repeatability (re) of lactation persistency for the period of the first three lactations was estimated by analysis of variance for one-way classification.

Relationships between lactation persistency in lactations 1 and 2, 2 and 3, and 1 and 3 were calculated by Pearson's simple correlation method in Statistica ver. 9.0.

Table 1. Length of life and efficiency of production in cows depending on their mean lifetime lactation persistency

			Group I (decrease in yield up to 30%)				Group II (decrease in yield of 30.1-50%)				Group III (decrease in yield over 50%)				Interaction of lactation persistency* yield at peak lactation
			yield at peak lactation (kg)				yield at peak lactation (kg)				yield at peak lactation (kg)				
			up to 20	20.1–30	over 30	mean	up to 20	20.1–30	over 30	mean	up to 20	20.1–30	over 30	mean	
N			34	95	41	170	40	215	96	351	45	160	34	239	
Decrease in production (%)		$\bar{x}$	19.0	19.2	20.5	19.4	40.6	40.3	40.7	40.4	60.2	58.7	59.9	59.2	NS
		SD	9.3	8.9	7.8	8.7	5.9	5.4	5.4	5.5	8.6	7.2	7.4	7.5	
Length of life	days	$\bar{x}$	1,645.8 B	1,871.3	2,037.6 A	1,866.3 Y	1,655.5 B	2,119.6 A	2,167.1 A	2,079.7 X	1,990.6	2,050.8	2,201.9	2,060.9 X	NS
		SD	476.7	605.1	612.7	594.8	517.9	641.3	517.9	614.6	567.5	670.4	675.9	653.4	
	months	$\bar{x}$	54.9 B	62.4	67.9 A	62.2 Y	55.2 B	70.7 A	72.2 A	69.3 X	66.4	68.4	73.4	68.7 X	
		SD	15.9	20.2	20.4	19.8	17.3	21.4	17.3	20.5	18.9	22.3	22.5	21.8	
Length of productive life	days	$\bar{x}$	837.6 B	1,061.9	1,225.6 A	1,056.5 Y	869.2 B	1,307.8 A	1,376.5 A	1,276.6 X	1,216.6	1,253.2	1,417.8	1,269.8 X	NS
		SD	496.0	578.2	593.1	577.8	473.1	629.2	499.5	597.5	573.8	660.4	666.1	646.2	
	months	$\bar{x}$	27.9 B	35.4	40.9 A	35.2 Y	29.0 B	43.6 A	45.9 A	42.6 X	40.6	41.8	47.3	42.3 X	
		SD	16.5	19.3	19.8	19.3	15.8	21.0	16.7	19.9	19.1	22.0	22.2	21.5	
Days in milk		$\bar{x}$	757.4 B	959.2	1,092.0 A	950.9 Y	763.6 B	1,156.8 A	1,229.5 A	1,131.8 X	1,059.4	1,099.6	1,239.1	1,111.9 X	NS
		SD	442.6	508.2	541.8	513.6	422.2	542.6	443.9	521.4	490.1	557.4	596.5	551.6	
Number of lactations		$\bar{x}$	2.1 Bb	2.7 a	3.0 A	2.6 Y	2.5 B	3.4 A	3.5 A	3.4 X	3.7	3.5	3.7	3.6 X	*
		SD	1.1	1.4	1.3	1.4	1.3	1.5	1.2	1.5	1.5	1.7	1.7	1.6	
Ratio of days in milk to productive life (%)		$\bar{x}$	91.2	91.4	88.8	90.7 Xx	88.1	89.6	89.5 y	89.4	87.3	88.9	87.6	88.4 Y	NS
		SD	8.4	5.4	7.6	6.7	8.3	6.2	3.8	5.9	5.5	5.5	7.1	5.8	
Ratio of productive life to length of life (%)		$\bar{x}$	47.6 Bb	53.1 a	56.8 A	52.9 Y	49.6 B	58.2 A	61.6 A	58.2 X	57.9	57.5	60.8	58.0 X	*
		SD	13.5	12.7	12.4	13.0	11.5	13.3	9.1	12.6	12.9	12.7	13.2	12.8	

A, B, C – means with different letters are statistically significantly different at P<0.01 within individual groups of yield at peak lactation.
a, b, c – means with different letters are statistically significantly different at P<0.05 within individual groups of yield at peak lactation.
X, Y, Z – means with different letters are statistically significantly different at P<0.01 between groups of decrease in yield during lactation.
x, y, z – means with different letters are statistically significantly different at P<0.05 between groups of decrease in yield during lactation.
* – interaction of lactation persistency*yield at peak lactation statistically significant at P<0.05.

