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THE USE OF LACTATION PERSISTENCE AS AN INDICATOR IN THE SELECTION OF THE MATERNAL LINES OF HF COWS

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Abstract. The research material for this study consisted of a group of 163 Polish Holstein Friesian cows (PHF). For the study, the cows were assigned to 14 maternal lineages covering three generations. The aim of this study was to indicate possibilities for selecting cows with the goal of maintaining lineages on the farm which are characterised high productive qualities based on lactation persistency index. Basic milk parameters were analysed over a 305-day lactation cycle and information on somatic cell content was also gathered based on sample milkings. A characterisation of lactation persistency for a given lactation was generated as a percent difference between milk yield in the 2nd and 10th month of lactation, and a lactation persistency curve was developed for particular lineages in successive lactations, representing changes in the productivity of the cows. It was determined that together with increasing numbers of lactations among the cows studied, the average lactation persistency index also increased. For younger cows, this index did not exceed 30%, while in the older group this index amounted to 70%. Cows with the highest lactation persistency values 70.1–80% were also characterised by the highest milk production in average daily milk yields during peak lactation, amounting to 56.14 kg at values of for the index. Cows which began their milk production stage with a high persistency index in the 1st and 2nd lactations, in successive lactations saw a significant decrease in this index. Breeding cattle within maternal lines characterized by a high and stable level of lactation persistence index can ensure a high level of milk production in this line of cows.

Key words: cattle, lactation persistency, milk production.

INTRODUCTION

In the population of cattle, intensive selection for productive features has led to a significant decrease in the productive lifespan of dairy cows (Filistowicz 2013). It is generally believed that one of the factors responsible for this shorter productive life among dairy cows is the increased milk yields of the animals (Różańska-Zawieja et al. 2008a; Słoniewski 2010; Pokorska et al. 2012). According to Juszczak et al. (2003) and Kancer et al. (2001), it is economic profitable to use animals over at least four lactation cycles. Różańska-Zawieja et al. (2008b) believe that an average age for culling below 5 years is inappropriate as this does not cover the costs of raising the cattle. On the other hand, a study by Żarnecki and Jagusiak (2003) indicated a positive cor-

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relation between the viability of the cows and their milk production characteristics. Essl (1998) noted that increasing milk yield is accompanied by many negative phenomena, including deterioration of health and a shortening of productive life. Guliński and Młynek (2003) stated that the age of the animal is a factor which strongly influences the decrease in persistency of milk production during lactation. In a later study, Salomończyk and Guliński (2010) indicated that the highest lactation persistency indexes were shown by first-time lactation cows, among whom there was however a low peak lactation with a slow decrease in yield in subsequent months. Furthermore, in an analysis by Guliński et al. (2003), it was shown that an increase in daily milk yield from 20 kg to 40 kg was accompanied by a more than fourfold decrease in the analysed indexes of lactation persistency.

The aim of this study was to indicate possibilities for selecting cows with the goal of maintaining lineages on the farm which are characterised high productive qualities based on lactation persistency index.

MATERIALS AND METHODS

The study material consisted of a group of 163 Polish Holstein Friesian cows (PHF) kept at a National Agricultural Support Centre. The farm was in milk control by the Polish Federation of Cattle Breeders and Dairy Farmers (PFCBDF) using the A4 method. An analysis of the milk (fat, protein, lactose, dry matter, SCC) was conducted at a milk laboratory under the control of the PFCBDF using the infrared method with a Foss Electronic Milkoscan (Combifoss 6000) in accordance with the accepted PN-ISO 9622:2006 norm, whereas the number of somatic cells was determined by flow cytometry in a Foss Electronic Fossomatic (Combifoss 6000) in accordance with the PN-EN ISO 13366-2:2007 norm. As part of the study, individual cows were assigned to 14 maternal lineages covering three generations of cows. In total, 61 cows were included in the F1 generation, 69 cows in the F2 generation, and 33 in the F3 generation (based on birth records in SYMLEK). The largest group of cows was in lineage 711, amounting to 21 cows, while the smallest groups were lineages 170, 701, 937, 1019, amounting to 9 cows. Basic production parameters were analysed, including milk yield, fat, protein, lactose, and dry matter during a 305-day lactation cycle. Information on somatic cells was also gathered based on sample milkings for each cow during successive lactations. For this purpose, production data from the SYMLEK (milk control) system was also used. A characterisation of given lactation persistencies was also generated as the percent difference between milk yield in the 2nd and 10th month of lactation according to the following formula:

