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EFFECT OF SOME FACTORS ON SEX OF THE CALF BORN, AND OF SEX OF THE CALF ON PERFORMANCE OF DAIRY COWS

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Abstract. Records of 384 965 parturitions and milk and reproductive performance in subsequent production cycles of 114 526 Black-and-White Polish Holstein-Friesian cows were collected from the SYMLEK database. The animals represented the active population in Pomorze and Kujawy regions, first calved in 2000–2012, and were used or culled until the end of 2013. The GLM and FREQ procedures of the SAS package were used in the statistical calculations. Sex of the calf influenced milk and reproductive performance of Polish Holstein-Friesian dairy cows and the effect was more favourable after a female calf was born. The advantage in milk performance of the cows which gave birth to female calves at first calving may be of importance in modern dairy herds, considering the increasing availability of sexed semen. Significant but small (around 1%) differences in the sex ratio of calves born within factors such as cow's age or production level in the previous lactation do not allow taking these factors into consideration when controlling the sex of the calves born.

Key words: dairy cows, sex of the calf born, performance

INTRODUCTION

The proportion of male to female calves born should be 1:1 [Roche et al. 2006]. Practical experience and research results indicate that the sex ratio of calves born may be different due to the effect of factors such as breed, number of calves born, age of cow, lactation number, milk yield, conception date, season of the year, indoor climate, and herd management [Singh et al. 2004, Demiral et al.

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2007, Kaygisiz and Vanli 2008, Iwata 2012]. In dairy herds it is desirable that as many calves born as possible are heifers, which will be used for herd replacement [Yilmaz et al. 2010]. The possible subsequent use of heifers in milk production is not the only positive aspect of giving birth to a female calf, because Hinde et al. [2014] report that cows that gave birth to a heifer produce more milk than those that had a bull.

The objective of the study was to prove or reject the hypothesis that some factors have an effect on the sex of calves born and that sex of the calf affects cow productivity.

MATERIAL AND METHODS

The experiment used records from the SYMLEK database on 384 965 parturitions as well as milk and reproductive performance in the subsequent production cycles of 114 526 Black-and-White Polish Holstein-Friesian cows. The animals represented the active population in Pomorze and Kujawy regions, first calved in 2000–2012, and were used or culled until the end of 2013. Multiple pregnancies and pregnancy losses were excluded from the statistical calculations.

The chi–square test of independence [SAS 2013] was used to analyse the frequency of heifer or bull births depending on:

- cow's age (primiparous, multiparous),
- calving season (III–V, VI–VIII, IX–XI, XII–II),
- for multiparous cows – milk production during the previous full lactation ($\leq$ 6000 kg, 6001–8000 kg, 8001–10 000 kg and >10 000 kg milk),
- for primiparous cows – year of calving (2000–2001, 2002–2003, 2004––2005, 2006–2007, 2008–2009, 2010–2011 and 2012).

Analysis of variance [SAS 2013] was used to estimate:

1. The effect of sex of the calf (heifer H, bull B) on performance (full lactation and daily milk yield, lactation length, length of calving interval (LCI), reproductive rest period (RRP), service period (SP), number of inseminations (NI), number of calves born alive, length of pregnancy) of primiparous and multiparous cows; the following linear model was used in the statistical analysis (GLM procedure of SAS):

$$y_{op} = \mu + w_o + p_p + (w \times p)_{op} + e_{op}$$

where: μ – mean, w_o – effect of sex of the calf (heifer, bull), p_p – effect of cow's age (primiparous cow, multiparous cow), $(w \times p)_{op}$ – calf sex $\times$ cow's age interaction, e_{op} – random error of observation.

2. The effect of sex of the calf (heifer H, bull B) during the first and second pregnancy on first and second full lactation milk yield, based on the following sex classes: H_1H_2, H_1B_2, B_1H_2, B_1B_2; the following linear model was used in the statistical analysis (GLM procedure of SAS):

$$y_o = \mu + w_o + e_o$$

where: μ – mean, w_o – effect of calf sex class (H_1H_2, H_1B_2, B_1H_2, B_1B_2), e_o – random error of observation.

