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RELATIONSHIP BETWEEN AGE AT FIRST CALVING AND SELECTED FEATURES OF THE LIFETIME PERFORMANCE OF MONTBÉLIARDE COWS

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ABSTRACT

A study on the effect of age at first calving on selected features of lifetime performance was carried out in one of the largest herds of Montbéliarde cows in Poland. Data from 205 culled cows included 12,430 test-day milking results and data pertaining to lifetime performance – length of life and productive life; number of calvings; lifetime actual yield of milk, fat, protein and dry matter; the content of these constituents in the milk; and FPCM per day of life and productive life. The values of the lifetime performance traits of the Montbéliarde cows varied depending on their age at first calving. The most favourable age at first calving for the lifetime performance traits of the Montbéliarde cows was 27–30 months (824–915 days), while calving too early (less than 824 days) or too late (above 1038 days) was least favourable. Cows calving for the first time at the age of 824–915 days had the most favourable average daily milk yield (26.6 kg), lactation persistence (34.5% decrease), length of life and productive life (3215 and 2360 days), number of calvings (5.2), lifetime yield of milk and FPCM (49,330 and 50,104 kg), and lifetime yield of FPCM per day of life and productive life (15.7 and 21.4 kg) in relation to the other groups of cows. Differences in the values of these traits between cows that first calved at the age of 824–915 days and cows calving earliest and latest were statistically significant ($P \leq 0.01$).

Key words: length of life, length of productive life, Montbéliarde breed, age at first calving, milk yield, lactation persistence

INTRODUCTION

Longevity in dairy cows is one of the most important indicators of their performance efficiency and for this reason is included among modern selection indices [Brzozowski 2003]. In addition, the lifespan of cows has a significant impact on the economic outcome of milk production [Pirlo et al. 2000]. Dairy cows used for a longer time produce more milk and milk constituents over the course of their lives, give birth to more calves, and exhibit better health [Nogalski 2004, Brickell and Wathes 2011]. Moreover, longer use reduces costs associated with rebuilding of the herd and allows proper selection to be carried out in it. Longevity of dairy cows depends on many factors, both genetic and non-genetic [Groenendaal et al. 2004]. Among genetic factors, breed is thought to be one of the most important. The Holstein-Friesian breed is one of the most productive dairy breeds in the world, but due to its intensive use, breeders have a problem with longevity in this breed [Haworth et al. 2008]. Long-lived dairy cattle breeds primarily include those with a long breeding history and resistance to unfavourable living conditions resulting from many years of selection. One such breed is Montbéliarde [Trela 2003]. A number of non-genetic factors have also been found to significantly affect the longevity of dairy cows [Haworth et al. 2008, Hultgren et al. 2011, Heins et al. 2012, Jankowska et al. 2014]. These include housing conditions, feeding system, susceptibility to diseases, fertility, and age at first calving. According to Weller and Ezra [2015], cows born in February and March had the shortest productive lives, while those born in September were exploited lon-

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gest. According to Jankowska et al. [2014], attempts to maximize milk yield in the first lactation (>10,000 kg) may shorten the life of cows. A study by Nilforooshan and Edriss [2004], as well as Teke and Murat [2013] demonstrated that when milk production is begun too early ($\leq$22 months) or too late (particularly after 30 months), lifetime performance is substantially reduced. Moreover, cows' culling due to low milk yield and diseases of the udder increases.

The aim of the study was to determine to what extent age at first calving in Montbéliarde cows influences selected features of their lifetime performance and to determine the optimal age at first calving for this breed housed in analysed breeding condtions.

MATERIAL AND METHODS

The research was carried out on one of the largest Polish farms raising Montbéliarde cattle. It began operating in 2005, focusing on milk production. The herd was started with 190 springing Montbéliarde heifers purchased in France. In the following years, the herd was increased mainly with cows born on the farm. In 2016, the foundation herd consisted of 316 Montbéliarde cows with an average yield of 9374 kg of milk with an average content of 3.83% fat and 3.63% protein [Polish Federation of Cattle Breeders and Dairy Farmers 2017].