$$Y = \frac{W_2 - W_{10}}{W_2} \times 100\%$$

where:
Y – lactation persistency,
W_2 – daily milk yield in the 2nd month of lactation,
W_{10} – daily milk yield in the 10th month of lactation.

A lactation persistency curve was generated for individual lineages in successive lactations, indicating changes in the productivity of the cows. Eight distributions were isolated for lactation persistency in order to analyse average daily milk yield among cows during peak lactation. Distributions for the value of this index were within the ranges of: 1.0–10.0, 10.1–20.0, 20.1–30.0, 30.1–40.0, 40.1–50.0, 50.1–60.0, 60.1–70.0, and 70.1–80.0.

In the statistical part of the study, two- and three-factor analysis of variance was applied using the linear model below based on repeated information developed using the SAS 9.1 statistical package:

1) $Y_{ijkl} = m + A_i + B_j + c_k + e_{ijkl}$

where:

Y_{ijkl} – value of the studied quality,
m – overall mean within the population,
A_i – effect of the constant factor (no. of the lineage),
B_j – effect of the constant factor (no. of the lactation),
c_k – effect of the random factor (no. of the sire),
e_{ijkl} – random error.

2) $Y_{ijkl} = m + A_i + c_j + e_{ijk}$

where:

Y_{ijk} – value of the studied quality,
m – overall mean within the population,
A_i – effect of the constant factor (percentage group for lactation persistency),
c_j – effect of the random factor (no. of the sire),
e_{ijk} – random error.

The means in the tables are presented as arithmetic means, while differences were used to estimate the differences means corrected for the regression effect taking into account unequal numbers (LSMEANS procedure). The variability was presented using the standard deviation SD and the coefficient of variation V.

RESULTS AND DISCUSSION

An analysis of the lactation persistency index (%) which shows the lactation curve among dairy cows demonstrates that together with an increasing number of lactations among the cows studied, there was also an increase in the average lactation persistency index (Table 1). For cows with fewer than 2 lactations, this value did not exceed 30%. For cows with an average of fewer than 3 lactations, this number was 40%, while in the group with fewer than 4 lactations, the number was 70%. One essential fact is that, as shown in the study by Guliński and Młynek (2003), production during peak lactation is the factor which has the highest impact on lactation performance among cows. On the other hand, a study by Mustafa (2003) indicated that increasing milk yield during peak lactation in successive lactations with regard to first-time lactation is associated with lower lactation persistency, something which was not confirmed in our own research. Cows with the highest lactation persistency values (Table 1) were characterised by the highest average daily milk yield during peak lactation (56.14 kg) with index values of 70.1–80%, while the lowest (36.99 kg) was for values of 10.1–20% ($P \leq 0.01$). Cole and Van Raden (2006) stated that cows characterised by high lactation persistency have a tendency to lower milk yield than would be expected from the initial stage of lactation. The results do not confirm this. As can be seen from the results of the study (Table 1), a low value of the lactation persistency index is also accompanied by a low fat content and high levels of lactose which was confirmed statistically for lactose. In the group of cows with very high indexes at the level of 60.1–70.0%, the lowest levels of protein content and lactose content in the milk were observed, with the highest fat content. It is worth noting that despite the increasing lactation persistency index and milk yield of the cows, the level of somatic cells in the milk remained at a low level, below 300 000, only exceeding 400 000 in a single case (40.1–50.0 for $P \leq 0.05$). The dry matter value did not fundamentally change together with changes in the index. In an analysis by Guliński et al. (2003), it was shown

that an increase in daily milk yield from 20 kg to 40 kg is accompanied by a more than fourfold decrease in the analysed indexes of lactation persistency. The results of the study on maternal lineages presented did not confirm this fact, because the increase in productivity was accompanied by an increase in the index value. Another study by Salomończyk and Guliński (2010) showed that the studied lactation persistency was not only co-dependent with milk production level, but also with age at first calving. Conversely, in a study by Krężel-Czopek (after Sawa 2011), cows with a lactation persistency index of 80.1–90% lived and were used in the herd the longest, as is confirmed by the current study.

