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ASSESSMENT OF BREEDING AND MILKING PERFORMANCE OF POLISH HOLSTEIN-FRIESIAN BLACK-AND-WHITE COWS (HO) AND CROSSES WITH THE NORWEGIAN RED BREED (HO × NR)

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Abstract. The aim of this study was to compare breeding performance traits (in heifers) and milking performance (primiparous cows) of the Polish Holstein-Friesian Black-and-White breed (HO) with those of the Polish Holstein-Friesian Black-and-White × Norwegian Red (HO × NR) F1 crosses kept under uniform environmental conditions. More advantageous breeding parameters and higher daily milk yields as well as lower daily contents of fat, protein, casein and dry matter and lower somatic cell counts in milk were recorded for F1 crosses (HO × NR) compared to purebred HO cows. In view of milk yield per lactation, greater contents of milk, fat and protein as well as lower concentrations of fat and dry matter in milk during the first 100 days in milk were found for crossbred primiparous cows. In turn, in the standard 305-day lactation milk coming from HO cows contained higher levels of protein and dry matter. In order to confirm the results obtained in this study it is advisable to conduct further investigations on a larger population of cows of both genotypes, including assessment of their functional and production traits over their productive lives.

Key words: cattle, Polish Holstein-Friesian Black-and-White cows, crossbred, Polish Holstein-Friesian Black-and-White × Norwegian Red cows, reproduction, milk yield.

INTRODUCTION

In view of the considerable competition on the market dairy cattle breeders and raw milk producers are searching for various solutions to reduce production costs. One of these methods is to ensure continuous improvement of functional traits in high-yielding purebred dairy cattle. An alternative is provided by interbreed crossing. An advantage of such a solution results from the so-called heterosis effect, which may be used in commercial herds.

Holstein-Friesian cows are classified as high-yielding cattle. However, in the case of this breed high productivity is often observed together with typical disorders, such as reproduction problems, *mastitis*, metabolic disease, mineral metabolism disorders and lameness. This results in the relatively short productive life in this breed (on average 3 lactations).

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The primary aim in crossing of Holstein-Friesian cows with bulls of other dairy breeds or crossbred bulls is to improve performance traits (Puppel et al. 2018). One of the potential variants, making it possible to obtain valuable crosses (in terms of functional traits), may be connected with crossing Polish Holstein-Friesian Black-and-White cows (HO) with Norwegian Red bulls (NR). Analyses conducted by many researchers showed that Norwegian Red cows compared to Holstein-Friesian cows were characterised e.g. by higher fecundity, lower susceptibility to mastitis, easier calving, lower number of stillborn calves and their higher survival rates as well as lesser problems with hooves. In the opinion of Diaz-Lundahl et al. (2021) the Norwegian Red breeding program has emphasized fertility and health for decades. As a rule, milking performance in Norwegian Red cows differs only slightly from that of Holstein-Friesian cows. In the opinion of Holtsmark et al. (2008) the genetic value of Norwegian Red cattle is most probably the result of simultaneous selection conducted over several recent decades and aiming at milk yield, good health and fecundity.

The aim of this study was to compare breeding performance (in heifers) and milking performance (in primiparous cows) of Polish Holstein-Friesian Black-and-White cows (HO) with those of F1 crosses of Polish Holstein-Friesian Black-and-White × Norwegian Red (HO × NR) kept in a large commercial farm.

MATERIAL AND METHODS

Source data for this study were collected for the period of 2016–2018 from a cow herd kept in a large commercial farm. Animals covered by the analyses were heifers and primiparous cows of the Polish Holstein-Friesian Black-and-White breed (46 head) and Polish Holstein-Friesian Black-and-White × Norwegian Red hybrids with the 50% share of each breed in their genotype (21 head). Experimental cows were kept under identical housing conditions, at identical milking and feeding regimes. The feed ration was balanced.

Conducted analyses consisted in a comparison of breeding and milking performance traits of both genetic groups of cows. For each experimental cow data were collected from the performance documentation within the milk recording system using the A4 method and executed by the Polish Federation of Cattle Breeders and Dairy Farmers (PFHBMiPM). Breeding performance traits included body weight of calf at birth, age at first insemination, breeding window, the number of semen portions per successful insemination (insemination index), length of pregnancy and age at first calving. Milk yields of primiparous cows were assessed based on the daily milking performance covering milk yield, contents of fat, protein, casein, lactose, dry matter as well as urea concentration and actual and logarithmic somatic cell counts in milk. Traits of daily milking performance in Polish Holstein-Friesian Black-and-White cows (HO) and crosses of this breed with Norwegian Red cattle (HO × NR) were evaluated in cows with healthy mammary glands diagnosed based on the somatic cell count (SCC) in milk. The health status of the mammary gland was defined as diseased when SCC was ≥300 000/ml. The lactation performance was assessed based on milking performance traits of cows in 100-day and 305-day lactations. The actual somatic cell count in milk was transformed into a natural logarithm according to Ali and Shook (1980).