Significance of differences were estimated using the Scheffe test [SAS 2013].

RESULTS AND DISCUSSION

The sex ratio of the calves born was 47.21 to 52.79% (female to male) (Table 1) and differed from the expected 1:1 ratio. Quesnel et al. [1995] and Echternkamp et al. [2007] reported that heifers and bulls accounted for 48 and 52% of the calves born, respectively. In a study with Holstein-Friesian cattle [Silva del Río et al. 2007], the bull to heifer ratio was 53.3 : 46.7. Similar results were obtained by Atrey [2003], Banik and Naskar [2006] and Goshu and Singh [2013].

Differences ($P \leq 0.01$) were found in the sex ratio of calves born to primiparous and multiparous cows (Table 1). The proportion of heifers was higher for calves born to primiparous (47.74%) compared to multiparous cows (46.89%). Similar studies performed by other authors show varying results. Kaygisiz et al. [2003], Lari [2006] and Roche et al. [2006] observed no statistically significant effect of the number of calving on the sex ratio of calves born, whereas Singh et al. [2004] did find such an effect. Berry and Cromie [2007] concluded that the probability of giving birth to a bull was significantly higher in older compared to younger cows. According to Goshu and Singh [2013], the proportion of heifers born was 48% at first calving and later ranged from 44% (second calving) to 51% (fifth–seventh calving).

The sex ratio of calves born was uniform in individual calving seasons. Likewise, Mukherjee et al. [2000], Atrey [2003], Lari [2006] and Goshu and Singh [2013] observed no significant relationship between season of the year and the sex ratio of calves born. However, Singh et al. [2004] found calving season to have a slight effect on the sex ratio of the calves. According to Roche et al. [2006], the probability of a bull being born increased with increasing air temperature and humidity around the time of conception.

Analysis of the effect of milk production level in the previous lactation demonstrated that it increased with the increasing proportion of heifers born to calves,

Table 1. Effect of some factors on the sex ratio of the calves born

Tabela 1. Wpływ wybranych czynników na stosunek płci urodzonych cieląt

Factor Czynnik		Number of calves, individuals Liczba cieląt, osobniki	Proportion, % Udział, %	
			heifers jałówki	bulls buhajki
Total Ogółem		384 965	47.21	52.79
Age of cow Wiek krowy $Chi^2 = 26.1^{xx}$	primiparous pierwiastka	114 526	47.74	52.26
	multiparous wieloródka	240 439	46.89	53.11
Calving season Sezon wycielenia $Chi^2 = 3.1$	III–V	93 416	47.02	52.98
	VI–VIII	95 616	47.14	52.86
	IX–XI	93 996	47.41	52.59
	XII–II	101 937	47.26	52.74
Previous lactation milk yield, kg Poziom wydajności mleka w poprzedniej laktacji, kg $Chi^2 = 23.8^{xx}$	≤ 6000	61 991	46.05	53.95
	6001–8000	76 168	47.06	52.94
	8001–10 000	53 596	47.23	52.77
	≤ 10 000	48 153	47.28	52.72
Year of first calving Rok pierwszego wycielenia $Chi^2 = 192.5^{xx}$	2000–2001	19 988	45.50	54.50
	2002–2003	21 970	46.30	53.70
	2004–2005	22 791	46.57	53.43
	2006–2007	22 916	47.61	52.39
	2008–2009	22 892	48.25	51.75
	2010–2011	24 337	49.89	50.11
	2012	9630	52.12	47.88

^{xx} $P \leq 0.01$.

from 46% for cows yielding up to 6000 kg milk to 47.3% for cows with a milk yield exceeding 10 000 kg.

The year of first calving had an effect on the sex ratio of calves ($P \leq 0.01$). The number of heifers born increased every year during the analysed period, from 45.53% in 2000–2001 to 52.12% in 2012. A significant ($P \leq 0.01$) relationship between the year of calving and the sex ratio of the calves was also reported by Kumar et al. [1992], Lathwal and Kumar [1993], Berry and Cromie [2007], and Goshu and Singh [2013]. In the study by Berry and Cromie [2007], the bull to heifer ratio ranged from 49:51 in 2000, to 50:50 in 2001 and 2002, and to 51:49 in 2005.