Table 1. Average (LSM) lactation persistency indexes for milk parameters during peak lactation

Distributions of values for lactation persistency %	Average lactation value	Average daily milk yield during peak lactation						Average lactation persistency %
		milk in kg	fat %	protein %	lactose %.	dry matter %	number of somatic cells thou./ml	
	x/sd	x/sd	x/sd	x/sd	x/sd	x/sd	x/sd	x/sd
1.0–10.0	1.82	39.18 ABC	3.47	3.05	5.02 ABCD	12.21	89.18	5.51 A
	1.25	11.04	0.83	0.27	0.15	0.98	71.12	1.88
10.1–20.0	1.26	36.99 DEF	3.66	2.98	5.04 EFGH	12.32	162.27	14.17 A
	0.75	5.84	0.85	0.20	0.16	0.85	253.14	2.49
20.1–30.0	1.56	39.61 GHI	3.87	3.14	4.99 IJKL	12.65 a	287.32 Aa	25.81 A
	1.13	7.03	0.88	0.14	0.20	0.84	450.89	2.93
30.1–40.0	2.70	45.38 ADGJK	3.79	3.03	4.99 Mabc	12.44	233.24	34.82 A
	1.97	9.77	0.83	0.20	0.14	0.87	782.66	2.64
40.1–50.0	3.06	50.37 ADGa	3.60	2.98	4.91 AEIa	12.16	495.69 a	44.42 A
	1.63	8.48	0.69	0.29	0.19	0.78	171.,91	2.65
50.1–60.0	3.31	52.20 BEHJL	3.58	2.98	4.95 BFJb	12.16 a	245.02 A	55.40 A
	1.70	10.40	0.93	0.24	0.19	0.98	696.58	2.70
60.1–70.0	3.92	55.17 CFIKab	3.94	2.92	4.88 CGKM	12.39	184.68	64.53 A
	1.91	8.85	0.81	0.24	0.19	0.90	457.46	2.40
70.1–80.0	4.15	56.14 ADGLb	3.89	2.99	4.90 DHLc	12.47	289.54	74.74 A
	2.12	13.98	1.08	0.19	0.17	1.20	463.06	3.88

Within columns between distributions, AA – $P \leq 0.01$, aa – $P \leq 0.05$.

In the detailed distribution for individual examined maternal lines with regard to the level of the average lactation persistency index, it was shown that the highest values occurred in lineage 937 with a level of 52.61% for an average of 2.80 lactations, while the lowest values occurred in lineage 759 with a level of 30.68% for an average of 2.55 lactations (Table 2). The average index value for the studied lineages did not exceed 51% with a spread in average number of lactations in lineages of 1.91 to 3.67. Lineage 937 was characterised by the highest level of lactation persistency index with an average daily yield of 44.20 kg of milk. However, the differences were not statistically confirmed. The average level of somatic cells in the milk of the studied cows was, however, higher than the norm at a level of 543 930. In the case of lineage 415, the second in terms of the studied index, the average value of the lactation persistency index was 50.42%, and the cows were distinguished by the highest daily yield among

the lineages analysed, amounting to 52.80 kg of milk. Simultaneously, at an average fat level (3.30%), the milk from these cows was characterised by the lowest levels of protein (2.77%) and dry matter (11.56%). Despite high productivity, the level of somatic cells was very low, amounting to 131 770.