Cows kept in a free-stall system, fed TMR rations balanced according to DLG standards, are divided into six feeding groups, each of which receives a compound feed adjusted to the cows' living and production needs. The basis of the feed ration of each group is maize silage, haylage and hay. The concentrate feed consists of spent grain, barley meal, soybean meal and rapeseed meal. The feed is supplemented with vitamin and mineral supplements, the type and amount of which depend on the feeding group.

The data for the study came from the cows' dairy performance evaluations and from documentation kept on the farm. For 205 cows culled from the herd in 2009–2014, a combined 12,430 test-day milking results were collected, as well as data on the lifetime performance of these cows: length of life and productive life, number of calvings, lifetime yield of milk, fat, protein and dry matter, and their content in the milk. Based on the results for lifetime milk yield and its composition, the formula given by Subnel et al. [1994] was used to calculate lifetime yield of FPCM (fat- and protein-corrected milk), which was then calculated per day of the cow's life and productive life.

Data on daily milk yield were used to plot curves showing its changes over the course of lactation. The lactation was divided into 11 months/periods: 1, 2, 3, . . . , 10 and >10 months. The average milk yield was calculated for each period.

The statistical analysis of the variation in the traits of the Montbéliarde cows took into account the age at first calving as an experimental factor, on the basis of which the cows were divided into 4 groups: $\leq$823, 824–915, 916–1038 and >1038 days of age. Statistical calculations were performed in SPSS software. Significance of differences between means was estimated using Duncan's test at significance levels of $P \leq 0.01$ and $P \leq 0.05$.

RESULTS AND DISCUSSION

Table 1 shows that the group of Montbéliarde cows produced on average 24.4 kg of milk per day with an average content of 3.88% fat, 3.65% protein, 4.79% lactose and 12.61% dry matter. The fat-to-protein ratio (1.06) was favourable, but the somatic cell count was not, as the mean exceeded current standards for raw milk, at 481,000 $\cdot$ ml^{-1}. Only in the milk of cows calving for the first time between the 27th and 30th month and between the 30th and 34th month of life did the somatic cell count not exceed the standard, at 377,000 $\cdot$ ml^{-1} and 386,000 $\cdot$ ml^{-1}, respectively.

Age at first calving was a factor differentiating the values for the basic features of the daily productivity of the Montbéliarde cows. The most pronounced differences in means of individual traits were noted between cows that first calved at the age of 824–915 or 916–1038 days and those that first calved earliest (up to 823 days) and latest (>1038 days). According to Trela [2003], heifers of this breed imported from France calved for the first time at the age of 985 days. In a study by Januś and Borkowska [2014] milk production in the Montbéliarde heifers born in Poland began 97 days earlier, as the mean age at first calving was 888 days. In a study by Koç [2011], the age of Montbéliarde heifers at first calving was 952 days. Gołębiewski and Brzozowski [2009] found that Montbéliarde heifers gave birth for the first time when they were 912 days old. It should be emphasized that research on the influence of age at first calving on cows' subsequent productivity has not provided a conclusive answer as to the optimal age for the first calving [Krężel-Czopek and Sawa 2008]. Many authors claim that in the case of Holstein-Friesian cows, the age of 24–27 months is the most suitable for the initiation of milk production [Niedziałek et al. 2002, Borkowska and Januś 2004, Nogalski 2004]. Majewska et al. [2002] showed that cows calving on average at the age of 839 days (about 27.5 mo.) attained significantly higher yield (on average 3057 kg) than cows calving for the first time a month later.