The results in Table 2 indicate an advantage of heifer dams over bull dams in lactational performance, but it was statistically significant only for primiparous cows. However, the advantage of primiparous cows (68 kg milk) is lower than that reported in a U.S. study (142 kg) for around 1 490 000 Holstein-Friesian

cows [Hinde et al. 2014]. The smaller effect of calf sex on the lactation yield of multiparous cows found in our study concurs with the findings of Hinde et al. [2014].

Table 2. Effect of sex of the calf on performance of primiparous and multiparous cows

Tabela 2. Wpływ płci cielęcia na użytkowość pierwiastek i wieloródek

Item Wyszczególnienie	Primiparous cows Pierwiastki		Multiparous cows Wieloródki	
Calf sex Płeć cielęcia	heifers jałówki	bulls buhajki	heifers jałówki	bulls buhajki
Number of cows, indiv. Liczba krów, osob.	68 996	75 530	112 742	127 697
Days of milking Dni doju	359 A	366 A	334	344
Milk yield, kg Wydajność mleka, kg	7555A	7487 A	7693	7661
Milk yield per day, kg Wydajność leka na dzień, kg	21.1 A	20.6 A	23.3 A	23.2 A
Number of calves born alive Liczba cieląt żywo urodzonych	0.96 A	0.89 A	0.97 A	0.93 A
LCI, days OMW, dni	428 A	431 A	420 A	423 A
RRP, days OSR, dni	94 A	95 A	93 A	94 A
SP, days OU, dni	53 A	55 A	46 A	48 A
NI II	2.16 A	2.19 A	2.03 A	2.07 A
Pregnancy length, days Długość ciąży, dni	279.3 A	280.6 A	282.0 A	284.0 A

Means with the same letters differ significantly at $P \leq 0.01$.
Wartości cech oznaczone tymi samymi literami różnią się istotnie przy $P \leq 0{,}01$.
LCI – length of calving interval; RRP – reproductive rest period, SP – service period; NI – number of inseminations.
OMW – długość okresu międzywycieleniowego; OSR – długość okresu spoczynku rozrodczego; OU – długość okresu usługi; II – indeks inseminacji.

Although the lactations of heifer dams were shorter than those of bull dams, their daily milk yield was higher (by 0.5 kg for primiparous cows and by 0.1 kg for multiparous cows). Meanwhile, Habib et al. [2010] reported no statistically significant effect of calf sex on milk production traits such as lactation length, daily yield, and lactation yield.

The risk of giving birth to a dead calf was found to be higher for male fetus ($P \leq 0.01$) (Table 2). The increased periparturient mortality among bulls is confirmed by Nogalski [2004] whose analysis showed that larger body dimensions of male calves are the reason for higher periparturient mortality.

Our analysis showed a significant effect of the sex of the calves on subsequent fertility of their mothers. After giving birth to a bull, the next calvings of their mothers were 3 to 4 days later than after giving birth to a heifer. According to a study with African cattle, calving interval increased by 14 days after a bull was born [Obese et al. 2013]. The results in Table 2 indicate that sex of the calf had an effect ($P \leq 0.01$) also on the other indicators of fertility, with heifer dams showing better fertility regardless of the cow's age. In these dams, the mean RRP and SP were shorter by 1 and 2 days, respectively.

Female pregnancies in the analysed herd were shorter than male pregnancies (by 1.3 days for heifers and by 2 days for cows), which is supported in the literature. The difference between pregnancy length in a cow and heifer ranges from 0.3 to 1.8 days [Silva et al. 1992, Normana et al. 2009].