Table 2. Average lactation persistency of cows and average daily milk yield during peak lactation in particular maternal lineages

Lineage numer	Average lactation value	Age daily milk yield during peak lactation						Average lactation persistency %
		milk in kg	fat %	protein %	lactose %.	dry mat-ter %	number of somatic cells	
	x/sd	x/sd	x/sd	x/sd	x/sd	x/sd	thou./ml x/sd	x/sd
170	3.67 2.35	47.06a 8.81	3.57 0.99	2.97Aa 0.19	4.97Aa 0.10	12.15a 0.97	93.92a 87.15	46.59ab 20.67
415	3.14 1.96	52.80 11.97	3.30 1.18	2.77 CDEO 0.23	4.76Bc 0.19	11.56bc 1.34	131.77 124.36	50.42e 20.95
701	3.08 2.02	49.68 9.27	4.19 0.80	2.85FGL bdefg 0.18	4.86 0.11	12.59 0.79	39.83 Ab 35.59	39.27 11.96
711	2.71 1.65	49.26 B 15.01	3.61 0.63	2.99 Hdh 0.25	4.96 0.19	12.25 0.58	728.87 d 2213.57	39.79 f 19.21
731	2.55 1.81	44.95d 10.54	3.63 0.64	3.10Ie 0.20	5.01 0.14	12.36 0.77	306.36e 702.07	38.43fgh 16.58
759	2.55 1.79	49.39e 11.13	3.60a 0.51	3.02Jij 0.29	4.93c 0.20	12.19b 0.65	313.55f 1108.87	30.68acgi 16.87
921	2.55 1.81	48.13AB CDEF acdefg 14.73	3.62 0.70	3.06 Kk 0.15	5.06 d 0.15	12.33 0.75	140.55 B 206.55	50.15 16.07
937	2.80 1.97	44.20 7.29	3.68 0.56	2.97 fl 0.23	5.00 0.14	12.33 0.56	543.93 ABCac defg 679.85	52.61 13.80
1019	3.38 1.69	50.25C 9.22	3.29ab 1.19	2.94D 0.15	4.74e 0.28	11.65d 1.27	603.75g 1314.17	34.33 Abdeh 14.98
1135	2.11 1.45	49.16 15.41	3.57 0.59	3.08m 0.26	5.03ad 0.20	12.31 0.90	55.56 37.57	45.22Ai 20.02
1118	2.17 1.34	50.48f 10.06	3.29 0.60	3.05ABC FHIJK- Mlm 0.14	4l99f 0l10	11.97a 0.71	59.42C 47.13	33.79 15.54
1141	3.50 1.58	51.64 DG 8.20	3.97 0.77	2.86 LNahik 0.38	5l03 0.11	12.51 0.89	446.40 1064.59	46.34 18.07
1319	1.91 1.30	39.93 Eh 8.62	3.84 b 0.24	3.10 EGNg 0.24	5.14 Bbef 0.12	12.64 cd 0.62	480.64 1391.34	42.76 13.74
1390	2.60 1.71	48.86g 14.99	3.90 0.62	3.11jo 0.22	4.99 0.12	12.64 0.65	94.80 95.73	38.80 19.48

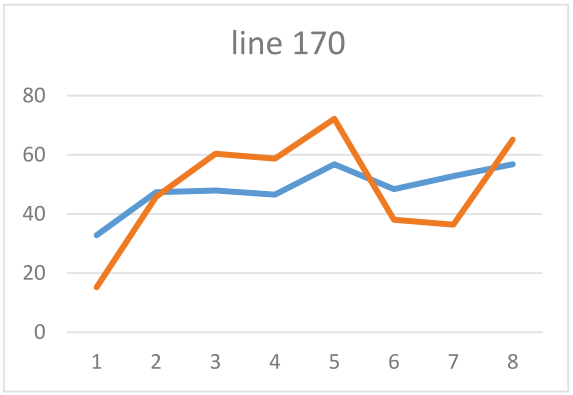
Within columns between lineages, for AA – $P \leq 0.01$, aa – $P \leq 0.05$.

