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Fertility indices of cows in a high-yielding herd

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The aim of the study was to analyse the effect of non-genetic factors on fertility indices in high-yielding Black-and-White Polish Holstein-Friesian cows. The analysis covered 2414 reproductive periods in 1063 cows born in the years 1999-2008. Fertility indices of the cows were evaluated. The age of heifers at first calving was found to decrease in successive years in the population analysed. A shorter rearing period for heifers was not found to negatively affect fertility indices during their later productive life. A significant decrease in reproductive efficiency was observed in the case of yield exceeding 3600 kg over 100 days of lactation in primiparous cows. However, milk yield in the previous standard lactation had the strongest influence on fertility indices. Where milk yield exceeded 9000 kg, each increase of 2000 kg had a significant (P≤0.01) negative effect on all the fertility indices evaluated in the study.

KEY WORDS: cows / high yield / fertility indices

In 2011 an increase was once again noted in the milk yield of cows undergoing production value assessment in Poland. Compared with 2010, milk yield increased by 155 kg (from 6980 to 7135 kg), while the number of cows included in the active population increased by 2% [18]. The growing production potential of dairy cows can negatively affect reproductive indices. Reproduction maintained at a proper level affects genetic improvement, milk yield, and the profitability of milk production [12]. Increasing reproductive problems particularly affect cows with high yield, which often exceeds 10 000 kg per lactation [2]. Culling due to sterility and reproductive disorders is becoming the main reason for the elimination of cows from the herd. Reproductive disorders are the second most serious health problem in dairy cattle breeding, after mastitis, which means that a substantial percentage of cows is eliminated from the herd before achieving their full production potential [9, 12].

Fertility indices in high-yielding cows are influenced by a number of factors, mainly non-genetic ones (feeding, care, and rearing of heifers, production level, proper herd organization and management) [1, 2, 3, 6, 9, 12, 15, 16, 17]. One factor reducing reproductive efficiency is ineffective oestrus detection [1, 6]. This element has the greatest effect on the probability of another pregnancy. A tendency to mate cows too early after calving in order to improve some fertility factors has been observed in many herds. This should be considered an improper course of action, as it takes place at the cost of the rest period [10, 11]. Reproductive efficiency is affected to a lesser degree by genetic factors [8, 16]. Kruk et al. [13] report that fertility disorders are only about 10% of those genetically conditioned.

The aim of the study was to analyse the effect of non-genetic factors on fertility indices in high-yielding Black-and-White Polish Holstein-Friesian cows.

Material and methods

The study analysed the results of production value assessments taken on a farm on which 454 Black-and-White Polish Holstein-Friesian cows, with average yield of 11 037 kg, were kept in 2011. The cows were kept in free-stall housing all year, fed on total mixed rations (TMR), and milked in a herringbone milking parlour. The analysis included 2414 reproductive periods in 1063 cows born in the years 1999-2008. The birth dates of each cow, the dates of their calvings and dry periods, the dates of first services after calving and successful services, and the number of services per conception were obtained from breeding documentation for the period from 1999 to mid-2011. Based on the mentioned information, the following fertility indices were calculated: age at first calving (AFC); length of the calving interval (CI), calving-to-conception interval (CCI), calving-to-first-service interval (CFSI), and service period (SP); and services per conception (SC). Data were also collected on the productivity (kg milk) of primiparous cows in the first trimester after calving and of all cows during standard lactation.

Two-way and multifactor analysis of variance was used for the statistical analysis, which was performed using the software SAS. Two-way ANOVA was employed to evaluate the effect of year of birth (1999-2001; 2001-2004; >2004) and season of birth (spring – March-May, summer – June-August, autumn – September-November, winter – December-February) on the age of the heifers at first calving. The remaining fertility indices were analysed taking into account the following factors:

– year of birth (1999-2001; 2001-2004; >2004);

– age (in days) at first calving (up to 739; 731-793; 794-915; >915);

– calving number (1, 2, 3, 4+);

– milk yield (kg milk) of primiparous cows during the first 100 days of lactation (up to 3000; 3001-3600; >3600);

– milk yield (kg milk) in the previous standard lactation (up to 9000; 9001-11000; >11000).

The frequency of occurrence of different values for age at the first calving and length of service period were also calculated for the factors taken into account in the statistical analysis.