Table 2. Lifetime milk yield of cows with different lactation persistency

		Group I				Group II				Group III				Interaction of lactation persistency* yield at peak lactation
		Yield at peak lactation (kg)				Yield at peak lactation (kg)				Yield at peak lactation (kg)				
		up to 20	20.1–30	over 30	mean	up to 20	20.1–30	over 30	mean	up to 20	20.1–30	over 30	mean	
N		34	95	41	170	40	215	96	351	45	160	34	239	
Lifetime milk yield (kg)	$\bar{x}$	9,448.5 C	17,683.4 B	25,716.9 A	17,973.9 Y	9,807.2 C	20,185.9 B	27,627.3 A	21,038.4 X	12,586.8 C	18,188.4 B	26,283.5 A	18,285.3 Y	NS
	SD	6,033.7	9,552.8	13,928.1	11,532.4	5548.9	9,452.4	9,966.6	10,573.2	6,342.5	9,649.3	13,186.2	10,441.9	
Yield per year of productive life (kg)	$\bar{x}$	4,125.1 C	6,149.2 B	7,606.9 A	6,096.0 X	4,129.1 C	5,741.8 B	7,400.7 A	6,011.7 X	3,786.2 C	5,363.3 B	6,723.6 A	5,259.9 Y	NS
	SD	775.3	904.7	1,243.0	1,508.4	663.8	867.0	880.0	1,303.0	615.2	762.8	883.9	1,136.2	
Yield per day in milk (kg)	$\bar{x}$	12.5 C	18.5 B	23.4 A	18.5 X	12.8 C	17.6 B	22.7 A	18.4 X	11.9 C	16.6 B	21.1 A	16.3 Y	NS
	SD	2.4	2.8	2.6	4.5	1.5	2.4	2.6	3.8	1.8	2.4	2.8	3.5	
Yield per day of productive life (kg)	$\bar{x}$	11.3 C	16.8 B	20.8 A	16.7 X	11.3 C	15.7 B	20.3 A	16.5 X	10.4 C	14.7 B	18.4 A	14.4 Y	NS
	SD	2.1	2.5	3.4	4.1	1.8	2.4	2.4	3.6	1.7	2.1	2.4	3.1	
Yield per day of life (kg)	$\bar{x}$	5.4 C	8.9 B	11.8 A	8.9 Y	5.6 C	9.1 B	12.4 A	9.6 X	6.0 C	8.4 B	11.2 A	8.3 Z	NS
	SD	1.8	2.3	3.3	3.3	1.5	2.2	2.0	2.9	1.6	2.0	3.0	2.6	

A, B, C – means with different letters are statistically significantly different at $P<0.01$ within individual groups of yield at peak lactation.
X, Y, Z – means with different letters are statistically significantly different at $P<0.01$ between groups of decrease in yield during lactation.

Results

Length of life

The mean length of life and productive life for all 760 cows was 2,026 days of life (67.5 months) and 1,225 days of productive life (40.8 months). The most efficient were the cows of group II, with mean lactation persistency of 40% (Table 1). The results for the cows in this group were 2,080 days of life (69.3 months), 1,277 days of productive life (42.6 months) and 1,132 days in milk. The cows in group I (with the best lactation persistency, i.e. up to 30%) had significantly shorter lives and productive lives, and the differences ranged from 10.2% for days of life ($P \leq 0.05$) to 17.2% for days of productive life ($P \leq 0.01$). The length of productive life, and length of life, increased with the level of yield at peak lactation. The highest total number of days in milk – 1,239, days of productive life – 1,418 (47.3 months) and days of life – 2,202 (73.4 months) were noted in the group III cows (with the poorest lactation persistency), whose yield at peak lactation exceeded 30 kg of milk.

