

The effect of the country of origin of the sire on milk performance of primiparous Jersey cows

**Jaroslaw Pytlewski¹, Ireneusz Ryszard Antkowiak^{1#},
Daniel Stanislawski², Joanna Siejak¹**

Poznań University of Life Sciences, Faculty of Veterinary Medicine and Animal Science,

¹Animal Breeding and Product Quality Assessment,

Złotniki, ul. Słoneczna 1, 62-002 Suchy Las; #e-mail: ireneusz.antkowiak@up.poznan.pl

²Faculty Computer Laboratory,

ul. Wołyńska 33, 60-637 Poznań

The aim of this study was to determine the effect of the country of origin of the sire on the milk performance of primiparous Jersey cows kept under identical management conditions in Poland. Experimental cows were divided into four groups: daughters of bulls from the USA, Denmark, Canada and Poland. The effect of the paternal group on the milk performance of primiparous cows was estimated. A two-way contingency table was prepared to assess the association between the sire's country of origin and peak lactation. To present the course of daily milk yield during 305-day lactation, linear graphs were plotted with linear trends depending on the origin of sires of primiparous cows. Daughters of Polish bulls, in comparison to the other genetic groups of primiparous cows, had by the lowest daily milk yields, as well as the lowest concentrations of protein and dry matter in their milk. Primiparous cows sired by bulls from Denmark had the highest daily milk yields and the lowest fat-to-protein ratios in their milk. Analysis of the effect of the origin of the sire on the milk performance of primiparous Jersey cows during 305-day lactation revealed significantly the lowest milk, protein and dry matter yield and the lowest content of protein in the milk for the daughters of Polish bulls. Primiparous cows from this group and the daughters of bulls from the USA had significantly the lowest fat yield and the lowest dry matter content in their milk. Daughters of Polish bulls in comparison to daughters of foreign bulls had a significantly higher concentration of lactose in their milk. The vast majority of primiparous Jersey cows sired by imported bulls reached peak daily milk yields from day 31 to day 60 of lactation. The lactation curve and the first-order trend for daily milk yields were most advantageous in primiparous cows sired by bulls from the USA and Canada. The use of semen from imported Jersey bulls in the Polish population of this cattle breed results in increased milk yields in primiparous cows sired by those bulls, as well as beneficial concentrations of milk constituents. The results of this study indicate that under Polish management conditions the use of semen from Danish bulls is preferable, although further research

should be conducted to determine the lifetime productivity of cows and concentrations of milk constituents.

KEY WORDS: Jersey breed, country of origin of bulls, milk performance

Production and functional features in a herd of dairy cows are determined by many factors, which according to Mai et al. [7] and Prendiville et al. [9] include the breed or variety of cattle. Many dairy cattle breeds and varieties are currently used around the world. Some are characterized by high milk yield, while others produce milk of high nutritional value, depending on its chemical composition.

Jersey cattle are the second most populous dairy breed in the world. The qualities of animals of this breed are widely known and their importance is continually growing, due to the globalization of the milk and dairy products market. Milk with suitable composition for processing, as well as the highly favourable functional features of Jersey cattle (reproduction, health, feed conversion, milk yield and behaviour), can have a decisive impact on economic indicators of milk production and processing. Jersey cattle are bred in different regions of the world under varying environmental conditions, and each country with a population of this breed carries out targeted selection in accordance with the goals of the breeding programme.

In Poland, the estimated population of Jersey cows is small, accounting for about 0.12% of all dairy cows in 2018. However, there is a breeding programme for this breed, implemented by the Polish Federation of Cattle Breeders and Dairy Farmers [2]. Its most important goal is to increase genetic gain in terms of dairy performance traits, as well as type and conformation. This is meant to improve the Jersey cattle population by shifting it towards a single-purpose dairy type and thus increase the profitability of milk production. The programme is based on the use of semen of Jersey bulls of the highest breeding value from various breeding farms in countries around the world, including the United States, Denmark and Canada. Until June 2010, it was also possible to use semen from breeders raised in Poland, although they had no estimated breeding value.