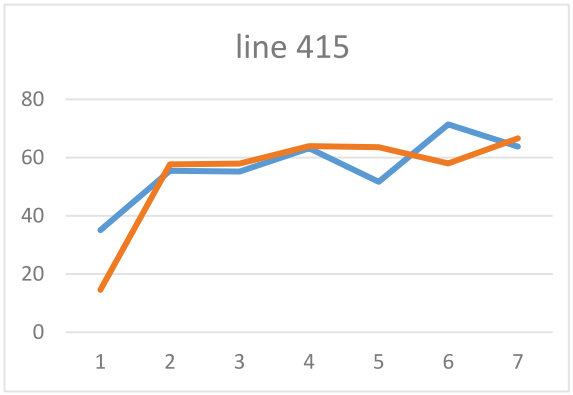
Of the 14 analysed lineages, cows from lineage 1390 achieved the highest protein content (3.11%) and dry matter content (12.64%) at average milk production levels – 48.86 kg. Worth noting is lineage 1319, with a lactation persistency index of 42.76%. This lineage was not only the one with the lowest average lactation value among those studied (1.91), but also had the lowest daily milk yield, amounting to 39.93 kg. In this case, a confirmation is provided by the study by Salomończyk and Guliński (2010) cited earlier, indicating the correlation between yield and lactation. Cows from the lineage studied 1319 achieved the highest lactose content levels (5.14%) and dry matter levels (12.64%) with one of the higher levels of somatic cells in the milk (480 640). The lowest levels of fat content were observed in lineages 1019 and 1118 (3.29%), while the lowest lactose content (4.74%) was observed in lineage 1019. In the group with lactation persistency higher than 70%, there were barely 10 cows, while in the group between 60.1–70.0%, there were 11 animals. These were to be found among 15 lineages. Studies by Topolski et al. (2008), Lin and Togashi (2005) and Cole and Van Raden (2006) indicate the necessity to pay greater attention to the lactation persistency index, its enhancement via selection, and its connections with stages of lactation. On the other hand, the results of a study by Gengler et al. (2001) and Strabel et al. (2001) do not inspire optimism, as this quality is only slightly dependent on genetic factors, considering that the coefficients of heritability range from $h^2 = 0.11$ to $h^2 = 0.17$.

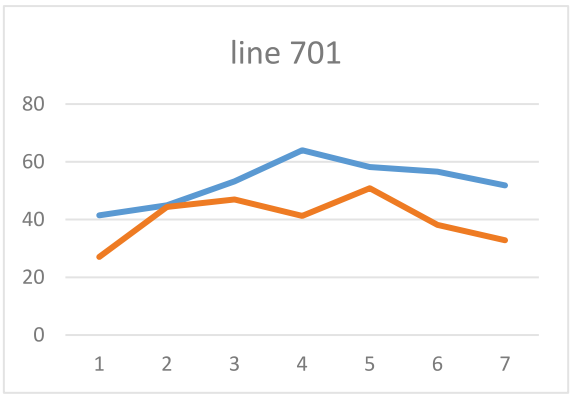
Taking into consideration the fact that lactation persistency determines the ability to maintain stable productivity during lactation and the productive life of the animal, there is an effort to maintain this lactation at a constant level. By analysing the lactation persistency curves in the isolated maternal lineages in the context of the productivity of cows from these lineages, it was determined that for the most part there were dependencies between the indexes studied (charts 1–13, Fig. 1). Cows which began their productive life with a high lactation persistency index in the 1st or 2nd lactation (lineages 921, 937, 1141, and 1319) amounting to 40% or more, with production yields during peak lactation approaching 50 kg, in subsequent lactations were characterised by fluctuations in both indexes, and as a result the curves met in several charts. In the study by Salomończyk and Guliński (2010), it was shown that the highest lactation persistency index was demonstrated by cows in the first lactation, among whom however a low peak lactation was observed with a slow drop in productivity in successive months. This was also confirmed in a study by Guliński and Młynek (2003). In the current study, the highest lactation persistency values were observed for the most part in the second or third lactation in the studied maternal lineages, however in subsequent years of service this led to the previously mentioned decrease in lactation persistency. Sawa (2011) points out that excessively high yields among first-lactation cows cause a shortening of the cow's life and service period, and that efforts to achieve maximum productivity already in the first lactation may significantly shorten the productive life of the cow. A later study by Salomończyk and Guliński (2011) also indicated that the highest lactation persistencies were displayed by cows with the shortest dry periods (shorter than 45 days), or according to Soleimami et al. (2010), shorter than 60 days.