Table 3. Effect of sex of the calf in the first (H_1B_1) and second pregnancy (H_2B_2) on the first and second lactation milk yield

Tabela 3. Wpływ płci cielęcia w pierwszej (J_1 B_1) i drugiej ciąży (J_2 B_2) na wydajność mleka w pierwszej i drugiej laktacji

Item Wyszczególnienie	Sex of calves in first and second pregnancy Płeć cieląt w pierwszej i drugiej ciąży			
	H_1H_2 J_1J_2	B_1B_2 B_1B_2	H_1B_2 J_1B_2	B_1H_2 B_1J_2
Number of cows Liczba krów	22 309	26 973	24 448	22 981
Milk quantity in first full lactation, kg Ilość mleka w I laktaji pełnej, kg	7715 AaB	7595 A	7638 a	7616 B
Milk quantity in second full lactation, kg Ilość mleka w II laktacji pełnej	7784 Aa	7772 A	7793 a	7794

Means with the same letter differ significantly: capital letters at $P \leq 0.01$, small letters at $P \leq 0.05$.
Wartości średnie cech oznaczone tymi samymi literami różnią się statystycznie istonie: dużymi przy $P \leq 0{,}01$; małymi przy $P \leq 0{,}05$.

The results presented in Table 3 show that first lactation milk yield depended on the sex of the calf during both the first and second pregnancy. The highest yield occurred in primiparous cows that gave birth to a heifer calf and carried a female fetus; it was 120 kg milk higher ($P \leq 0.01$) than the yield of their contemporaries that had bulls in their first and second calvings. A greater difference (180 kg milk) between H_1H_2 and B_1B_2 dams was reported by Hinde et al. [2014]. Similar to the study by Hinde et al. [2014], we found that female pregnancy partly "saved" first lactation yield of the cows that gave birth to bulls (B_1H_2), but their milk yield was lower than that obtained by heifer dams (H_1H_2). Fetal sex in the second pregnancy had no effect on the yield of cows that had a bull in their first pregnancy (B_1H_2, B_1B_2). Hinde et al. [2014] stress that first pregnancy with a female heifer increases milk production in two lactations and protects against the "negative" effects of the second pregnancy with a male fetus. Giving birth to a bull at first

calving depresses milk production during the first two lactations, but the second pregnancy with a female fetus partly improves the yield of milk.

CONCLUSIONS

The present study demonstrated that giving birth to a heifer calf had a positive effect on the milk and reproductive performance of Polish Holstein-Friesian cows. The advantage in milk performance of the cows which gave birth to female calves at first calving may be of importance in modern dairy herds, considering the increasing availability of sexed semen. Significant but small (around 1%) differences in the sex ratio of calves born within factors such as cow's age or production level in the previous lactation do not allow taking these factors into consideration when controlling the sex of the calves born.

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WPŁYW WYBRANYCH CZYNNIKÓW NA PŁEĆ URODZONEGO CIELĘCIA I PŁCI CIELĘCIA NA UŻYTKOWOŚĆ KRÓW MLECZNYCH

Streszczenie. Z bazy danych SYMLEK zebrano informacje o 384 965 porodach oraz użytkowości mlecznej i rozpłodowej w następujących po nich cyklach produkcyjnych 114 526 krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej, należących do populacji aktywnej na Pomorzu i Kujawach, które wycieliły się po raz pierwszy w latach 2000–2012 i były użytkowane lub wybrakowane do końca 2013 roku. W obliczeniach statystycznych wykorzystano procedury (GLM, FREQ) z pakietu SAS. Stwierdzono wpływ płci cielęcia na użytkowość mleczną i rozpłodową krów mlecznej rasy phf, bardziej korzystny po urodzeniu cieliczki. Wykazana przewaga wydajności mlecznej krów, które przy pierwszym wycieleniu urodziły cieliczki może mieć znaczenie w nowoczesnych stadach mlecznych, wobec coraz szerszej dostępności nasienia seksowanego. Potwierdzone statystycznie, ale niewielkie (około 1%) zróżnicowanie stosunku płci urodzonych cieląt w obrębie takich czynników jak wiek krowy, czy poziom wydajności w poprzedniej laktacji, nie upoważniają do wskazania tych czynników, jako proponowanych do uwzględnienia, w sterowaniu wyborem płci rodzących się cieląt.

Słowa kluczowe: krowy mleczne, płeć urodzonego cielęcia, użytkowość

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