The aim of the study was to determine the influence of the sire's country of origin on the milk performance traits of primiparous Jersey cows raised in identical environmental conditions in Poland.

Material and methods

The study was carried out in a herd of Jersey cows kept at the Iwno Sp. z o.o. horse stud on the Wiktorowo farm. Until 2014 the cows were kept in a tie-stall system, and after that in a free-stall barn. The TMR feeding system was used. The cow barn has a 20-stall side-by-side milking parlour.

The subject of the research was 261 primiparous cows that calved between 17 September 2007 and 26 July 2016. The animals were divided into four groups: daughters of bulls

from the United States (US), Denmark (DK), Canada (CA) and Poland (PL). Information on the milk performance of each cow was obtained from milk performance evaluation reports. The information included daily milk yield (kg), percentage of fat, protein, lactose and dry matter in the milk, fat-to-protein ratio, somatic cell count (1000/ml) and urea level (mg/l). In total, 1747 milk samples were analysed.

The first 11 milk samples obtained according to the official methodology for assessing dairy performance of cattle in Poland were used in the statistical calculations. Somatic cell count was log-transformed according to Ali and Shook [1] to obtain a normal distribution.

The influence of the paternal group on the milk performance of primiparous cows was estimated.

The statistical analyses were performed using the SAS statistics package [10]. The significance of the influence of experimental factors was analysed using the following linear models:

– for test-day milking:

$$y_{ijklmn} = \mu + r_i + s_j + p_k + \beta_1 d_l + \beta_2 w_m + \beta_3 m_n + e_{ijklmn}$$

– for 305-day lactation

$$y_{ijkl} = \mu + r_i + s_j + p_k + \beta_1 w_l + e_{ijkl}$$

where:

y_{ijklmn} , y_{ijkl} – phenotypic value of the feature

μ – average for the population

r_i – fixed effect of i-th year of calving ($i = 1, 2, \dots, 10$)

s_j – fixed effect of j-th season of calving ($j = 1, 2, 3, 4$)

p_k – fixed effect of k-th country of origin of sire ($k = 1, 2, 3, 4$)

$\beta_1, \beta_2, \beta_3$ – partial coefficients of first-order linear regression

d_l – day in milk

w_m, w_l – age at first calving

m_n – daily milk yield

e_{ijklmn}, e_{ijkl} – sampling error

Insignificant effects were eliminated, and the calculations were carried out again. In the detailed comparison of means, a series of multiple comparisons was performed using the Tukey test.

A two-way contingency table was prepared to assess the association between the sire's country of origin and the cows' peak lactation period. The significance of the relationship between the factors was estimated using Fisher's exact test.

To present the course of 305-day lactation, linear graphs were plotted with linear trends for daily milk yield depending on the origin of the sires of the cows.

All calculations and analyses were performed on primiparous cows whose milk had a somatic cell count of less than 300,000/ml.

Results and discussion

Table 1 presents a comparison of the daily milk yield of primiparous cows whose sires came from different countries. The statistical analysis showed significant differences between the means for protein and lactose content in the milk ($P \leq 0.01$) and for daily milk yield, dry matter content, and fat-to-protein ratio ($P \leq 0.05$). Daughters of Polish bulls had the lowest (19.3 kg) daily milk yield and the lowest concentration of protein and dry matter in the milk (3.81% and 14.31%, respectively). However, the milk of this group of animals had the highest (4.96%) lactose content. The lowest fat-to-protein ratio (1.26) was found in cows whose sires came from Denmark. However, this genetic group was distinguished by the highest (22.4 kg) daily milk yield. In terms of daily milk yield, daughters of Danish bulls differed significantly ($P \leq 0.05$) from the other genetic groups of primiparous cows. Milk obtained from all genetic groups of cows had a low somatic cell count, and the urea content in it was normal. There were no statistically significant differences between the means of these features.