Production efficiency

The most efficient in terms of lifetime milk yield were the group II cows, whose decline in production during lactation was between 30% and 50%. During 3.4 lactations they produced on average 21,038 kg of milk (Table 2). Lower lifetime yield (by 13–15%) was obtained in the other two groups – 17,974 kg in group I and 18,285 in group III. The differences were statistically significant ($P \leq 0.01$). Within each of the three groups the highest lifetime yield was noted for the cows with yield of over 30 kg at the peak of lactation, ranging from 25,717 kg in group I to 27,627 kg in group II.

When lifetime milk yield is converted to yield per year of productive life and per day in milk (Table 2), the cows in group I (with the most persistent lactation) are found to be the most efficient. They produced on average 6,096 kg of milk per year and 18.5 kg per day in milk. The cows in group II had only slightly lower annual yield (6,012 kg) and yield per day in milk (18.4 kg), whereas yield in the group III cows (with the poorest lactation persistency, i.e. about 60%) was about 14% lower ($P \leq 0.01$). In all groups the highest annual yield was attained by cows producing over 30 kg of milk at peak lactation, and the differences with respect to the other groups were statistically significant ($P \leq 0.01$).

The repeatability coefficient for lactation persistency in the cow population, calculated by analysis of variance, was $re=0.241^{xxx}$ (Table 3), while Pearson's simple correlation coefficient was $r=0.213^{xxx}$ for the first and third lactations, $r=0.287^{xxx}$ for the first and second, and $r=0.304^{xxx}$ for the second and third.

Table 3. Repeatability and correlation coefficients for lactation persistency

	Repeatability coefficient (re)	Pearson's correlation coefficient (r)	P
For the first 3 lactations	0.241	-	0.000000
Between 1st and 2nd lactation	-	0.287	0.000000
Between 2nd and 3rd lactation	-	0.304	0.000000
Between 1st and 3rd lactation	-	0.213	0.000023

Table 4. Length of life and production efficiency in cows depending on persistency in first lactation

Item			Group I				Group II				Group III				Interaction of lactation persistency* yield at peak lactation
			yield at peak lactation (kg)				yield at peak lactation (kg)				yield at peak lactation (kg)				
			up to 20	20.1–30	over 30	mean	up to 20	20.1–30	over 30	mean	up to 20	20.1–30	over 30	mean	
N			99	139	25	263	103	157	22	282	70	117	28	215	
Decrease in production (%)		x̄	15.4	15.4	15.7	15.4	41.4	40.8	40.5	41.0	60.6	60.5	61.7	60.7	NS
		SD	10.7	9.7	10.1	10.1	6.6	10.7	7.0	9.1	9.7	9.8	7.5	9.5	
Length of life	days	x̄	2,143.1 A	1,957.3	1,697.8 B	2,002.6 y	2,041.0	1,946.5	1,952.0	1,981.4 y	2,185.7	2,084.1	2,054.2	2,113,3 x	NS
		SD	657.3	577.6	304.0	602.7	598.6	594.1	405.1	583.4	757.5	684.3	657.7	704,3	
	months	x̄	71.4 A	65.2	56.6 B	66.8 y	68.0	64.9	65.1	66.0 y	72.9	69.5	68.5	70,4 x	
		SD	21.9	19.3	10.1	20.1	20.0	19.8	13.5	19.4	25.3	22.8	21.9	23,5	
Length of productive life	days	x̄	1,333.3 A	1,158.3 a	898.1 Bb	1,199.4 y	1,248.6	1,136.3	1,147.7	1,178.2 y	1,408.5	1,278.5	1,260.8	1,318,5 x	NS
		SD	638.6	561.6	301.1	585.9	569.2	591.1	372.4	569.9	738.4	675.2	660.3	694,2	
	months	x̄	44.4 A	38.6 a	29.9 Bb	40.0 y	41.6	37.9	38.3	39.3 y	46.9	42.6	42.0	44,0 x	
		SD	21.3	18.7	10.0	19.5	19.0	19.7	12.4	19.0	24.6	22.5	22.0	23,1	
Days in milk		x̄	1,186.2 A	1,041.2 a	797.1 Bb	1,072.5	1,095.0	1,011.7	1,021.6	1,042.9 y	1,238.3	1,117.3	1,110.3	1,155.8 x	NS
		SD	564.3	494.9	285.3	517.9	500.3	505.6	314.2	491.7	638.4	573.2	589.1	597.2	
Number of lactations		x̄	3.4 A	3.0 a	2.3 Bb	3.1 Y	3.3	3.0	3.0	3.1 Y	4.0	3.6	3.4	3.7 X	NS
		SD	1.5	1.4	0.9	1.4	1.4	1.4	0.9	1.4	1.8	1.7	1.7	1.7	
Ratio of days in milk to productive life (%)		x̄	89.4	90.6	88.8	90.0 X	88.1	90.4	89.6	89.5 x	88.2	88.5	88.6	88.4 Yy	NS
		SD	6.4	5.4	8.6	6.1	6.8	5.8	3.9	6.1	5.0	6.1	7.2	5.9	
Ratio of productive life to length of life (%)		x̄	58.8 a	55.8	51.5 b	56.5	58.2	54.7	57.4	56.2	60.5	57.5	57.3	58.4	NS
		SD	12.9	12.5	9.2	12.5	11.7	13.7	8.1	12.7	13.4	13.4	14.1	13.5	