The significance of the effect of the factors on the traits analysed was estimated using Duncan's test and the χ^2 test.

Results and discussion

Age at the first calving, together with the length of the intercalving interval, is the most frequently used indicator for evaluating the reproductive performance of cows. In the active cow population in Poland over the last 10 years it has ranged from 817 to 839 days [18]. The cows in the study calved for the first time at the age of 805 days (26.4 months) on average, within a range of 1.5 to about 3 years (Tab. 1). A clear majority of the cows calved at the age of 2-2.5 years; calvings within the range of 731-915 days constituted 84.1% of the total. Earlier or later calvings occurred much less frequently (8.2% and 7.7%, respectively). In successive periods, specified as ranges of years of birth, the age at which heifers calved for the first time decreased significantly ($P \leq 0.01$ and $P \leq 0.05$). Heifers born in 1999-2001 calved on average at the age of 835 days, while the averages calculated for the remaining groups were 33 and 43 days lower. Also observed in these successive periods was an increase in the percentage of primiparous cows that calved up to the age of 730 days (by 2.6% and 4.4%) and from 731 to 793 days (by 12.1% and 1.4%), accompanied by a decrease in the percentage of cows that calved after the age of 794-915 days (by 5.7% and 3.5%) and later (by 9.2%). The value for the χ^2 test indicates a clear relationship between period of birth and age at first calving. The results presented indicate a downward trend for age at first calving.

Analysis of the effect of the season of birth on age at the first calving revealed slight fluctuations in average values. Heifers born in autumn calved earliest, while those born in winter calved latest. The difference between these groups was 14 days ($P \leq 0.05$). The χ^2 test indicated an association ($P \leq 0.01$) between season of birth and age at first calving. Cows that calved within the range of 731-793 days were most often born in spring or autumn (45.4% and 46.5% of the total). The highest percentage of cows that calved at a later age (794-915 days) was recorded in animals born in the summer (44.2%) and winter (45.8%). The earliest calvings occurred most frequently (13.1%) in the case of summer births, and least often (4.7%) in cows born in winter. No clear relationship was recorded between season of birth and the frequency of later calvings (over 915 days).

Table 2 presents values of indices for evaluating fertility in dairy herds. The most important of these parameters is considered to be calving interval (CI). Its length has a deciding influence on the length of lactation, as well as other periods of the reproductive cycle [19]. CI is considered normal if it is within a range of 360-400 or 340-380 days. It has been demonstrated [8] that prolonging the calving interval reduces lifetime milk yield and the number of calves obtained. If the interval is shortened, insemination following calving is less likely to be successful, and milk production decreases in the current and subsequent lactations. The average length of the calving interval in the population studied was 427 days. This trait was significantly ($P \leq 0.01$ and $P \leq 0.05$) influenced by all factors taken into account in the analysis. The length of the calving interval increased with that of the rearing period, but only up to 915 days. Heifers that calved latest (>915 days) had the most favourable values for CI, calving-to-conception interval (CCI), and services per conception (SC). The highest values for different periods of the reproductive cycle were noted in the group of cows whose first calving was at the age of 794-915 days. The differences between groups for these traits were significant at $P \leq 0.01$ and $P \leq 0.05$. This factor was not found to significantly influence services per conception (SC), which ranged from 2.6 to 2.8 and considerably exceeded the values considered to be satisfactory (1.6-1.8) [5].

Analysis of the effect of successive calvings showed a general upward tendency for length of CI, CCI and calving-to-first-service interval (CFSI), as well as an increase in

Table 1 – Tabela 1

Age at the first calving (days) of heifers born in different years and seasons

Wiek przy pierwszym wycieleniu (dni) jałowic urodzonych w różnych latach i sezonach