The results of the study indicate differences in milk performance traits between the daughters of Jersey bulls of four origin groups. This is most likely due to years of breeding work on this breed of cattle carried out in many countries with different goals. Jersey cattle were imported to North America as early as 1815, and due to great interest in the breed, imports and development of the population began to be recorded in 1850 [4]. In Europe, Denmark has a long history of breeding Jersey cattle, with the first individuals imported in 1896. Initially, the priority in selection in this breed was to increase the content and yield of fat in the milk [6]. In the 1980s, however, there was a shift in the goals of breeding work in Denmark, and it became focused primarily on protein concentration and the protein-to-fat ratio in the milk [11]. The first Jersey cows were brought to Poland in the 1940s as part of UNRRA relief [3]. A large number of pregnant heifers were imported from Denmark to the Horse Stud in Iwno in the years 1985-1989. In subsequent years, as a result of Polish-Danish cooperation (the PHARE programme), heifers of this breed were purchased for use in Warmia and Mazury [5]. The current active population of Jersey cows is small; in 2018 it averaged 1012.3 cows kept in 430 herds [8]. Szarek et al. [12], comparing selected lines of bulls in terms of dairy performance in Polish conditions, showed large differences indicating marked variation in the herd, which should be exploited in further breeding work in the Jersey cow population. The results of our research confirm the impact of global trends in the breeding of these cattle. They indicate that the daughters of foreign bulls produce milk with higher protein content than primiparous

Table 1
Daily milk performance of primiparous Jersey cows depending on the country of origin of the sire

Traits	Country of origin of sire of primiparous cow										Total (n=1747)	P-value					
	US (n=1107)		DK (n=208)		CA (n=298)		PL (n=134)		\bar{x}	SD		r _i	s _j	P _k	d _l	w _m	m _n
	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD									
Milk (kg)	21.0 ^a	4.5	22.4 ^b	4.3	20.8 ^a	4.1	19.3 ^c	3.9	20.8	4.6	0.0001	0.0001	0.0450	0.0001	0.0001	–	
Fat (%)	5.01	0.79	4.99	0.75	5.13	0.71	4.94	0.71	5.05	0.79	0.0001	0.0001	0.0876	0.0001	0.0288	0.0001	
Protein (%)	3.94 ^A	0.43	3.96 ^A	0.47	3.96 ^A	0.41	3.81 ^B	0.40	3.96	0.43	0.0001	0.0006	0.0041	0.0001	0.0972	0.0001	
Lactose (%)	4.87 ^A	0.15	4.91 ^B	0.16	4.87 ^A	0.15	4.96 ^C	0.16	4.84	0.19	0.0001	0.0001	0.0041	0.0001	0.0001	0.0001	
Dry matter (%)	14.51 ^a	1.04	14.57 ^a	1.07	14.62 ^a	0.93	14.31 ^b	0.93	14.54	1.03	0.0001	0.0001	0.0449	0.0001	0.0426	0.0001	
SCC (1000/ml)	124	70	133	67	125	68	110	68	480	1114	0.0001	0.0031	0.0961	0.0310	0.0007	0.0038	
ln(SCC)	11.55	0.63	11.65	0.60	11.57	0.63	11.43	0.63	12.16	1.18	0.0001	0.0025	0.0739	0.0110	0.0004	0.0014	
Urea (mg/l)	236	75	239	63	235	72	201	69	232	72	0.0001	0.0007	0.2945	0.0001	0.4639	0.2569	
Fat/Protein	1.27 ^a	0.16	1.26 ^a	0.14	1.30 ^b	0.17	1.30 ^b	0.14	1.28	0.17	0.0001	0.0001	0.6941	0.0001	0.7557	0.0001	

Means with different letters (in row) differ statistically: A, B, C – highly significantly (P≤0.01); a, b, c – significantly (P≤0.05).
Origin of primiparous cows: US – daughters of bulls from the USA, DK – daughters of Danish bulls, CA – daughters of Canadian bulls, PL – daughters of Polish bulls

Table 2
Milk performance of primiparous Jersey cows depending on the country of origin of the sire in 305-day lactation