In our study, first calving at the age of 27–30 months (824–915 days) was found to be the most favourable ($P \leq 0.01$) for the daily milk yield of Montbéliarde cows. Cows calving at that age produced 1.8–4.2 kg of

Table 1. Daily yield, content of basic constituents, fat-to-protein ratio and somatic cell count in the milk of Montbéliarde cows calving at different ages

Tabela 1. Dobowa wydajność, zawartość podstawowych składników, stosunek tłuszczu do białka i liczba komórek somatycznych w mleku krów rasy montbeliarde cielących się w różnym wieku

Characteristics Cechy	Age at first calving, days Wiek przy pierwszym wycieleniu, dni				Total and average Ogółem i średnio
	≤823	824–915	916–1038	>1038	
Number of milk samples – Liczba prób mleka	2846	4834	3170	1580	12,430
Daily yield of milk, kg – Dobowa wydajność mleka, kg	23.8 ^{A}	26.6 ^{B}	24.8 ^{Aa}	22.4 ^{Ab}	24.4
Content in milk of, % – Zawartość w mleku, %					
fat – tłuszczu	3.98 ^{A}	3.82 ^{B}	3.83 ^{B}	4.01 ^{A}	3.88
protein – białka	3.71 ^{A}	3.58 ^{B}	3.61 ^{B}	3.79 ^{A}	3.65
lactose – laktozy	4.86 ^{A}	4.77 ^{B}	4.76 ^{B}	4.78 ^{AB}	4.79
dry matter – suchej masy	12.85 ^{A}	12.47 ^{B}	12.50 ^{B}	12.88 ^{A}	12.61
Fat/protein ratio – Stosunek tłuszcz/białko	1.07	1.07	1.06	1.06	1.06
Somatic cell count, 1000 · ml^{-1} – Liczba komórek somatycznych, tys. · ml^{-1}	598 ^{A}	397 ^{B}	386 ^{B}	647 ^{A}	481

Means in rows with different superscript letters differ significantly: capital letters at $P \leq 0.01$, lower case letters at $P \leq 0.05$.
Średnie w wierszach oznaczone różnymi literami różnią się istotnie: wielkie litery przy $P \leq 0{,}01$, małe litery przy $P \leq 0{,}05$.

milk more than those whose first calving took place earlier or later. In terms of fat, protein and dry matter content in the milk, significant differences were found between cows calving for the first time at the age of 27–34 months and the other groups. The milk with the highest content of these constituents (4.01%, 3.79% and 12.88%, respectively) was obtained from cows that first calved after the age of 34 months, while the least favourable in this regard was calving at the age of 824–915 days (3.82%, 3.58% and 12.47%, respectively). The fat-to-protein ratio differed only slightly between groups; it was 1.07 in the case of calving at the age of ≤823 days and 824–915 days, and just 0.01 lower in all other cases. A study by Bortacki et al. [2016] found the highest protein content in the milk of cows calving before the age of 23 months, but there was no clear relationship between age at first calving and fat content in the milk.

The highest fat, protein and dry matter content in the milk of cows calving for the first time at >34 months was accompanied by one of the lowest lactose concentrations (4.78%). The highest content of this constituent, as much as 4.86%, was found in the milk of cows whose milk production began earliest (≤823 days of age).

A significantly ($P \leq 0.01$) higher somatic cell count in the milk was found to be associated with the earliest (≤823 days of age) and the latest (>34 months) first calving in the Montbéliarde cows. The mean value of this trait was most favourable for cows calving for the first time at the age of 30–34 months, at 386,000 · ml^{-1}. In a study by Borkowska and Januś [2010] somatic cell count and the share of samples indicated as worse cytological quality of milk of Montbéliarde cows increased in successive lactation and lactation period, whereas a decrease of this parameters with an increase of daily milk yield and in winter season were observed. The somatic cell count is used as an indirect indicator of subclinical mastitis in cows [Sender et al. 2010]. An elevated somatic cell count is usually accompanied by a reduction in milk production and significant changes in its composition, leading to deterioration of nutritional quality and suitability for processing [Pawlik et al. 2010]. According to Malinowski [2001], a somatic cell count exceeding 100,000 · ml^{-1} causes daily milk losses of 0.4 kg in primiparous cows and 0.6 kg in multiparous cows. Besides a diseased state of the mammary gland, the somatic cell count in milk is indirectly influenced by the stage after calving, season of the year, breed, lactation number, the age of the cow, and stress [Koç and Kizilkaya 2009].