A, B, C – means with different letters are statistically significantly different at P<0.01 within individual groups of yield at peak lactation.
a, b, c – means with different letters are statistically significantly different at P<0.05 within individual groups of yield at peak lactation.
X, Y, Z – means with different letters are statistically significantly different at P<0.01 between groups of decrease in yield during lactation.
x, y, z – means with different letters are statistically significantly different at P<0.05 between groups of decrease in yield during lactation.

Table 5. Lifetime milk yield of cows depending on persistency in first lactation

Item		Group I				Group II				Group III				Interaction of lactation persistency* yield at peak lactation
		yield at peak lactation (kg)				yield at peak lactation (kg)				Yield at peak lactation (kg)				
		up to 20	20.1–30	over 30	mean	up to 20	20.1–30	over 30	mean	up to 20	20.1–30	over 30	mean	
N		99	139	25	263	103	157	22	282	70	117	28	215	
Lifetime milk yield (kg)	$\bar{x}$	18,918.4	21,383.2	19,185.4	20,246.5	16,646.4 B	19,341.5	23,377.1 A	18,672.0	17,418.9 b	20,095.0	23,195.6 a	19,627.5	NS
	SD	10,772.3	11,619.0	7564.5	11,009.7	9,404.8	10,648.7	6,684.7	10,093.8	9,904.5	11,788.3	13,319.4	11,520.4	
Yield per year of productive life (kg)	$\bar{x}$	4,982.5 C	6,631.1 B	7,799.1 A	6,121.5 X	4,709.2 C	6,232.4 B	7,637.8 A	5,785.7 Y	4,458.5 C	5,661.5 B	6,697.0 A	5404.7 Z	NS
	SD	1,001.2	990.7	1,367.0	1,399.9	987.7	1,070.2	1,224.6	1,380.9	857.3	812.4	1,085.2	1,136.1	
Yield per day in milk (kg)	$\bar{x}$	15.3 C	20.1 B	24.0 A	18.7 X	14.7 C	18.9 B	23.3 A	17.7 Y	13.8 C	17.6 B	20.8 A	16.8 Z	NS
	SD	3.1	3.0	3.3	4.2	3.0	3.1	3.3	4.0	2.5	2.6	3.5	3.5	
Yield per day of productive life (kg)	$\bar{x}$	13.7 C	18.2 B	21.4 A	16.8 X	12.9 C	17.1 B	20.9 A	15.9 Y	12.2 C	15.5 B	18.3 A	14.8 Z	NS
	SD	2.7	2.7	3.7	3.8	2.7	2.9	3.4	3.8	2.3	2.2	3.0	3.1	
Yield per day of life (kg)	$\bar{x}$	8.2 B	10.2 A	11.0 A	9.5 Xx	7.6 C	9.3 B	11.9 A	8.9 y	7.4 C	9.0 B	10.5 A	8.7 Y	NS
	SD	2.8	3.0	2.7	3.1	2.5	2.9	1.9	2.9	2.3	2.7	3.2	2.8	

