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The differences in production of Holstein Friesian and Holstein Friesian x Norwegian Red F1 crossbreeds

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Abstract

The aim of this study was to compare the production, health and fertility traits of Holstein Friesian (HF) and their F1 crosses with Norwegian Red cows (HF x NRF F1). Only the production data's from finished first lactations of the total 57 HF x NRF F1 crosses and 401 HF cows, and for health and fertility traits of 120 HF x NRF F1 crosses and 255 HF cows, were used. The differences in production traits were tested by a least square means using the GLM procedure in SAS. The milk yield in both lactation (standard 305 days and full lactation) were higher in HF x NRF F1 crosses for approximately 400 kg, but without significance. The differences in production traits (fat and protein (kg and %)) were significant (p<0.001; p<0.05) with higher values for HF x NRF F1 crosses comparing to HF cows, with exception of protein in full lactation. Regarding the fertility traits, HF x NRF F1 crosses had a better conception rate (+1.58 %), a lower number of the insemination per pregnancy (-0.43) and a shorter duration of the service period (-22.2) comparable to HF cows. F1 crosses had better health traits (with except for hoofs problem) comparing to HF cows, they had less cows with mastitis (-11.9 %), ketosis (-0.5 %), retained placenta (-4.8 %) and dislocation of the abomasum (-1.0 %), respectively. Because of the fact that all results were obtained on the basis of data from the first lactation cows, it is necessary to do more analyses of all studied traits in subsequent lactations, in order to get a much clearer insight into the studied issues.

Introduction

After the long-term breeding work in dairy production aimed at achieving high production per cow, the fertility, longevity, and health traits have been reduced (Seegers et al., 2003; Windig et al., 2005; Hare et al., 2006). Consequently, the economic losses are increasing. Weller (1994) pointed out the progeny of the crosses are more profitable than either parental breed. According to Weigel and Barlass (2003) the use of crossbreed cows may be an alternative solution to combine good production and fitness. Dechow et al. (2007) pointed out that the first crossbreed generation tended to exhibit better functional traits and fat production than purebred cows. Further, Weigel (2007) emphasized that crossbreeding had less influence on production traits than on functional traits. According to Dechow et al. (2007) crossbreeding contributes to a substantial increase in the economic performance of dairy production systems, mostly for longevity and functional traits, except for mastitis, and somewhat lower for milk production. Sørensen et al. (2008) emphasized if crossbreeding is used at the expense of genetic gain in the pure breeds, the overall economic benefit over time will be negatively affected. When used properly, heterosis can be a bonus on top of the gain from traditional dairy cattle breeding programs. On contrary, Ezra et al. (2016) stated that crossbreeding is a common strategy for most agricultural animal species, including poultry, swine, sheep and beef cattle but for dairy cattle crossbreeding has generally not been considered as an economically viable option. According to Buckley et al. (2014) the economic improvement using crossbreeding can be achieved by introducing favourable genes from another breed selected more strongly for traits of interest; removing the negative effects associated with inbreeding depression; or by benefits of heterosis effect. Crossbreeding is of particular interest for dairy producers focusing on functional traits, because heterosis effects tend to be greater for these traits. According to many researches, heterosis for various crossbreeds, ranged (in percentage) from 1.7 to 8.4 for fat, and from 1.5 to 8.2 for proteins (Ericson et al., 1988; Touchberry 1992; Van-Raden and Sanders, 2003; Dechow et al., 2007; Sørensen et al., 2008). In dairy cattle production, the Holstein Friesian breed is the leader breed, but according to Pryce et al. (2014) intensive selection for an increased milk yield resulted in unfavourable correlated responses for health and fertility in that breed. On the other hand, the breeding goal of the Norwegian Red focused on fertility and health along with milk production (Miglior et al., 2005). Resulting therefrom, the Norwegian Red cattle and their crossbreeds with Holsteins have better fertility, a lower somatic cell count and a lower incidence of mastitis (Heins et al., 2006; Begley et al., 2009; Cartwright et al., 2011; Heins and Hansen, 2012). The same was confirmed by results of Rinell and Heringstad (2018), which stated that crossbreeding Norwegian Red and Holstein can produce cows with better fertility that are less susceptible to postpartum disorders. Therefore, the aim of this study was to compare the production, health and fertility traits between Holstein Friesian cows and there F1 crosses with Norwegian Red cows (Holstein Friesian x Norwegian Red F1 crossbreeds) after finished first lactations at Croatian conditions.

