THE EFFECTS OF SELECTED GENETIC AND ENVIRONMENTAL FACTORS ON THE LIFETIME PRODUCTIVITY OF COWS

J. Miciński, J. Pogorzelska, E. Zabłocka, W. Sobotka, Sz. Statkiewicz

University of Warmia and Mazury in Olsztyn,
Faculty of Animal Bioengineering,
Department of Cattle Breeding and Milk Quality Evaluation,
Oczapowskiego 5, 10-718 Olsztyn, Poland

In Poland, the main dairy cattle breeds are Polish Black-and-White and Red-and-White Holstein-Friesian (PHF), Polish Red (PR), Jersey (JER), Simentaler (SIM) and White-Backed (WB), and imported breeds: Montbeliarde (MB), Norwegian Red (NR) and Danish Red (DR) [Kaczmarek 2001]. Both in Poland and in the world, milk production relies mostly on HF cattle. Poland is the sixth largest producer of cow's milk in the European Union, after Germany, France, the United Kingdom, the Netherlands and Italy. The EU milk market is closely monitored and regulated under the Common Agricultural Policy (CAP) [Seremak-Bulge 2008, *www.arr.gov.pl*].

The milk market in the EU is regulated by a quota system, first introduced in 1984 and subsequently revised. Every member state has a national production quota which it distributes to farmers. The quota system, supported by other instruments, affects the levels of milk production and the development of the dairy sector in Europe. Poland, where the quota is around 0.23 t of milk per capita per year, ranks 17 among the EU member states [Mierzecka 2007]. Milk quotas contribute to bringing milk production under control and are used to intervene in the market. If a member state exceeds its quota, it has to pay a penalty to the EU. The quota allocated to Poland is 8 964 000 tons out of 120 505 000 tons for the 2008 – 2015 period. The above amount has been increased by 1% per year since 2008 (*www.arr.gov.pl*).

The aim of this study was to determine the effects of the proportion of HF genes, the length of inter-calving intervals, the peak daily milk yield per lactation, average milk production in the first and second 305-day lactations and lifetime milk production on the lifetime productivity of cows in a dairy cattle herd kept in the Region of Warmia and Mazury (NE Poland).

Materials and Methods. The experimental materials comprised 370 Polish HF cows in a dairy cattle herd kept in the Region of Warmia and Mazury (NE Poland). The cows were entered into the Performance Testing Scheme, and were evaluated by the Polish Federation of Cattle Breeders and Dairy Farmers (PFCBDF 2012). To analyze the effect of genetic factors on lifetime milk production, the cows were divided into two groups: group 1 –

cows with a proportion of HF genes up to 93.75%, group 2 - cows with a proportion of HF genes above 93.75%. To analyze the effect of environmental factors on lifetime milk production, the cows were divided into groups based on:

- the length of inter-calving intervals (ICI): group 1 – ICI shorter than 405 days, group 2 – ICI from 405 to 485 days, group 3 – ICI longer than 485 days.
- the peak daily milk yield per lactation: group 1 – milk yield below 25 kg, group 2 – milk yield from 25 to 35 kg, group 3 – milk yield above 35 kg.
- average milk production in the first and second 305-day lactations: group 1 – milk production below 6 000 kg, group 2 – milk production from 6 000 to 8 000 kg, group 3 – milk production above 8 000 kg.
- lifetime milk production: group 1 – below 15 000 kg milk, group 2 – above 15 000 kg milk.

Milk yield and composition were analyzed during successive 305-day and full lactations. The yield (kg) of milk, fat, protein, lactose an dry matter were determined for each cow. The actual amount of produced milk (kg) was converted into the amount of average daily value-corrected milk (VCM), according to the following formula:

VCM (kg) = -0.5 * milk (kg) + 8.66 * fat (kg) + 25.98 * protein (kg)

The results were processed statistically using Statistica ver. 9.0 software (StatSoft 2010). Least squares means (LSM) and standard errors (Se) were calculated for the analyzed parameters. The significance of differences between means was estimated by Duncan's test.