A, B, C – means with different letters are statistically significantly different at $P<0.01$ within individual groups of yield at peak lactation.
X, Y, Z – means with different letters are statistically significantly different at $P<0.01$ between groups of decrease in yield during lactation.

Yield of primiparous cows and their later utility

The data in Table 4 show that the shortest (P≤0.01) length of life (56.6 months) was observed in cows which produced more than 30 kg of milk in their first lactation and maintained this level of yield for nearly the entire lactation, i.e. their mean yield in the tenth month of lactation was only 15.7% lower than in the second month after calving. In consequence, they had significantly (P≤0.01) the shortest productive life (29.9 months), the fewest days in milk (797.1) and the fewest lactations (2.3). The animals that lived the longest (on average 72.9 months) were those which as primiparous cows had the lowest yield at peak lactation (up to 20 kg) and the highest decrease in milk yield during lactation, i.e. over 50%.

The highest lifetime yield, i.e. over 23,000 kg of milk (Table 5), was noted in the cows that produced over 30 kg of milk at the peak of the first lactation, but in which daily yield decreased significantly during lactation (groups II and III). Lactation persistency in primiparous cows significantly differentiated (P≤0.01) milk yield per year of productive life. This value was the highest (6,121.5 kg) in group I (with the best lactation persistency), followed by group II (5,785.7 kg), and the lowest (5,404.7 kg) in group III (with the lowest lactation persistency). This affected the other three indicators evaluated, i.e. yield per day in milk (18.7, 17.7 and 16.8 kg), per day of productive life (16.8, 15.9 and 14.8 kg) and per day of life (9.5, 8.9 and 8.7 kg).

Discussion

The survival rate for the first lactation in the analysed cow population was 88.6%, compared to only 21.8% for the fourth lactation. Archer et al. (2013), analysing survival of the first lactation in cows depending on the somatic cell count in the first month after calving (between days 5 and 30), found that the survival rate was 75–81%, compared to only 13–17% for the fourth lactation. Ahlman et al. (2011) reported similar results, i.e. a survival rate of 72–75% for the first lactation, 63% for the second and 43% for the third.

Bergk and Swalve (2011) report that over 10% of primiparous cows are eliminated from herds in Germany in the first 300 days, and over 20% by the 450th day after calving. According to Mohd Nor et al. (2013), the mean percentage of cows culled for slaughter in 1,903 dairy cattle herds in the Netherlands was 25.4%, ranging from 23% in 2007 to 28% in 2010, thus showing an upward trend. Martens and Bange (2013) claim that milk yield in cows in Germany increased over 40 years from 3,500 kg of milk per lactation in 1970 to 7,000 kg in 2011. During the same period the mean length of productive life decreased from about 3.5 lactations to 2.5–3.0, which means that many cows are currently culled after 2–3 calvings. Gnyp (2014) showed that the lifetime VCM (Value Corrected Milk) yield of the active population in the Lublin region over the last 35 years has increased by about 7,000 kg. This is an increase of about 1 kg per day of life, 5.5 kg per day of productive life, and 6 kg per day in milk.