Traits	Country of origin of sire of primiparous cow						Total (n=261) \bar{x}	SD	P-value					
	US (n=172) \bar{x}	SD	DK (n=30) \bar{x}	SD	CA (n=41) \bar{x}	SD			PL (n=18) \bar{x}	SD	f_i	s_i	P_k	w_i
Milk (kg)	6078.4 ^a	1098.3	6027.0 ^b	788.4	6019.6 ^a	926.1	5699.0 ^b	1036.9	6037.0	1041.2	0.0092	0.0450	0.0485	0.0009
Fat (kg)	296.0 ^{ab}	46.5	300.6 ^a	39.2	307.5 ^a	47.8	277.8 ^b	54.4	296.9	46.9	0.0305	0.0217	0.0401	0.0835
Fat (%)	4.91	0.52	5.01	0.52	5.12	0.43	4.89	0.48	4.95	0.51	0.0037	0.0361	0.0826	0.0137
Protein (kg)	234.4 ^a	39.2	238.0 ^a	31.5	235.5 ^a	37.2	214.0 ^b	40.8	233.5	38.5	0.0004	0.0188	0.0458	0.0017
Protein (%)	3.87 ^a	0.22	3.95 ^a	0.23	3.92 ^a	0.24	3.75 ^b	0.20	3.88	0.23	0.0005	0.2671	0.0167	0.1488
Lactose (kg)	293.1	53.2	296.2	40.5	292.7	45.2	280.4	51.3	292.4	50.6	0.0239	0.0316	0.1466	0.0039
Lactose (%)	4.82 ^A	0.16	4.91 ^A	0.10	4.86 ^A	0.09	4.93 ^B	0.19	4.85	0.16	0.0504	0.7264	0.0029	0.1000
Dry matter (kg)	866.1 ^a	141.6	876.4 ^a	108.3	876.2 ^a	132.0	807.5 ^b	147.4	864.4	137.8	0.0051	0.0308	0.0259	0.0050
Dry mass (%)	14.30 ^{ab}	0.70	14.57 ^a	0.71	14.58 ^a	0.57	14.19 ^b	0.62	14.36	0.69	0.0255	0.0490	0.0300	0.0202

Means with different letters (in row) differ statistically: A, B – highly significantly ($P \leq 0.01$); a, b – significantly ($P \leq 0.05$)

Origin of primiparous cows: US – daughters of bulls from the USA, DK – daughters of Danish bulls, CA – daughters of Canadian bulls, PL – daughters of Polish bulls

cows sired by Polish breeders. On the other hand, the daughters of bulls from Denmark were found to be superior to all other genetic groups of cows in terms of daily milk yield. In addition, cows sired by bulls from Denmark produced milk with a lower fat-to-protein ratio than the daughters of Polish and Canadian bulls.

Analysis of the milk yield of the primiparous Jersey cows during 305-day lactation, taking into account the origin of the sire (Table 2), showed that cows sired by breeders from Poland produced significantly ($P \leq 0.05$) the lowest yield of milk, protein and dry matter, and their milk had the lowest protein content. These cows, together with daughters of bulls from the United States, achieved significantly ($P \leq 0.05$) the lowest fat yield and dry matter content in milk among all groups. However, the daughters of Polish breeders produced milk with a significantly higher ($P \leq 0.01$) lactose concentration than the daughters of foreign bulls. On the other hand, Antkowiak [2] reported the highest actual

Table 3

Distribution of the lactation peak period for daily milk yields in primiparous of Jersey cows from various sire groups

Country of origin of sire of primiparous cow		Peak of lactation (days)				Σ (%)
		≤ 30	31-60	61-90	> 90	
US	n	33	66	39	34	172
	% ¹	19.19	38.37	22.67	19.77	65.90
	% ²	57.89	67.35	76.47	61.82	
DK	n	5	14	1	10	30
	% ¹	16.67	46.67	3.33	33.33	11.49
	% ²	8.77	14.29	1.96	18.18	
CA	n	8	15	9	9	41
	% ¹	19.51	36.59	21.95	21.95	15.71
	% ²	14.04	15.31	17.65	16.36	
PL	n	11	3	2	2	18
	% ¹	61.11	16.67	11.11	11.11	6.90
	% ²	19.30	3.06	3.92	3.64	
Σ	n	57	98	51	55	261
	% ¹	21.84	37.55	19.54	21.07	100.00