Collected source data were subjected to statistical analysis using the SAS® software (2017).

The effect of experimental factors included in this study, i.e. the year, season, age at first calving and stage of lactation, was estimated using multivariate analysis of covariance according to the following linear model (the GLM – SAS procedures).

For reproduction traits:

$$y_{ijklmn} = \mu + r_i + s_j + c_k + b_l + \beta_1 w_m + e_{ijklmn}$$

where:

y_{ijklmn} – phenotypic value of a trait;

μ – population mean;
r_i – fixed effect of year of calving (i = 1, 2);
s_j – fixed effect of season of calving (j = 1, 2, 3, 4);
c_k – fixed effect of group of calving (k = 1, 2)
b_l – fixed effect of genotype (l = 1, 2);
β_1 – partial coefficient of first order linear regression;
w_m – age at first calving of the cow;
e_{ijklmn} – random residual effect (random error).

For milking performance traits:

$$y_{ijklm} = \mu + s_i + b_j + \beta_1 w_k + \beta_2 d_l + e_{ijklm}$$

where:
y_{ijklm} – phenotypic value of a trait;
μ – population mean;
s_i – fixed effect of season (i = 1, 2, 3, 4);
b_j – fixed effect of genotype (j = 1, 2);
β_1, β_2 – partial coefficients of first order linear regression;
w_k – age at first calving of the cow;
d_l – day in milk in lactation;
e_{ijklm} – random residual effect (random error).

Statistically non-significant effects were eliminated from the linear model. Individual variables were characterised using the MEANS procedure. Detailed comparisons of object means were made using Tukey's Student t-Test.

RESULTS

Analyses of the results concerning selected breeding performance parameters in Polish Holstein-Friesian Black-and-White heifers and crosses of that breed with the Norwegian Red cattle (Table 1) showed significantly (P ≤ 0.01) younger age at first insemination and first calving and a shorter breeding window, as well as lower values of the insemination index (P ≤ 0.05) in the group of crossbred cows (HO × NR) in relation to Polish Holstein-Friesian Black-and-White cows (Table 1).

Table 1. Reproductive parameters in Polish Holstein-Friesian Black-and-White heifers (HO) and crosses with the Norwegian Red breed (HF × NR)

Traits	Genotype					
	HO			HO × NR		
	N	$\bar{x}$	SD	N	$\bar{x}$	SD
Calf weight (kg)	46	43.7	3.4	21	44,1	3.5
Age at first fertilization (days)	46	425^{A}	43	21	416^{B}	33
Age at first fertilization (month)	46	13.9^{A}	1.4	21	13.7^{B}	1.1
Age at first calving (days)	46	723^{A}	79	21	703^{B}	52
Age at first calving (month)	46	23.7^{A}	2.6	21	23.0^{B}	1.7
Period of insemination service (days)	46	65^{A}	96	21	25^{B}	46
Insemination index	46	3.0^{a}	3.0	21	2.1^{b}	1.3
Pregnancy (days)	46	276	7	21	277	6

Means denoted with different letters (in rows) differ statistically: A, B – highly significantly (P ≤ 0.01); a, b – significantly (P ≤ 0.05).

Table 2. Daily milking performance in Polish Holstein-Friesian Black-and-White primiparous cows (HF) and crosses with the Norwegian Red breed (HF × NR)

Traits	Significance of effect genotype	Genotype					
		HO			HO × NR		
		N	$\bar{x}$	SD	N	$\bar{x}$	SD
Milk (kg)	*	468	20.5^{A}	6.3	183	24.5^{B}	6.2
Fat (%)	*	468	4.92^{A}	0.92	183	4.63^{B}	0.75
Protein (%)	*	468	3.65^{A}	0.45	183	3.36^{B}	0.40
Casein (%)	*	468	2.88^{A}	0.37	183	2.66^{B}	0.33
Lactose (%)	NS	468	4.80	0.20	183	4.89	0.13
Dry mass (%)	*	468	14.15^{A}	1.17	183	13.64^{B}	0.98
Urea (mg/l)	NS	468	169	56	183	173	61
SCC (thous./ml)	*	468	841^{A}	1723	183	404^{B}	1089
LNSCC (in 1 ml)	*	468	12.41^{A}	1.52	183	11.67^{B}	1.31
Fat/Protein	NS	468	1.36	0.24	183	1.39	0.21