During the first month of lactation, the daily yield of the Montbéliarde cows was not found to differ significantly depending on their age at first calving (Fig. 1). Cows that first calved at 916–1038 or >1038 days of age had the lowest daily yield in this period, producing on average 25.4 kg of milk. The highest daily yield in the first month, 27.1 kg, was found for cows calving for the first time at 824–915 days of age. In the second month, milk yield increased in each of the groups as compared to the first month. The increase was greatest, at 6.5 kg, in the group of cows calving at the age of 916–1038 days. As a result, 31.9 kg of milk was obtained from these cows at the peak of lactation. In spite of this largest increase, these cows produced 0.8 kg of milk less than cows whose first calving took place between 824 and 915 days of age. In the remaining groups (age at first calving ≤823 and >1038 days), the increase in daily yield between the 1st

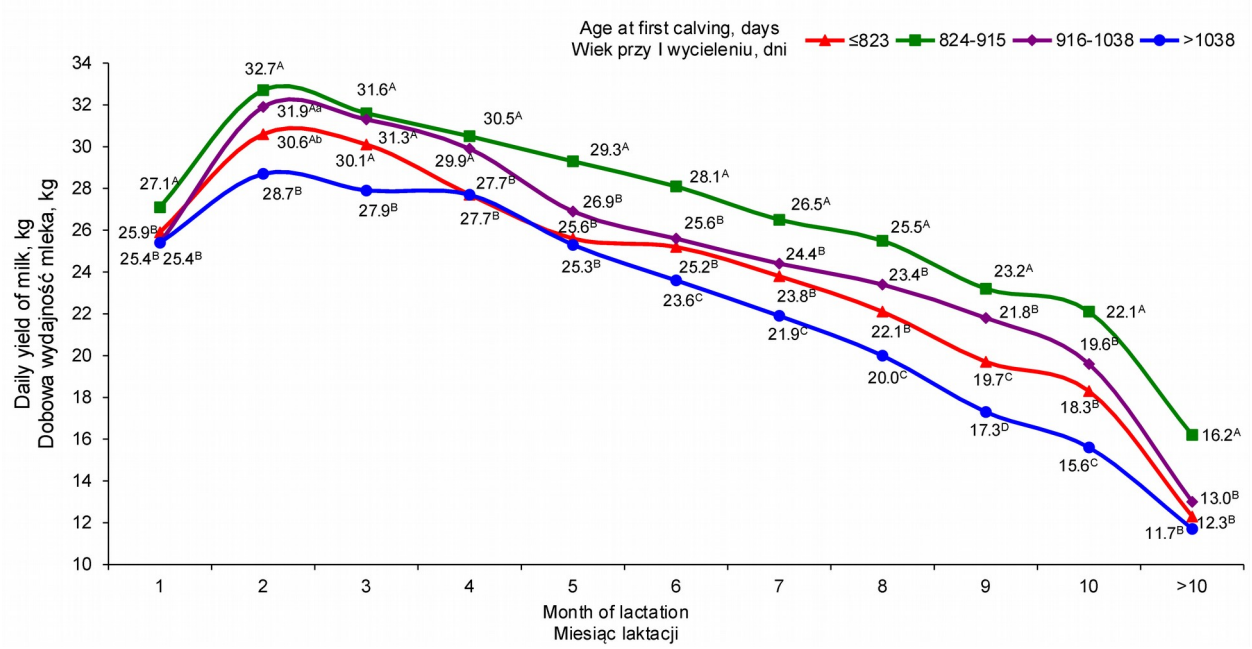

Fig. 1. Changes in daily milk yield over the course of lactation in Montbéliarde cows calving at different ages; means in different months designated with different letters differ significantly: capital letters at $P \leq 0.01$, lower case letters at $P \leq 0.05$.