Results and Discussion. ICI duration had a significant ($p \leq 0.01$) effect on milk production (Table 1). The highest milk yield (19 790 kg) was noted in group 1 ("<405 days"), and it was significantly higher than in the other groups. Thus, the shorter the ICI, the higher the lifetime productivity of cows, most probably due to better health and a longer lifespan of cows. Similar conclusions were formulated by Dymnicki et al. (2003) and Miciński (2009). The same trend was observed when the actual amount of produced milk was converted to VCM – cows with the shortest ICI were characterized by the highest VCM yield.

The length of ICI had no significant effect on the protein-to-fat ratio in milk. The values observed in all groups were similar, and no significant differences were noted between groups. Our results corroborate the findings of Gnyp et al. (2006) and Krzyżewski et al. (2004).

Milk fat yield varied significantly ($p \leq 0.05$) depending on ICI duration between all groups, while significant differences at $p \leq 0.01$ were noted between groups "<405 days" and ">485 days" in which milk fat yield reached 827 kg and 745 kg, respectively. Krzyżewski (2003) demonstrated that prolonged ICI was correlated with a decrease in the fat content of milk.

Table 1 − The effect of the length of inter-calving intervals and the proportion of HF genes on the lifetime productivity of cows and milk composition

Specification	Statistical measures	Length of inter-calving intervals [days]			Proportion of HF genes [%]	
		<405	405-485	>485	<93.75	>93.75
Milk [kg]	LSM	19 790^{A}	18 631^{B}	17 351^{C}	18 927	19 447^{xx}
	Sd	10009	9335	8615	9341	10063
VCM [kg]	LSM	23 028^{A}	21 989^{B}	20 792^{C}	22 013	22 901^{xx}
	Sd	11757	11146	10428	10922	11912
Protein-to-fat ratio	LSM	0.79	0.79	0.79	0.79	0.80
	Sd	0.09	0.09	0.10	0.08	0.09
Fat [kg]	LSM	827^{Aa}	791^{b}	745^{Bc}	794	818^{x}
	Sd	427.79	407.17	378.77	400.15	433.57
Protein [kg]	LSM	649^{a}	619^{b}	586^{c}	619	646^{x}
	Sd	331.15	313.17	294.14	306.67	335.54
Lactose [kg]	LSM	224^{a}	196^{a}	169^{b}	209	215
	Sd	136.91	135.89	110.17	123.02	142.27
Dry matter [kg]	LSM	612^{Aa}	535^{b}	459^{Bc}	570	585
	Sd	376.36	373.47	299.06	338.98	389.87

Significant differences for inter-calving intervals: ABC - at $p \leq 0.01$, abc - at $p \leq 0.05$

Significant differences for the proportion of HF genes: xx – at $p \leq 0.01$, x – at $p \leq 0.05$

Similar trends were reported for milk protein yield (Table 1). Significant differences were noted at $p \leq 0.05$. Longer ICI was correlated with lower milk protein content, which reached 649 kg for ICI <405 days, 619 kg for ICI 405-484 days and 586 kg for ICI >485 days.

Prolonged ICI was accompanied by a significant ($p \leq 0.05$) decrease in milk dry matter yield, which was determined at 612 kg, 535 kg and 459 kg, respectively. A significant difference at $p \leq 0.01$ was found between groups "<405 days" and ">485 days".

Table 1 data show that the proportion of HF genes in the analyzed cows had a significant ($p \leq 0.01$) effect on the amount of produced milk. Cows that had less than 93.75% HF genes produced 18 927 kg milk, and cows with more than 93.75% HF genes were characterized by a significantly higher milk yield at 19 447 kg. There were no significant differences between groups in the protein-to-fat ratio. The highest yields of fat, protein lactose and dry matter were noted in cows with a higher percentage of HF genes (>93.75%). The respective values were 818 kg, 646 kg, 215 kg and 585 kg.

Cows with the highest peak daily milk yield per lactation were also characterized by the highest lifetime milk production (Table 2), and the dif-

ferences between groups were statistically significant ($p \leq 0.01$). No significant differences were observed between groups with respect to the protein-to-fat ratio. The lowest yields of fat, protein, lactose and dry matter were noted in cows with the lowest peak daily milk yield (<25 kg), and the differences between groups were significant at $p \leq 0.01$ and $p \leq 0.05$.