Analysis of the ratio of the length of productive life to length of life (Table 1) shows that the group II cows (with mean lactation persistency of 40%) were the most efficient. It was 58.2% for the entire group, with the best results for the subgroup with yield of over 30 kg of milk at peak lactation – 61.6%. The ratio of the number of days in milk to the number of days of productive life was highest (90.7%) in group I, i.e. in the cows with the best lactation persistency, which shows that these cows had the shortest dry periods. Significantly lower values ($P \leq 0.05$ and $P \leq 0.01$) were noted for groups II and III (89.4 and 88.4%, respectively).

Albarrán-Portillo and Pollott (2013), evaluating the relationships between the course of lactation and fertility in cows, observed an increase in daily milk yield of 148 g from the beginning of lactation to its peak, mean peak lactation of 28 kg persisting for 34.3 days, and then a decrease of 50 g/day until the end of lactation. The repeatability coefficients obtained by these authors for parameters of the course of lactation were re=0.22 for lactation persistency after the peak and for daily changes in yield at the start of lactation, re=0.33 for peak yield, and re=0.41 for the day peak lactation was attained. Tekerli et al. (2000), analysing monthly yield in 754 lactations in 475 Turkish Holsteins, found repeatability of 0.26 for peak yield, 0.34 for lactation yield and from 0.06 to 0.20 for the remaining traits.

The significant ($P \leq 0.001$) value for the repeatability coefficient (re=0.241) noted in the present study for persistency in the first three lactations led the authors to analyse possible connections between persistency in the first lactation and later length of life, length of productive life and lifetime yield in the cows evaluated.

The data obtained (Tables 4 and 5) show that yield at peak lactation in primiparous cows and lactation persistency influenced future length of life and lifetime milk yield. Cows whose yield decreased by over 50% (group III) in their first lactation (irrespective of yield at peak lactation), and thus had poor lactation persistency (Table 4), had the most favourable indicators for length of life (70.4 months), length of productive life (44.0 months), days in milk (1,156) and number of lactations (3.7). The values were higher than in the other two groups by about 4 months in the case of length of life ($P \leq 0.05$), about 100 days in milk ($P \leq 0.05$) and 0.6 lactations ($P \leq 0.01$). However, the highest mean lifetime yield (Table 5) was obtained in group I, i.e. from the 263 cows that had the best persistency in their first lactation (under 30%), although the differences with respect to the other two groups (1,574 and 619 kg) were statistically insignificant. More detailed analysis of the lifetime yield of cows in this group (with the best lactation persistency) shows that the long period of high peak yield (over 30 kg of milk) in primiparous cows proved to be detrimental in the long term. These cows (as mentioned above) had significantly the shortest life and productive life and the fewest lactations, so that their lifetime yield (19,185 kg) was over 4,000 kg less than cows with similar yield at peak lactation (over 30 kg) but belonging to groups II and III, i.e. with poorer persistency. This lower lifetime yield was obtained despite the significantly ($P \leq 0.01$) highest yield per year of productive life (7,799.1 kg). It should be emphasized that in this group of primiparous cows, i.e. those with the best lactation persistency, lifetime yield was over 2,000 kg of milk higher in the cows that produced from 20 to 30 kg of milk at peak lactation.

Several authors have identified the significant importance of the first lactation in the overall productive life of the cow. Do et al. (2013) reported that income for the entire productive life of a cow increased from $727.30 to $2,363.60 when the age at first calving was reduced from 32.8 months to 22.3 months. They also indicate a negative genetic correlation (r=–0.265) between the length of the first calving interval and the lifetime income from the cow. Archer et al. (2013) state that higher SCC in the milk of primiparous cows between days 5 and 30 after calving was negatively correlated with lifetime milk yield. The increase in natural log-transformed SCC in primiparous cows was linked to a reduction in lifetime yield by 864 kg of milk, including 105 kg in the first lactation.

Lactation persistency had a significant effect on length of life and efficiency of milk production in the analysed cow population. The cows that lived longest (over 6 years) and produced the most milk (nearly 28,000 kg) were those with yield over 30 kg at peak lactation with a moderate decrease in yield, i.e. 40%. Yield at peak lactation in primiparous cows and the course of lactation were found to significantly affect length of life and lifetime yield in the cows analysed.

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