Factor Czynnik	Number of cows Liczba krów	Age at first calving Wiek I wycielenia $\overline{x}$ (Sd)	Number (%) of heifers calved at different ages Liczba (%) jałowic cielących się w wieku				Value for χ^2 test Wartość testu χ^2
			≤730	731-793	794-915	>915	
Year of birth: Lata urodzenia:							
1999-2001	258	835^{A} (79)	11 (4.3)	79 (30.6)	124 (48.1)	44 (17.0)	64.8*
2002-2004	347	802^{Ba} (68)	24 (6.9)	155 (44.7)	147 (42.4)	21 (6.0)	
>2004	458	792^{Bb} (63)	52 (11.3)	211 (46.1)	178 (38.9)	17 (3.7)	
Birth season: Sezon urodzenia:							
spring – wiosenny	249	803 (71)	20 (8.0)	113 (45.4)	97 (39.0)	19 (7.6)	21.9*
summer – letni	251	806 (77)	33 (13.1)	84 (33.5)	111 (44.2)	23 (9.2)	
autumn – jesienny	288	799^{a} (63)	21 (7.3)	134 (46.5)	115 (39.9)	18 (6.3)	
winter – zimowy	275	813^{b} (71)	13 (4.7)	114 (41.5)	126 (45.8)	22 (8.0)	
Total and average Ogółem i średnio	1063	805 (71)	87 (8.2)	445 (41.9)	449 (42.2)	82 (7.7)	–

Averages designated with different letters differ significantly: capital letters – at $P\leq0.01$; lower case letters – at $P\leq0.05$

Średnie oznaczone różnymi literami różnią się istotnie: wielkie litery – przy $P\leq0,01$; małe litery – przy $P\leq0,05$

*Value for the χ^2 test significant at $P\leq0.01$ – Wartość testu χ^2 istotna przy $P\leq0,01$

Table 2 – Tabela 2

Fertility indices taking into account the effect of the factors analysed

Wielkość wskaźników płodności krów w obrębie analizowanych czynników

Factors Czynniki	Length of periods (days) Długość okresów (dni) $\overline{x}$ (Sd)			SC IU $\overline{x}$ (Sd)
	CI OMW	CCI OMC	CFSI PP	
Age at first calving (days): Wiek przy I wycieleniu (dni):				
≤730	421 (78)	161^{a} (84)	80^{Aa} (26)	2.8 (1.9)
731-793	424^{a} (82)	166^{A} (93)	87^{b} (34)	2.8 (1.9)
794-915	433^{b} (84)	178^{Bb} (96)	90^{Ba} (36)	2.8 (1.8)
>915	415^{a} (76)	155^{A} (86)	83^{A} (30)	2.6 (1.7)
Calving number: Kolejne wycielenie:				
1	420^{a} (82)	162^{Aa} (97)	85^{Aa} (36)	2.6^{A} (1.8)
2	432^{b} (84)	173^{b} (91)	88^{b} (36)	2.9^{B} (1.9)
3	431 (80)	176^{b} (92)	90^{B} (32)	2.7 (1.8)
>3	436^{b} (82)	181^{B} (87)	90^{B} (29)	3.0^{B} (1.9)
Milk yield (kg) in 100 days of first lactation: Wydajność mleka (kg) za 100 dni I laktacji:				
≤3000	419^{A} (75)	159^{A} (86)	83^{A} (32)	2.6^{a} (1.7)
3001-3600	424^{A} (80)	168^{A} (92)	86^{A} (32)	2.8 (1.9)
>3600	446^{B} (95)	188^{B} (101)	97^{B} (41)	2.9^{b} (1.9)
Milk yield (kg) in 305 days of previous lactation: Wydajność mleka (kg) za 305 dni poprzedniej laktacji:				
≤9000	402^{A} (69)	139^{A} (79)	79^{A} (32)	2.4^{A} (1.6)
9001-11000	421^{B} (78)	163^{B} (88)	85^{B} (33)	2.6^{B} (1.7)
>11000	453^{C} (78)	200^{C} (99)	96^{C} (36)	3.2^{C} (2.0)
Average – Średnio	427 (82)	170 (93)	88 (34)	2.8 (1.8)

Averages within a factor designated with different letters differ significantly: capital letters – at P≤0.01; lower case letters – at P≤0.05

Średnie w obrębie czynnika oznaczone różnymi literami różnią się istotnie: wielkie litery – przy P0,01; małe litery – przy P≤0,05

CI – intercalving period – OMW – okres międzywycieleniowy

CCI – calving-to-conception interval – OMC – okres międzyciążowy

CFSI – calving-to-first-service interval – PP – przestój poiążowy

SC – services per conception – IU – indeks unasienień

services per conception (SC). The most favourable values were noted in primiparous cows (420, 162 and 85 days and 2.6 services per conception). However, the 420-day period between calvings in primiparous cows was longer than the recommended length. Prolongation of CI is beneficial in primiparous cows, which are characterized by more persistent lactation. It enables them to more quickly attain full maturity and proper body condition before the next conception [14]. CI calculated after each calving increased by 11-16 days, CCI by 11-19 days, CFSI by 3-5 days, and SC by 0.4 services. Some of the differences between groups were significant (P≤0.01 and P≤0.05). Other studies suggest that fertility indices become less favourable in successive lactations [20, 21].