Rys. 1. Zmiany dobowej wydajności mleka w przebiegu laktacji krów rasy montbeliarde cielących się w różnym wieku; średnie w kolejnych miesiącach oznaczone różnymi literami różnią się istotnie: wielkie litery przy $P \leq 0{,}01$, małe litery przy $P \leq 0{,}05$.

and 2nd month of lactation was smaller (4.7 and 3.3 kg, respectively).

According to Topolski et al. [2008], after reaching the peak of lactation, which usually occurs in the second month, the milk yield of cows gradually decreases, and the rate of change in this characteristic depends mainly on breed, age, nutrition, milking frequency, mammary gland diseases, and the length of lactation and of the dry period. In our research, the decrease in yield from the 2nd to 3rd month of lactation was greatest in the group of cows that calved for the first time between 824 and 915 days of age, as their productivity decreased by 1.1 kg. The daily yield of cows whose rearing period was up to 27 months, within the range of 916–1038, and more than 1038 days decreased by 0.5, 0.6 and 0.8 kg of milk, respectively. In subsequent months of lactation there was a further decrease in daily yield, whose intensity varied depending on the age at first calving. The amount of milk produced from the peak of lactation to the 10th month after calving decreased the most in cows whose productive life began at over 34 months of age. This decrease was 13.1 kg. This means that milk yield decreased by 45.6% between the 2nd and the 10th month, and indicates that lactation persistence was lowest in cows that calved latest. In the group in which the first births took place earliest (≤823 days of life), daily milk production between the 2nd and 10th month after calving decreased by 12.3 kg, or 40.2%. The same reduction in daily milk yield was also recorded in the cows that first calved at the age of 916–1038 days, but the decrease in productivity from the 2nd to the 10th month was only 38.6%. The most persistent lactation was noted in the group of cows calving for the first time between 824 and 915 days of age, with a drop in yield of 10.6 kg (32.4%). The cows in this group also had the highest yields for the entire lactation period.

Data from the Polish Federation of Cattle Breeders and Dairy Farmers [2017] show that Montbéliarde cows culled in Poland in 2016 were used for an average of 2.86 years and lived 5.46 years. During their productive lives, cows of this breed produced on average 21,157 kg of milk, 843 kg of fat and 740 kg of protein. Table 2 shows that the lifetime performance efficiency of the Montbéliarde cows on the farm was greater, as they had higher longevity indicators and much higher productivity. They lived on average 2904 days (nearly 8 years), were used on average 2016 days (5.5 years), and calved 4.5 times. During their production period, they produced a total of 39,932 kg of milk, 1671 kg of fat, 1458 kg of protein and 5291 kg of dry matter. Their lifetime productivity

Table 2. Indicators of lifetime performance of Montbéliarde cows according to their age at first calving

Tabela 2. Wskaźniki życiowej użytkowości krów rasy montbeliarde w zależności od wieku przy I wycieleniu

Characteristics Cechy	Age at first calving, days Wiek przy pierwszym wycieleniu, dni				Total and average Ogółem i średnio
	≤823	824–915	916–1038	>1038	
Number of cows – Liczba krów, szt.	45	178	55	27	205
Length of life, days – Długość życia, dni	2375 ^{A}	3215 ^{B}	3083 ^{B}	2473 ^{A}	2904
Length of productive life, days – Długość użytkowania, dni	1577 ^{A}	2360 ^{Ba}	2122 ^{Bb}	1425 ^{A}	2016
Number of calvings – Liczba wycieleń	3.8 ^{A}	5.2 ^{B}	4.8 ^{B}	3.4 ^{A}	4.5
Lifetime yield of, kg – Życiowa wydajność, kg					
milk – mleka	30,247 ^{Aa}	49,330 ^{B}	47,547 ^{B}	26,444 ^{Ab}	39,932
FPCM	31,185 ^{Aa}	50,104 ^{B}	48,546 ^{B}	28,114 ^{Ab}	42,057
fat – tłuszczu	1248 ^{A}	1991 ^{B}	1954 ^{B}	1176 ^{A}	1671
protein – białka	1091 ^{A}	1685 ^{B}	1672 ^{B}	1057 ^{A}	1458
dry matter – suchej masy	3950 ^{A}	6187 ^{B}	6032 ^{B}	3556 ^{A}	5291
Lifetime FPCM yield per day, kg – Życiowa wydajność FPCM na 1 dzień, kg					
of life – życia	13.2 ^{A}	15.7 ^{B}	15.8 ^{B}	11.4 ^{C}	14.5
of productive life – użytkowania	19.9 ^{a}	21.4 ^{b}	22.8 ^{b}	19.0 ^{a}	20.9
Content in milk of, % – Zawartość w mleku, %					
fat – tłuszczu	4.11 ^{a}	4.03 ^{b}	4.09 ^{b}	4.21 ^{c}	4.10
protein – białka	3.62 ^{a}	3.50 ^{b}	3.61	3.56	3.58
dry matter – suchej masy	13.01 ^{a}	12.93 ^{b}	13.02 ^{a}	13.13 ^{c}	13.00