Table 2 − The effect of the peak daily milk yield per lactation on the lifetime productivity of cows and milk composition

Specification	Statistical measures	Peak daily milk yield per lactation kg]		
		<25	25-35	>35
Milk [kg]	LSM	18 610^{A}	23 633^{B}	25 870^{C}
	Sd	8848	11231	12122
VCM [kg]	LSM	20 483^{A}	27 674^{B}	31 266^{C}
	Sd	9902	12676	13677
Protein-to-fat ratio	LSM	0.7895	0.7975	0.813
	Sd	0.08	0.09	0.09
Fat [kg]	LSM	784^{Aa}	993^{Bb}	1067^{Bc}
	Sd	385.36	485.61	521.17
Protein [kg]	LSM	615^{A}	781^{B}	857^{C}
	Sd	293.32	370.90	403.82
Lactose [kg]	LSM	396^{a}	420^{b}	465^{c}
	Sd	113.57	107.38	114.56
Dry matter [kg]	LSM	1083^{A}	1147^{B}	1260^{C}
	Sd	301.51	287.42	300.72

Significant differences for peak daily milk yield per lactation: ABC – at $p \leq 0.01$, abc - at $p \leq 0.05$

Table 3 data indicate that average milk production in the first and second 305-day lactations had a significant ($p \leq 0.01$) effect on the lifetime productivity of cows. The highest average milk yield (23 362 kg) was noted in the ">8000 kg" group. Cows with average milk production <6000 kg were characterized by the lowest protein-to-fat ratio. Cows with the lowest average milk yield in the first and second lactation had the lowest yields of fat, protein, lactose and dry matter, and the differences between groups were significant at $p \leq 0.01$ and $p \leq 0.05$.

Table 3 − The effect of average milk production in the first and second 305-day lactations on the lifetime productivity of cows and milk composition

Specification	Statistical measures	Average milk production in the first and second 305-day lactations [kg]		
		<6000	6000-8000	>8000
1	2	3	4	5
Milk [kg]	LSM	16 778^{A}	21 270^{B}	23 362^{C}
	Sd	8600.68	10344.70	9532.48
VCM [kg]	LSM	18 749^{A}	26 196^{B}	28 358^{C}
	Sd	9306.38	12 291.69	13 231.25

1	2	3	4	5
Protein-to-fat ratio	LSM	0.78^{a}	0.81^{a}	0.86^{b}
	Sd	0.08	0.09	0.11
Fat [kg]	LSM	715^{Aa}	893^{Aa}	922^{Bc}
	Sd	376.70	449.99	412.10
Protein [kg]	LSM	552^{A}	707^{B}	785^{C}
	Sd	283.39	343.44	315.91
Lactose [kg]	LSM	328^{A}	426^{B}	557^{C}
	Sd	78.93	85.71	99.24
Dry matter [kg]	LSM	906^{A}	$1\,167^{B}$	$1\,476^{C}$
	Sd	223.33	239.76	269.29

Significant differences for average milk production in the first and second 305-day lactations: ABC – at $p \leq 0.01$, abc – at $p \leq 0.05$

Table 4 data show that the amount of produced milk was significantly higher (29 315 kg) in cows with average lifetime productivity >15 000 kg, compared with the "<15 000 kg" group (15 918 kg). Cows with average lifetime productivity >15 000 kg were also characterized by higher yields of fat, protein, lactose and dry matter, and the noted differences were significant at $p \leq 0.01$.