% in line

% in column

Fisher test: P-value = 0.0069

Origin of primiparous cows: US – daughters of bulls from the USA, DK – daughters of Danish bulls, CA – daughters of Canadian bulls, PL – daughters of Polish bulls

milk yield in 305-day lactation for cows sired by Jersey bulls from the United States, which resulted in high corrected milk yield as expressed by ECM (energy-corrected milk yield), FCM (milk yield standardized for 4% fat) and VCM (factor correcting daily yield of milk components). The lowest milk yield in 305-day lactation, but with the highest content of total dry matter, including protein, fat and lactose, was obtained from cows sired by from bulls from Denmark. Intermediate values for the milk performance traits were found for the daughters of bulls from Canada. A study carried out in South Africa by Theron and Mostert [13] showed statistically significant differences in the milk performance of Jersey cows sired by local bulls compared to daughters of bulls from other countries.

Our research showed a significant ($P \leq 0.01$) influence of the country of origin of the sire of primiparous Jersey cows on the time of the lactation peak for daily milk yield (Table 3).

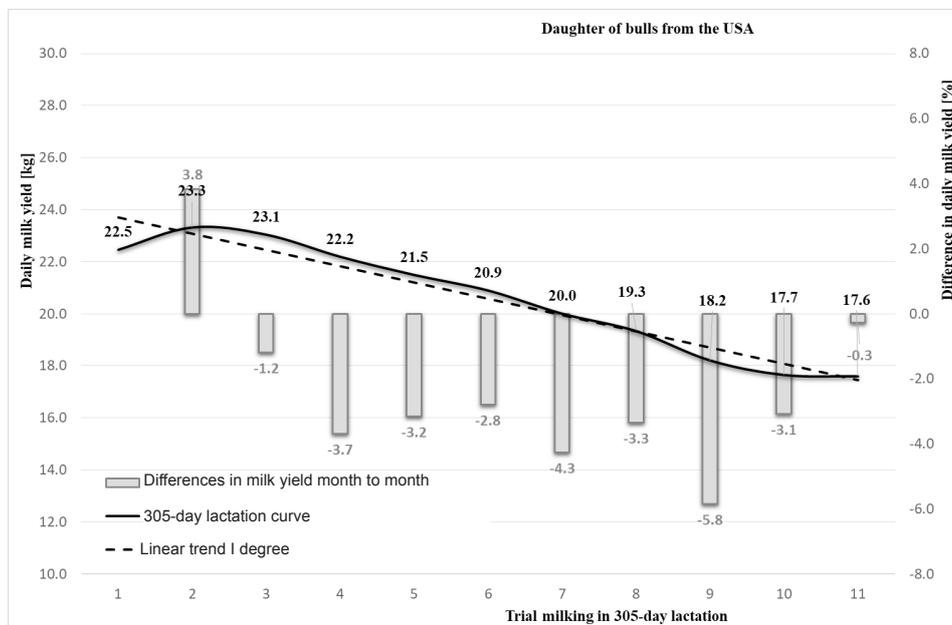


Fig. 1. Curve for daily milk yield in 305-day lactation with linear trend in primiparous Jersey cows sired by bulls from the USA

By far the most (38.37%) cows sired by American bulls produced their highest daily milk yield from days 31 to 60 of lactation. Similar results were found for the daughters of Danish (46.67%) and Canadian (36.59%) bulls. However, in some (33.33%) of the cows sired by bulls from Denmark, daily milk production was highest after the 90th day after calving as well. For daughters of Polish bulls, over 60% of the cows produced the highest daily milk yield up to the 30th day after calving. Taking into account the entire study population, by far the most (37.55%) cows reached the peak of lactation between 31 and 60 days after calving.