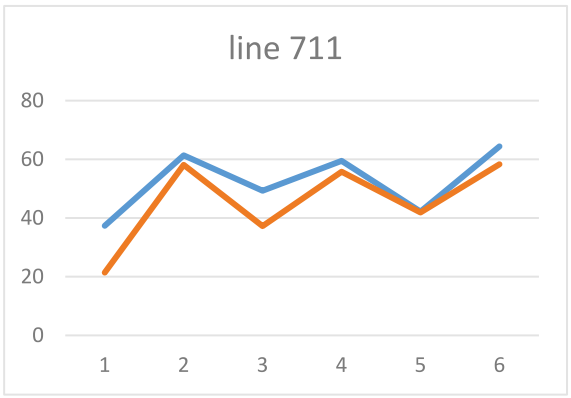
Among the 14 studied maternal lineages, in seven of them (711, 731, 1118, 1135, and 1390) lactation persistency curves conformed to peak production curves in individual lactations. At the same time, the most desirable values for describing production were the curves in lineages 415, 701, 711, 731, 1019, 1118, 1135, 1141, and 1390, where stable peak milk production values were maintained for a period of at least 5 successive years in a given maternal lineage. These observations contradict the results of Guliński and Młynek (2003), who claimed that the factor with the strongest impact on the reduction of milk production persistency during lactation is the age of the animal, and for that reason in their study the first-lactation cows displayed the highest indexes. In the current study, in the case of these lineages age did not affect the level of

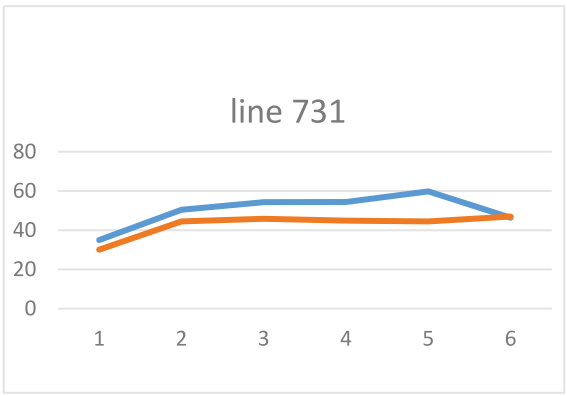
the indexes. Only in lineages 921 and 1319 was there observed a decrease in peak production and the value of lactation persistency. The most highly anticipated shape for the production and lactation persistency curve is that shown by lineages 415, 731 and 1135, where a steady increase in peak production levels is observed up to 5 lactations. In lineage 415, the curves for persistency successively grew from an average level of 14.55% to 66.61%, and in lineage 731 from 30.05% to 46.98%, while in lineage 1135 these levels increased from 30.04% to 67.14%. An analysis of the results indicated that most often after the 3rd lactation, we observe a change in the lactation persistency curves in individual lineages, and that this outlines further production trends, be they increasing or gradually decreasing trends. Thus, an analysis of the 2nd and 3rd lactations in terms of the values of lactation persistency index may influence the decision as to the appropriacy of maintaining cows in a given maternal lineage in a production maximisation regime. Since lineages 921, 937, and 1319 do not fit into this thesis, it would be worthwhile also to analyse average production among cows during their periods of peak lactation.