Effect: * – significant ($P \leq 0.05$); NS – non-significant ($P > 0.05$).
Means denoted with different letters (in rows) differ statistically: A, B – highly significantly ($P \leq 0.01$); a, b – significantly ($P \leq 0.05$).

Table 3. Milking performance of Polish Holstein-Friesian Black-and-White primiparous cows (HF) and crosses with the Norwegian Red breed (HF × NR) in a 100-day lactation and 305-day complete lactation

Traits	Genotype			
	HO N = 46		HO × NR N = 21	
	$\bar{x}$	SD	$\bar{x}$	SD
100-days lactation				
Milk (kg)	2727.4^{A}	334.1	3007.4^{B}	302.1
Fat (kg)	131.8^{A}	25.1	132.8^{B}	18.3
Fat (%)	4.81^{A}	0.57	4.43^{B}	0.50
Protein (kg)	84.1^{A}	13.9	92.8^{B}	9.6
Protein (%)	3.07	0.25	3.09	0.18
Dry mass (kg)	354.5	101.7	396.6	39.6
Dry mass (%)	13.61^{A}	0.58	13.20^{B}	0.53
305-days lactation				
Milk days	301	10	299	12
Milk (kg)	6939.6	638.3	7226.7	572.3
Fat (kg)	335.4	60.1	324.8	45.4
Fat (%)	4.81	0.61	4.50	0.58
Protein (kg)	240.4	31.8	234.7	19.2
Protein (%)	3.50^{A}	0.35	3.25^{B}	0.18
Dry mass (kg)	967.9	148.9	969.1	82.2
Dry mass (%)	14.00^{A}	0.70	13.42^{B}	0.67

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

Table 2 compared daily milking performance traits of primiparous cows of both genotypes. Statistical analysis showed that crossbred animals (HO × NR) were characterised by significantly ($P \leq 0.05$) higher milk yields and lower SCC and lower LNSCC in milk. In the case of the contents of basic milk components, i.e. fat, protein, casein and dry matter, significantly ($P \leq 0.05$) higher values for the above-mentioned daily milking performance parameters were recorded for purebred primiparous cows (HO) compared to crossbred cows (HO × NR). In turn, the investigated cow genotypes did not differ in terms of the concentration of lactose and urea and the fat do protein ratio in milk.

When comparing milking performance in lactation for both genotypes of primiparous cows (Table 3) a greater number of statistically significant differences ($P \leq 0.01$) were found between means in the 100-day lactation in relation to the standard 305-day lactation. In a 100-day lactation crossbred primiparous cows (HO × NR) in relation to purebred cows (HO) were characterised by greater yields of milk, fat and protein and lower contents of fat and dry matter in milk. In the case of standard 305-day lactation more advantageous results for selected milking performance traits were recorded for purebred primiparous cows (HO). Animals from this group produced higher levels of protein and dry matter in milk in relation to crossbred animals (HO × NR).