Means in rows with different superscript letters differ significantly: capital letters at P ≤ 0.01, lower case letters at P ≤ 0.05.
Średnie w wierszach oznaczone różnymi literami różnią się istotnie: wielkie litery przy P ≤ 0,01, małe litery przy P ≤ 0,05.

was 14.5 kg FPCM per day of life and 20.9 kg FPCM per day of productive life.

Indicators of the lifetime productivity of cows that calved for the first time at different ages differed statistically significantly. Cows that calved for the first time between the 27th and 30th months of life were found to live the longest (3215 days). These cows were also exploited the longest among all groups analysed. Cows that calved for the first time at the youngest age (≤27 months) had the shortest lives. However, this did not translate into a shorter production period, as this period was 152 days (5 months) longer than in the group of cows that calved latest and were used for 1425 days (less than 4 years).

The Montbéliarde cows whose first calving took place between 824 and 1038 days of age calved significantly (P ≤ 0.01) more often (4.8–5.2 times) than those whose first calving occurred up to 823 days of age (3.8 times) and after 1038 days of age (3.4 times). The same significant relationship between these groups was observed for lifetime yield of milk and its constituents. It was also found that cows calving for the first time between 27 and 30 months of age had the highest actual milk yield (49,330 kg), as well as the highest FPCM yield (50,104 kg). In this group, the cows also achieved the most favourable results in terms of lifetime yield of fat, protein and dry matter (1991, 1685 and 6187 kg, respectively). The best results for FPCM yield per day of life (15.8 kg) and productive life (22.8 kg) were obtained by cows that first calved at the age of 916–1038 days. The lowest yield of milk and its constituents, as well as FPCM yield per day of life and per day of productive life, was observed in cows that first calved at the age of over 34 months. It can therefore be concluded that the commencement of milk production by the Montbéliarde cows at an age exceeding 1038 days was the least favourable for their lifetime performance. In a study on the Holstein-Friesian breed, Nilforooshan and Edriss [2004] showed a positive effect of reducing the age at first calving on milk yield and length of productive life. However, the study suggested that shortening the rearing period of heifers too much (calving at the age of 21 months) adversely affected the yield of milk and fat. Haworth et al. [2008] found no significant relationship between age at first calving and the number of lactations or the length of productive life. Hultgren et al. [2011] indicate that 24 months should be considered an economically justified age for the first calving. Jankowska et al. [2014] reported a marked increase in culling due to sterility among cows that calved for the first time at the latest age (>30 months). A study by Nogalski [2004] showed that cows that calved for the first time between 24.1 and 26 months of age had the most favourable lifetime performance indicators: more calvings; longer life and productive life; higher milk production per day of life, day of productive life and day in milk; more total lifetime days in milk; and higher FCM production per day of rearing. The author also found that heifers that calved at under 24

months of age or over 28 months had a shorter productive life, lower lifetime production of milk, fat and protein, and less favourable indicators of lifetime performance efficiency. According to Brzozowski [2003] and Sitkowska and Mroczkowski [2004], on the other hand, the age at first calving had no significant influence on the lifetime yield of cows.