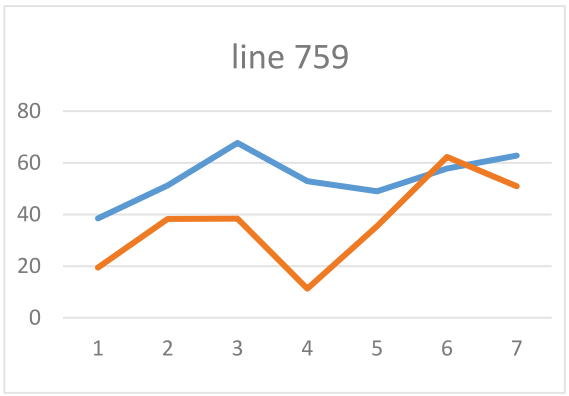












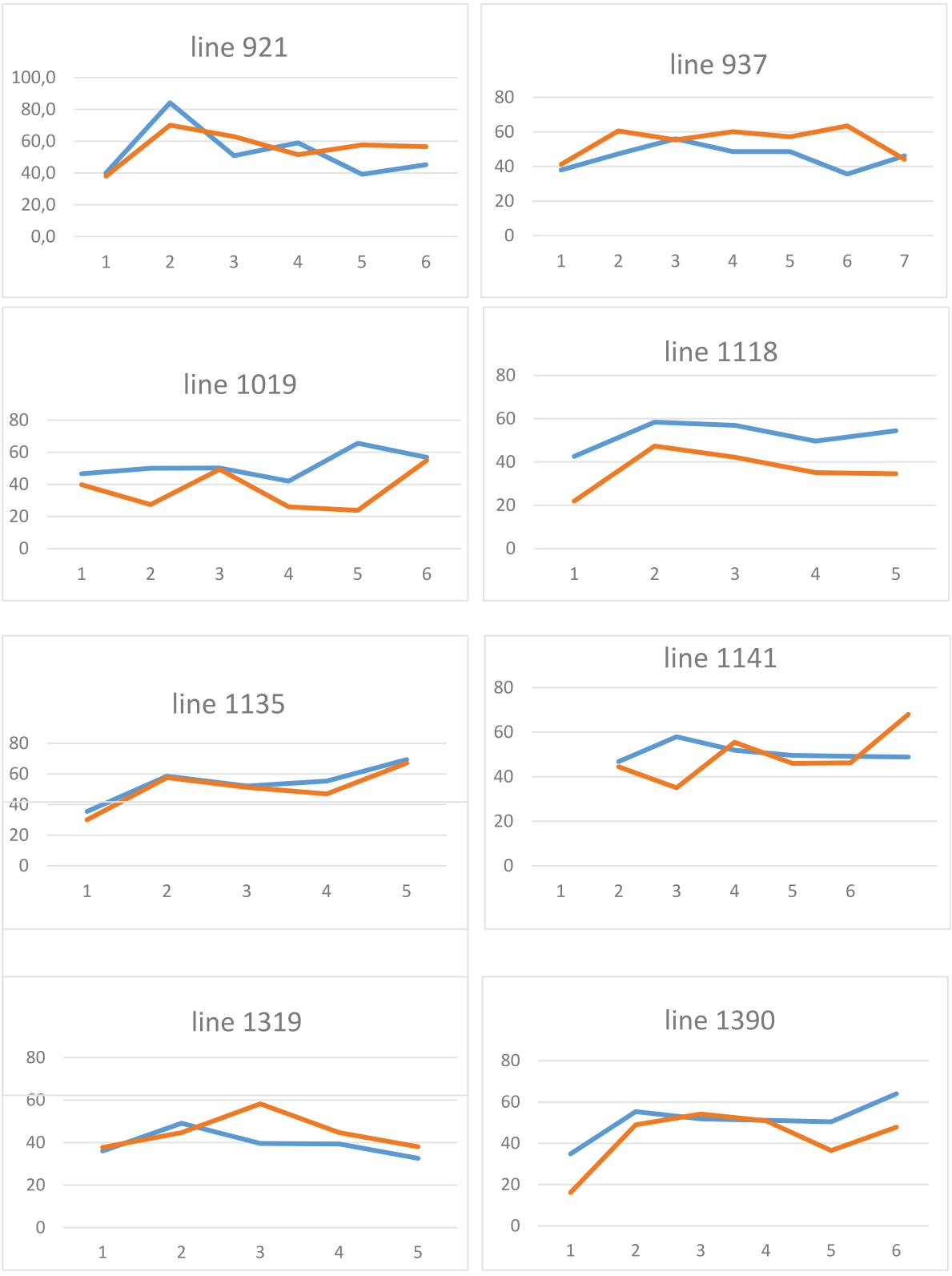


Fig. 1. Lactation persistency curve (0–80%) and daily performance (0–80 kg) during peak milk production (1–8) for a given maternal lineage

CONCLUSIONS

It has been observed that along with an increasing daily amount of lactation among the cows studied, the average lactation persistency index also increased. For cows undergoing their 2nd lactation, this index did not exceed 30%, while for cows in their 4th lactation this amounted to 70%. Thus, the cows with the highest lactation persistency indexes were also characterised by the highest daily production in average daily milking during peak lactation, with values of 56.14 kg at an index of 70.1–80%. Cows which began their milk production life stage with a high persistency index in the 1st or 2nd lactations, amounting to 40% or more with production levels during peak lactation of roughly 50 kg, in subsequent lactation cycles saw a significant decrease in this index. Cows which were characterised by low average lactation persistency indexes at the start of their milk production stage with production levels of up to 45 kg, in subsequent lactations saw a successive increase in lactation persistency of 41.23% to 66.61% or from 16.17% to 63.63%. Breeding cattle within maternal lines characterized by a high and stable level of lactation persistence index can ensure a high level of milk production in this line of cows.

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WYKORZYSTANIE WYTRWAŁOŚCI LAKTACJI JAKO WSKAŹNIKA W SELEKCJI LINII MATECZNYCH KRÓW RASY HF