Figure 1 shows the lactation curve for daily milk yield in daughters of American breeders. The curve is relatively uniform, which demonstrates stable milk production. Decreases in daily milk yield from month to month did not exceed 6%. The daily milk yield at the peak of lactation was 23.3 kg of milk.

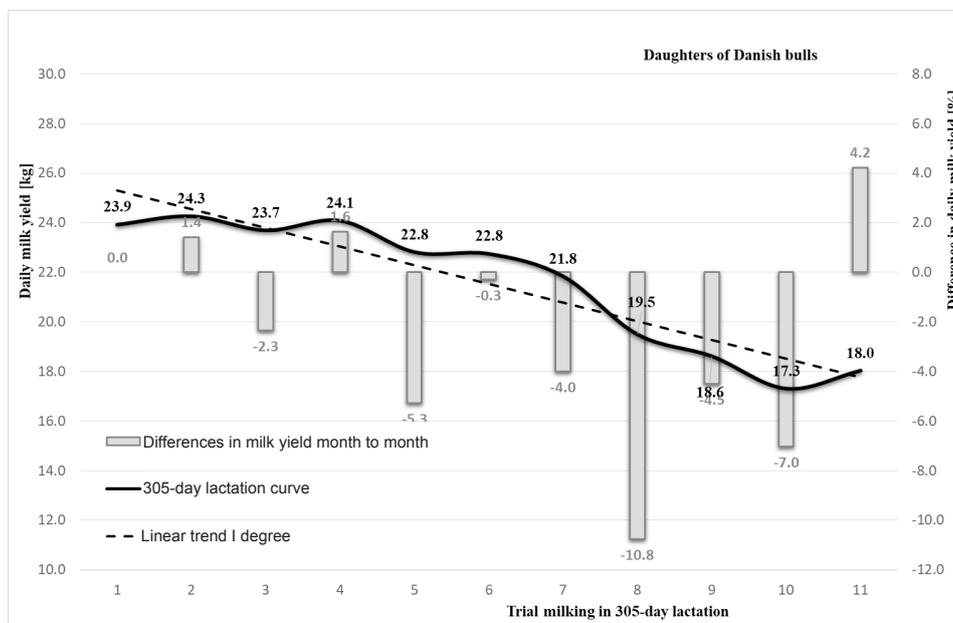


Fig. 2. Curve for daily milk yield in 305-day lactation with linear trend in primiparous Jersey cows sired by bulls from Denmark

In contrast, the daily milk yield curve determined for the primiparous cows sired by Danish bulls (Fig. 2) is quite irregular, with numerous rises and falls in yield. Two peaks can be distinguished during the lactation of these cows, on the second and fourth test days. Daily milk yield at the peak of lactation was slightly higher for these cows than for the daughters of US breeders. There was a noticeable lack of uniformity in the yield, and in one case (between the 7th and 8th test days) daily milk yield dropped by more than 10%.

Figure 3 presents the lactation curve for daily milk yield plotted for primiparous Jersey cows sired by Canadian bulls. Daily milk yield during the 305-day lactation period was fairly even in this group of cows. The month-to-month drops in yield did not exceed 7%. The peak of lactation was between the 2nd and 3rd test days (60-90 days). The daily yield of daughters of Canadian bulls at the peak of lactation was lower than that of their peers sired by bulls from Denmark, but higher than for the daughters of American breeders.