The age at first calving significantly differentiated the fat and dry matter content in the milk, while in the case of protein content no such clear differences were noted. The highest content of fat and dry matter (4.21% and 13.13%, respectively) was noted in the milk obtained from cows whose milk production began latest (>1038 days of life). The milk of cows whose first calving took place between 824 and 915 days of age had the lowest content of these constituents (4.03% and 12.93%, respectively). In terms of protein content in milk, only one difference was found, significant at $P \leq 0.05$. For the average concentration of this constituent, the earliest calvings ($\leq$823 days of age) were most favourable, while the lowest mean protein content was found in milk obtained from cows that calved for the first time at 824–915 days (3.62% and 3.50%, respectively). Pirlo et al. [2000] found that shortening the rearing period of heifers had a positive effect on the fat content in milk produced later in their productive life.

CONCLUSIONS

The values of the lifetime performance traits analysed in the Montbéliarde cows were found to vary depending on their age at first calving. Calving at 27–30 months (824–915 days) was the most favourable for average test-day milking results, milk yield during productive life, the lactation curve, and the length of life and productive life. In addition, these cows delivered the most calves over their lifetimes and produced the most milk, fat, protein and dry matter. The milk with the highest content of basic nutrients was obtained from cows that first calved at over 34 months of age, while calving at the age of 27–30 months was least favourable. The earliest ($\leq$823 days) and the latest (>34 months) age at first calving in Montbéliarde cows may predispose them to greater susceptibility to udder inflammation, as their milk had a significantly higher somatic cell count. The study showed that beginning milk production of Montbéliarde cows too early (before 823 days of life) or too late (over 1038 days of age) was the least beneficial to lifetime performance.

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ZALEŻNOŚĆ POMIĘDZY WIEKIEM PRZY PIERWSZYM OCIELENIU A WYBRANYMI CECHAMI ŻYCIOWEJ UŻYTKOWOŚCI KRÓW RASY MONTBELIARDE

STRESZCZENIE

Badania dotyczące wpływu wieku przy pierwszym wycieleniu na wybrane cechy życiowej użytkowości przeprowadzono w jednym z największych stad krów rasy montbeliarde w Polsce. Dla 205 krów wybrakowanych ze stada zebrano dane obejmujące łącznie 12 430 wyników próbnych udojów oraz dane dotyczące życiowej użytkowości tych krów – długość życia i użytkowania, liczba wycieleń, życiowa wydajność mleka, tłuszczu, białka i suchej masy oraz zawartość tych składników w mleku. Stwierdzono, że wartości analizowanych cech życiowej użytkowości krów rasy montbeliarde były zróżnicowane w zależności od wieku przy pierwszym wycieleniu. Wykazano, że najbardziej korzystnym dla wartości cech życiowej użytkowości krów rasy montbeliarde był wiek przy pierwszym ocieleniu 27–30 miesięcy (824–915 dni), a najmniej zbyt wczesny (poniżej 824 dnia) lub zbyt późny (powyżej 1038 dni). Krowy cielące się po raz pierwszy w wieku 824–915 dni uzyskały najkorzystniejsze: przeciętną dobową wydajność mleka (26,6 kg), wytrwałość laktacji (spadek o 34,5%), długość życia i użytkowania (3215 i 2360 dni), liczbę wycieleń (5,2), życiową wydajność mleka i FPCM (49 330 i 50 104 kg) oraz życiową wydajność FPCM na 1 dzień życia i użytkowania (15,7 i 21,4 kg) w stosunku do pozostałych grup krów. Różnice w wartościach tych cech pomiędzy krowami, których pierwsze wycielenia przypadały w wieku 824–915 dni, a krowami cielącymi się najwcześniej i najpóźniej były istotne statystycznie ($P \leq 0{,}01$).

Słowa kluczowe: długość życia, długość użytkowania, rasa montbeliarde, wiek przy pierwszym ocieleniu, wydajność mleka, wytrwałość laktacji