Table 4 − The effect of lifetime milk production on the lifetime productivity of cows and milk composition

Specification	Statistical measures	Lifetime milk production [kg]	
		<15000	>15000
Milk [kg]	LSM	15 918	$29\,315^{xx}$
	Sd	3480.07	5212
VCM [kg]	LSM	18 648	$34\,538^{xx}$
	Sd	18772.24	34537.85
Protein-to-fat ratio	LSM	0.79	0.79
	Sd	0.09	0.08
Fat [kg]	LSM	669	$1\,229^{xx}$
	Sd	165.54	249.96
Protein [kg]	LSM	526	966^{xx}
	Sd	119.94	181.03
Lactose [kg]	LSM	199	242^{xx}
	Sd	123.17	142.28
Dry matter [kg]	LSM	542	665^{xx}
	Sd	336.59	391.05

Significant differences for lifetime milk production: xx – at $p \leq 0.01$, x – at $p \leq 0.05$

Conclusions. The results of our study show that the lifetime productivity of cows, expressed in terms of VCM and the content of fat, protein, lactose and dry matter in milk, was highest in cows with the shortest ICI. Longer ICI had a significant effect on milk composition, but not on the protein-to-fat ratio. Cows with the highest percentage of HF genes were charac-

terized by the highest yields of milk, VCM, fat, protein, lactose and dry matter. Cows with the highest peak daily milk yield per lactation and the highest average milk production in the first and second 305-day lactations were characterized by the highest lifetime productivity. Cows with lifetime productivity higher than 15 000 kg milk produced 29315 kg milk and 34538 kg VCM as well as by ca. 50% more milk fat and protein than cows with lifetime productivity below 15 000 kg milk.

REFERENCES

1. Polska Federacja Hodowców Bydła i Producentów Mleka. 2012. Analiza i podsumowanie wyników oceny wartości użytkowej bydła w latach 2006-2011. *www.pfhb.pl. Warszawa.*
2. Dymnicki, E., Krzyżewski, J., Oprządek, J., Reklewski, Z., Oprządek, A. 2003. Zależność między długością okresu międzyocieleniowego a cechami użytkowości mlecznej krów rasy czarno-białej. Med. Wet., 59(9): 792-796.
3. Gnyp, J., Kowalski, P., Tietze, M. 2006. Wydajność mleka krów, jego skład i jakość cytologiczna w zależności od niektórych czynników środowiskowych. Zesz. Nauk. AR w Lublinie. Vol. XXIV, 3: 17-25.
4. Kaczmarek, A. 2001. Hodowla bydła w Wielkopolsce. Wydawnictwo AR Poznań.
5. Krzyżewski, J., Reklewski, Z. 2003. Wpływ przedłużonych laktacji krów na wydajność, skład chemiczny i jakość mleka oraz wskaźniki reprodukcji. Zesz. Nauk. Przegl. Hod., 67: 7-20.
6. Krzyżewski, J., Strzałkowska, N., Reklewski, Z., Dymnicki, E., Ryniewicz, Z. 2004. Wpływ długości okresów międzyciążowych u krów rasy hf na wydajność, skład chemiczny mleka oraz wybrane wskaźniki rozrodu. Med. Wet., 60(1): 76-79.
7. Miciński, J. 2009. Cechy mleczności i wskaźniki reprodukcji wysoko wydajnych krów w standardowym oraz przedłużonym cyklu produkcyjnym. Rozprawy i monografie. Wyd. UWM w Olsztynie. 147: 1-101.
8. Mierzecka, W. 2007. Kwoty mleczne w Unii Europejskiej. Rolniczy Magazyn Elektroniczny. Zasoby internetowe www.cbr.edu.pl.
9. Seremak-Bulge, J. 2008. Zmiany na rynku mleka. Przem. Spoż., 3: 15-18.
10. StatSoft Inc. 2010. Statistica (data analysis software system), ver. 9.
11. *www.arr.gov.pl*

LIFETIME PRODUCTIVITY OF POLISH HOLSTEIN-FRIESIAN (PHF) COWS

J. Miciński, E. Zabłocka, J. Pogorzelska, W. Sobotka, P. Anasik

University of Warmia and Mazury in Olsztyn,
Faculty of Animal Bioengineering,
Department of Cattle Breeding and Milk Quality Evaluation,
Oczapowskiego 5, 10-718 Olsztyn, Poland

Introduction. Dairy cattle breeding in Poland has changed considerably since 1990 when a significant decline in cattle population was accompanied by an increase in milk production (Niedziałek et al. 2003, Losand 2004). For instance, the average milk production of cows enrolled in the milk recording scheme was 2 855 kg in 1965 and over 7 396 kg in 2012