Fertility indices for the cows depended most strongly on milk yield, particularly that of the previous standard lactation. Evaluation of the effect of milk yield in primiparous cows over 100 days of lactation showed that yield higher than 3600 kg significantly (P≤0.01) prolonged CI, CCI and CFSI, which increased by 22-27, 20-29, and 11-14 days, respectively. The effect of milk yield in primiparous cows during 100 days of lactation on CFSI was smaller, as only the 0.3 difference noted between extreme yields (up to 3000 and >3600 kg of milk) was statistically significant (P≤0.05). Analysis of the effect of milk production in standard lactations showed that each 2000 kg increase in yield significantly (P≤0.01) decreased reproductive efficiency. CI increased from 402 to 421 and from 421 to 453 days, CCI from 130 to 200 days, and CFSI from 79 to 96 days. According to Sawa et al. [21], the calving-to-first-service interval should last from 40 to 70 days.

The average length of the calving-to-first-service interval in the present study was 88 days. In high-yielding cows the rest period comes at a time of high production, so that determining the optimal time for the first insemination after calving is of particular importance [20]. According to Sawa et al. [21], cows with yield of over 10 000 kg during lactation require at least a 100-120-day rest period. The results of the present study show that in cows with yield exceeding 9000 kg of milk in standard lactation, this rest period was too short – 85 and 96 days.

The high number of services per conception (2.4-3.2), particularly in the case of the highest milk yield, could be the consequence of an excessive metabolic burden on the organism of high-yielding cows. It has been demonstrated [4] that a high service-per-conception rate can result when the reproductive tract is inadequately prepared for implantation of an embryo, despite external signs of oestrus. Poor fertility indices can also be caused by a negative energy balance occurring in dairy cows during the early lactation period [20].

The service period, along with the calving-to-first-service interval, is part of the calving--to-conception interval. This period, during which the success of the services is evaluated, should be as short as possible [5]. The data presented in Table 3 show that pregnancy was noted after the first service in only 31.4% of cases. In 734 cases (30.4%) it lasted up to 90 days, but most often (38.2%) longer service periods were noted (>90 days). The frequency of occurrence of different values for this trait was not significantly influenced by age at first calving or milk yield in primiparous cows over 100 days of lactation. The values for the χ^2 test for these factors were statistically insignificant. However, analysis of the effect of milk yield in primiparous cows during 100 days of lactation showed a slight (3.2%) decrease in the percentage of cases with a service period within the range of 61-90 days, and an increase (8.3%) in the percentage of the longest SP range (>90 days). Following successive calvings, the percentage of cases in which conception occurred after the first service decreased by a total of 7.1%, while the frequency of SP exceeding 90 days increased by 10.6%. The significant effect (P≤0.01) of calving number on the frequency of different values for the service period was confirmed by the χ^2 test.

It has been shown [7] that the period between the first service and successful service is longer in cows with higher milk production. This was confirmed by the present study, which found that increasing milk yield was accompanied by a decrease in the percentage of cases in which the cows conceived after the first service (38.7%, 32.6%, and 25.0%). The frequency

Table 3 – Tabela 3

Frequency of different values of service period taking into account the effect of the factors analysed