Streszczenie. Materiał do badań stanowiła grupa bydła rasy polskiej holsztyńsko-fryzyjskiej (PHF) w liczbie 163 sztuk. W ramach podjętych badań krowy przypisano do 14 linii matecznych obejmujących trzy pokolenia. Celem badań było wskazanie możliwości prowadzenia selekcji krów w kierunku utrzymania w gospodarstwie linii matecznych charakteryzujących się wysokimi walorami produkcyjnymi określonymi przez wskaźnik wytrwałości laktacji. W tym celu analizie poddano podstawowe parametry produkcyjne w laktacji 305-dniowej oraz zgromadzono informacje o komórkach somatycznych na podstawie próbnych udojów. Dokonano charakterystyki wytrwałości danej laktacji jako procentowej różnicy pomiędzy produkcją mleka w 2. a 10. miesiącu laktacji oraz wykreślono krzywe wytrwałości laktacji dla poszczególnych linii w kolejnych laktacjach, śledząc zmiany w produkcyjności krów. Stwierdzono, że wraz z rosnącą średnią ilością laktacji u badanych krów wzrastał średni wskaźnik wytrwałości laktacji. Dla krów młodszych wartość wskaźnika nie przekraczała 30%, natomiast w grupie starszych – 70%. Krowy o największej wartości tego wskaźnika (70,1–80%) charakteryzowały się produkcją w szczycie laktacji na poziomie 56,14 kg. Zwierzęta, które rozpoczęły życiową produkcję z wysokim wskaźnikiem wytrwałości w I lub II laktacji, w kolejnej laktacji uzyskiwały znaczące zmniejszenie tego wskaźnika. Osobniki charakteryzujące się niskim średnim wskaźnikiem wytrwałości laktacji w chwili rozpoczęcia produkcji mleka w kolejnych laktacjach uzyskiwały sukcesywny wzrost wytrwałości. Hodowla bydła w obrębie linii matecznych charakteryzujących się wysokim i stabilnym poziomem wskaźnika wytrwałości laktacji może zapewnić wysoki poziom produkcji mleka u krów w tej linii.

Słowa kluczowe: bydło, wytrwałość laktacji, produkcja mleczna.