DISCUSSION

This study showed more advantageous values of the analysed breeding parameters in the group of crossbred heifers (HO × NR) in relation to purebred animals (HO). Reproduction is a crucial functional trait in dairy cattle, since it directly affects efficiency of raw milk production. Moreover, the most frequent cause for culling in dairy cows is related to sterility and reproduction system disorders. Problems with reproduction in dairy cows are frequently associated with metabolic diseases, which mostly result from the use of feed rations insufficiently balanced in relation to the nutritional needs of animals. A key functional trait in cattle is associated with easy delivery and frequency of stillbirths. Ferris et al. (2014) showed that Norwegian Red cows (NR) compared to Holstein-Friesian cows had fewer problems during the first and second calvings, while the frequency of stillbirths at first calving was 4% and 13%, respectively. Similarly, Refsdal (2007) indicated that most reproduction indexes in NR cows have advantageous values with a consistent trend for improvement. In turn, Buckley et al. (2014) stated an advantage of fecundity traits in crossbred NR × HF cows in relation to purebred HF cows. Similar results were obtained in this study. Results indicating the advantage of HO × NR hybrids compared to purebred HO cows in terms of reproduction indexes may result from the varied duration of estrus and the intensity of presentation of its external symptoms. In the opinion of Storli et al. (2017), at present NR heifers may optimise milk production in the first lactation, since they tend to calve at a younger age. Results of this study indicate a significantly younger age at first calving for HO × NR crosses in relation to purebred HO animals. Rinell and Heringstad (2018) stated that crosses (HO × NR) compared to HO cows were characterised by a shorter anestrus and lesser susceptibility to postpartum disorders. Sveberg et al. (2015) showed that NR cows in relation to HO cows were characterised by a longer estrus and its symptoms were manifested more strongly. Begley et al. (2009) suggest that improvements to udder health may result from crossbreeding with the NR. In the opinion of McClearn et al. (2020) raw milk production systems using pastures require fertile and healthy cows, which genotype is predisposed to produce large amounts of milk solids (fat and protein) rather than milk yield. Thanks to the fecundity traits and productivity the genotype of HO × NR hybrids may meet these requirements and may be used in highly profitable pasture-based milk production. However, in the case of milking performance in a 305-day lactation results of this study confirm those recorded by Ezra et al. (2016), which in-

dicate higher milking performance in a 305-day lactation in purebred HO cows when compared to crosses of this breed (HO × NR).

Summing up, it needs to be stated that more advantageous breeding parameters and higher daily milk yield as well as lower daily contents of fat, protein, casein and dry matter and lower somatic cell count in milk were found for F1 hybrids (HO × NR) compared to purebred HO cows. In terms of milking yield in lactation, crossbred primiparous cows showed higher yields of milk, fat and protein as well as lower concentrations of fat and dry matter in milk for the first 100 days in milk. In contrast, in the standard 305-day lactation milk produced by HO cows contained higher concentrations of protein and dry matter. In order to confirm the results of this analysis it is advisable to conduct further studies on a more numerous population of cows of both genotypes, including assessment of their functional and production traits for the entire lifetime of these animals.

CONCLUSION

The F1 crosses of Polish Holstein-Friesian Black-and-White × Norwegian Red (HO × NR) in relation to purebred Polish Holstein-Friesian Black-and-White cows (HO) kept under environmental conditions were characterised by significantly better reproduction indexes and selected milking performance parameters. Recorded results indicate that F1 crosses (Polish Holstein-Friesian × Norwegian Red) are distinguished by advantageous performance traits in agricultural practice.

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OCENA CECH UŻYTKOWOŚCI ROZRODCZEJ I MLECZNEJ KRÓW RASY POLSKIEJ HOLSZTYŃSKO-FRYZYJSKIEJ ODMIANY CZARNO-BIAŁEJ (HO) I MIESZAŃCÓW Z RASĄ NORWESKĄ CZERWONĄ (HO × NR)

Streszczenie. Celem pracy było porównanie cech użytkowości rozrodczej (jałowic) i mlecznej (pierwiastek) rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej (HO) z mieszańcami F1 – rasa polska holsztyńsko-fryzyjska odmiany czarno-białej × norweska czerwona (HO × NR) utrzymywanymi w jednolitych warunkach środowiskowych. Korzystniejszymi parametrami rozrodu, wyższą dobową wydajnością mleka, niższą dobową zawartością: tłuszczu, białka, kazeiny i suchej masy oraz mniejszą liczbą komórek somatycznych w mleku charakteryzowały się mieszańce F1 (HO × NR) w porównaniu z czysto rasowymi HO. Biorąc pod uwagę laktacyjną użytkowość mleczną, większą wydajność mleka, tłuszczu i białka oraz mniejszą koncentrację tłuszczu i suchej masy w mleku, za pierwsze 100 dni doju wyróżniały się pierwiastki mieszańce. Natomiast w laktacji standardowej 305-dniowej mleko pochodzące od krów HO zawierało wyższą koncentrację białka i suchej masy. W celu potwierdzenia uzyskanych rezultatów analiz własnych wskazane jest przeprowadzenie kolejnych badań na liczniejszej populacji krów obu genotypów z włączeniem oceny cech funkcjonalnych i produkcyjnych z okresu całego życia zwierząt.

Key words: bydło, rasa polska holsztyńsko-fryzyjska odmiany czarno-białej, mieszańce rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej × norweska czerwona, rozród, użytkowość mleczna.