Frekwencja różnych wartości dla okresu usługi w obrębie analizowanych czynników

Factor Czynnik	n	Number (%) of service periods of different lengths (days) Liczba (%) okresów usługi o różnej długości (dni)					Value for χ^2 test Wartość testu χ^2
		none brak	1-24	25-60	61-90	>90	
Age at first calving (days): Wiek przy I wycieleniu (dni):							
≤ 730	183	57 (31.2)	16 (8.7)	12 (6.6)	24 (13.1)	74 (40.4)	18.1
731-793	962	305 (31.7)	84 (8.7)	109 (11.3)	110 (11.5)	354 (36.8)	
794-915	1073	337 (31.4)	70 (6.5)	116 (10.8)	118 (11.0)	432 (40.3)	
>915	196	58 (29.6)	24 (12.3)	28 (14.3)	23 (11.7)	63 (32.1)	
Calving number: Kolejne wycielenie:							
1	954	329 (34.5)	86 (9.0)	109 (11.4)	106 (11.1)	324 (34.0)	24.7*
2	681	201 (29.5)	55 (8.1)	71 (10.4)	82 (12.0)	272 (40.0)	
3	407	125 (30.7)	26 (6.4)	39 (9.6)	56 (13.7)	161 (39.6)	
>3	372	102 (27.4)	27 (7.3)	46 (12.4)	31 (8.3)	166 (44.6)	
Milk yield (kg) in 100 days of first lactation: Wydajność mleka (kg) za 100 dni I laktacji:							
≤3000	627	193 (30.8)	62 (9.9)	71 (11.3)	77 (12.3)	224 (35.7)	14.4
3001-3600	1260	406 (32.2)	96 (7.6)	141 (11.2)	150 (11.9)	467 (37.1)	
>3600	527	158 (30.0)	36 (6.8)	53 (10.1)	48 (9.1)	232 (44.0)	
Milk yield (kg) in 305 days of previous lactation: Wydajność mleka (kg) za 305 dni poprzedniej laktacji:							
≤9000	602	233 (38.7)	63 (10.5)	69 (11.5)	75 (124)	162 (26.9)	89.4**
9001-11000	933	304 (32.6)	87 (9.3)	102 (10.9)	110 (11.8)	330 (35.4)	
>11000	879	220 (25.0)	44 (5.0)	94 (10.7)	90 (10.3)	431 (49.0)	
Total and average – Ogółem i średnio	2414	757 (31.4)	194 (8.0)	265 (11.0)	275 (11.4)	923 (38.2)	–

Value for the χ^2 test significant at $*P \leq 0.05$; $**P \leq 0.01$ – Wartość testu χ^2 istotna: $*$przy $P \leq 0{,}05$; $**$przy $P \leq 0{,}01$

of service periods lasting up to 90 days also decreased, while that of the longest SP range (>90 days) increased. Increasing milk yield in standard lactation was accompanied by an increase in the percentage of the longest service periods; these percentages were 26.9%, 35.4%, and 49.0%. The significant (P≤0.01) effect of this factor was confirmed by the χ^2 test.

The results of the study indicate that shortening the period for rearing heifers in high--yielding herds had no negative effect on fertility parameters in cows during their subsequent productive life. Reproductive efficiency was observed to be significantly lower in the case of primiparous cows with milk yield exceeding 3600 kg over 100 days of lactation. However, fertility indices in cows were most strongly differentiated by milk yield in the previous standard lactation. When milk yield exceeded 9000 kg, each increase of 2000 kg had a significant (P≤0.01) negative effect on all the fertility indices evaluated in the study.

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Kształtowanie się wskaźników płodności w stadzie krów wysokowydajnych

Streszczenie

Celem pracy była analiza wpływu czynników pozagenetycznych na kształtowanie się wskaźników rozrodu wysokowydajnych krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej. Analizą objęto 2414 okresów reprodukcyjnych 1063 krów urodzonych w latach 1999-2008. Oceniano wskaźniki płodności tych zwierząt. Wykazano, że w objętej analizą populacji krów w kolejnych latach obniżał się wiek zwierząt przy pierwszym wycieleniu. Stwierdzono, że skracanie okresu odchowu jałowic nie wpływało negatywnie na kształtowanie się wskaźników płodności krów w trakcie ich późniejszego użytkowania. Istotne pogorszenie się sprawności rozrodu krów obserwowano w przypadku wydajności pierwiastek powyżej 3600 kg mleka za 100 dni laktacji. Na kształtowanie się wskaźników płodności krów w największym stopniu wpływała jednak wydajność mleka w poprzedniej laktacji standardowej. Przy wydajności mleka powyżej 9 tys. kg każde jej zwiększenie o 2 tys. kg istotnie ($P \leq 0{,}01$) pogarszało wszystkie oceniane w pracy wskaźniki płodności krów.

SŁOWA KLUCZOWE: krowy / wysoka wydajność / wskaźniki płodności