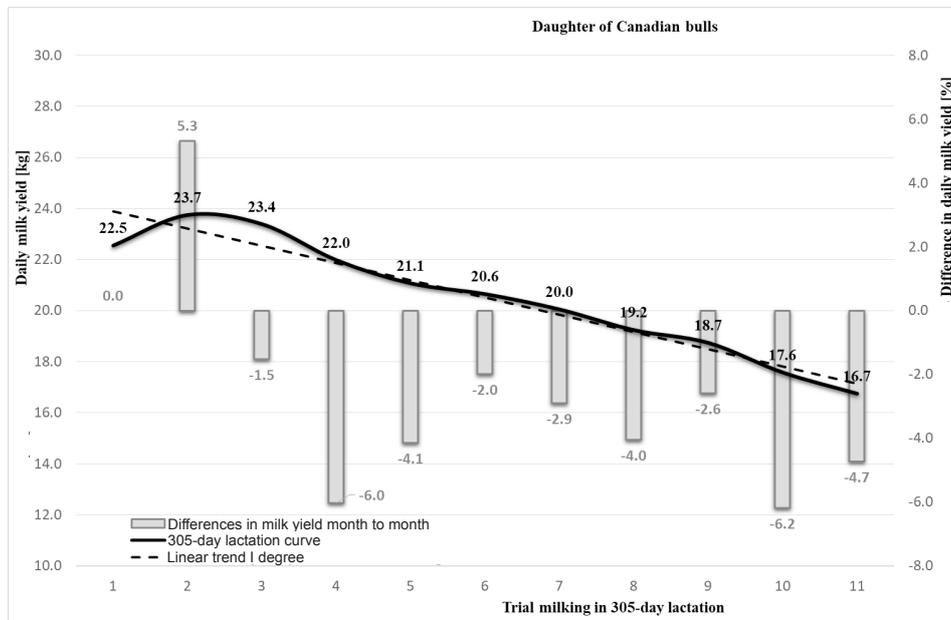


Fig. 3. Curve for daily milk yield in 305-day lactation with linear trend in primiparous Jersey cows sired by bulls from Canada

Analysis of the lactation curve for the daily milk yield of daughters of Polish bulls (Fig. 4) reveals that the peak of lactation occurred on the second test day. However, daily milk yields were significantly lower than in the other groups of cows. In addition, towards the end of lactation the curve was not even. Monthly drops in yield during the first lactation period were normal, followed by a sudden drop in yield of more than 17% (10th test day).

The lactation curve and the first-order trend for daily milk yield were most favourable for the cows whose sires were from the USA and Canada.

The results for milk performance traits were the least favourable in the group of daughters of bulls from Poland. This was most likely due to the lower breeding value of Polish breeders compared to foreign ones. Currently, only the semen of bulls with estimated breeding value can be used in Poland, and due to the small number of Jersey cows evaluated, domestic breeders are not assessed.

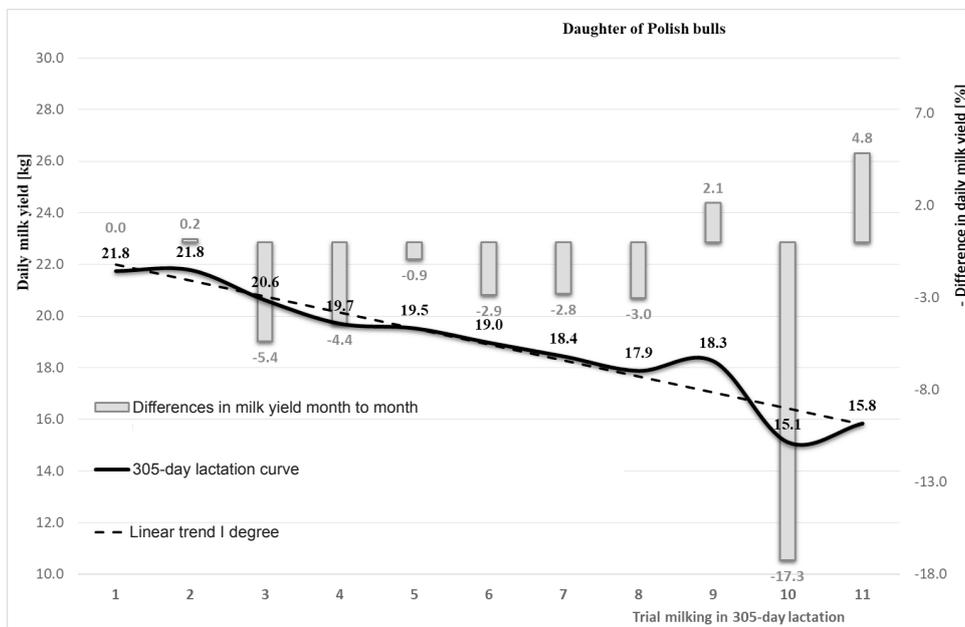


Fig. 4. Curve for daily milk yield in 305-day lactation with linear trend in primiparous Jersey cows sired by bulls from Poland

To sum up, the use of the semen of foreign Jersey bulls in the domestic population of cows of this breed caused an increase in milk yield in primiparous cows sired by these breeders, and the milk obtained had favourable concentrations of constituents. The results of the research indicate that in Polish conditions the use of semen of Danish bulls is preferable, although research should be continued to determine the lifetime productivity of cows and the concentrations of milk constituents that meet consumer demands, especially regarding the nutritional and health-promoting value of milk fat.

REFERENCES

1. ALI A.K.A., SHOOK G.E., 1980 – An optimum transformation for somatic cell concentration in milk. *Journal of Dairy Sciences* 63, 487-490.
2. ANTKOWIAK I.R., 2013 – Wydajność oraz skład chemiczny, jakość higieniczna i profil lipidowy mleka krów rasy jersey pochodzących po ojcach trzech odmian. *Rozprawy Naukowe* 467, Uniwersytet Przyrodniczy w Poznaniu.
3. KACZMAREK A., 2001 – Historia hodowli bydła jersey w Polsce. Proceeding International Sciences Conference „Status and perspective of Jersey cattle breeding in Poland and Europe”. Poznań – Iwno, 49-63.
4. KLUPCZYŃSKI J., 1998 – Historia oraz stan hodowli bydła jersey w Polsce i na świecie. Materiały konferencji „6 Szkoła Zimowa Hodowców Bydła”, Akademia Rolnicza w Krakowie, 132-150.
5. KLUPCZYŃSKI J., MICIŃSKI J., NOGALSKI Z., 2001 – Efektywność pięcioletniego użytkowania krów rasy jersey importowanych z Danii na teren województwa warmińsko-mazurskiego. Proceeding International Sciences Conference. Status and perspective of Jersey cattle breeding in Poland and Europe. Poznań – Iwno, 143-151.
6. LARSON P.G., 2001 – The protein – line project (You get what you go-but go for the right thing!). Proceeding International Sciences Conference. Status and perspective of Jersey cattle breeding in Poland and Europe. Poznań – Iwno, 83-85.
7. MAI M.D., RYCHTAROVA J., CYNKU V., LASSEN J., GULDBRANDTSEN B.J., 2010 – Quantitative trait loci for milk production and functional traits in two Danish cattle breeds. *Journal Animal Breeding and Genetic* 127, 469-473.
8. POLSKA FEDERACJA HODOWCÓW BYDŁA I PRODUCENTÓW MLEKA, 2019 – Ocena i hodowla bydła mlecznego. Dane za 2018 rok. Wyd. PFHBiPM, Warszawa.
9. PRENDIVILLE R., PIERCE K.M., BUCKLEY F., 2010 – A comparison between Holstein-Friesian and Jersey dairy cows and their F1 cross with regard to milk yield, somatic cell score, mastitis and milking characteristics under grazing condition. *Journal of Dairy Sciences* 93, 2741-2750.
10. SAS®, 2015 – user’s guide. Statistics version 9.4 edition. SAS Institute, Cary, NC, USA.
11. STENDAL M., 1993 – Dansk Jerseys ydelse er blandt verdens hojeste. *Jersey Blad* 10, 27.

12. SZAREK J., ADAMCZYK K., CIOŁEK U., 2005 – Ocena użytkowości mlecznej rodzin krów rasy jersey w Stadninie Koni Michałów Sp. z o.o. *Roczniki Naukowe Zootechniki*, suppl. 22, 633-636.
13. THERON H.E., MOSTERT B.E., 2009 – Production and breeding performance of South African dairy herds. *South Africa Journal of Animal Sciences* 39, 206-210.