Material and methods

The research was conducted at commercial dairy farm in company Belje Ltd., in the period from August 2015 to June 2016. The five Norwegian Red bulls (NRF): Dahle, Skei, Skjelvan, Gopollen and Rosnes were used for a one-way insemination of the 1.564 Holstein Friesian (HF) cows, while in the same period 3.493 HF cows were inseminated with Holstein bulls. All cows (HF and F1 crosses) were in the same microclimate condition, fed by the same food and all of them it was managed on the same way. For this research, only the production data from finished first lactations of the total 57 HF x NRF F1 crosses and 401 HF cows, and for health traits total 120 HF x NRF F1 crosses and 255 HF cows, were used. Regarding the calving date, animals were divided into two calving season classes (S - March, April, May, Jun, July, and August; W - September, October, November, December, January, and February).

Statistical analysis

The differences in production traits of Holstein Friesian (HF) and Holstein Friesian x Norwegian Red F1 crossbreeds (HF x NRF) were tested using least square means in GLM procedure in SAS (SAS Institute Inc., 2000). Following statistical model was used:

$$y_{ijkl} = \mu + b_1 a_i + B_j + S_k + e_{ijkl}$$

Where:

/ y_{ijk} = estimated production trait: Milk yield (kg) in standard lactation (M 305); Milk yield (kg) in full lactation (M Lac); Fat yield (kg) in standard lactation (SF); Fat yield (kg) in full lactation (LF); Protein yield (kg) in standard lactation (SP); Protein yield (kg) in full lactation (LP); Percentage value of the fat (%) in standard lactation (SFP); Percentage value of the fat (%) in full lactation (LFP); Percentage value of the protein (%) in standard lactation (SPP) and Percentage value of the protein (%) in full lactation (LPP);

/ μ = intercept;

/ b_1 = regression coefficients;

/ a_i = age at calving as linear regression (i = 630 to 1080 days);

/ B_j = fixed effect of breed class j (j = HF / HF x NRF);

/ S_k = fixed effect of calving season class k (k = S / W);

/ e_{ijk} = residual.

The significance of the differences in production traits between the analysed breeds (HF / HF x NRF) was tested by t-test.

In order to compare HF and HF x NRF crossbreeds regarding the fertility traits, prevalence of health disorders as well as the reasons of culling, the results of a farm manager program analysis were used. Following fertility traits was used: Conception rate (%) (calculated on the basis of the ratio of the number of used seed doses and the number of pregnant cows, presented as percentage); Insemination per pregnancy (n) (number of seed doses used per cow); Days open (days) (number of days from beginning of the lactation until confirm of pregnancy). As health traits the prevalence of mastitis, retained placenta, ketosis, displaced abomasum and lameness were used.

Results and discussion

The Holstein Friesian cows had in average 8278.00 kg M 305, 343.10 kg SF, 274.20 kg of the SP, with 4.17 and 3.33 % of SFP and SPP, respectively (Table 1). The range of the M 305 were between 2720.70 and 14206.90 kg. Furthermore, the F1 crosses (HF x NRF) had higher values of M 305 comparing to the HF cows, with exception of the maximum milk yield. The average milk yield was 8 672.29 kg, while it ranged between 4 980.00 and 14 102.70. The SF and SP were in range from 3.44 % to 5.38 % and from 2.99 % to 4.03 %, and in average were 4.40 and 3.38 %.

When comparing the results from full lactation among the analysed breeds, crossbreeds had also higher values in regards to Holstein Friesian. The average production of the crossbreds was 9358.98 kg for M Lac, 409.02 kg for LF and 315.66 kg for LP, which is higher compared to 9057.94 kg for M Lac, 377.04 kg for LF and 301.90 kg for LP, obtained of the HF cows.

According to the results presented in Table 2., which are referring to standard and full lactation, all study traits were higher for crossbreeds comparing to Holstein Friesian cows. The highest difference (over 400 kg) was found in the milk yield, but it was not statistically significant. A significant (p<0.001) difference among breeds regarding the SF and SFP, and the significance (p<0.05) difference for the SP, were established. Similar results were found in full lactation, approximately 400 kg (371.89; Table 2) higher milk yield for crossbred cows comparing to HF cows, but without significance. The amount of LF and LFP were significantly (p<0.01; p<0.001) higher in crossbreed comparing to Holstein Friesian cows (402.89, 4.46; 367.03, 4.22). Further, the LP was also higher in crossbreeds in comparison to HF (15.56 kg; Table 2), but not significantly. Heins et al. (2006) reported that pure HF had a significantly higher milk and protein production in 305 days than all crossbred groups, but pure Holsteins were not significantly different from Scandinavian Red x Holstein crossbreds for fat production. In the research of Malchiodi et al. (2011) Holstein cows did not differ (p>0.05) from crossbreds for fat percentage and SCS, but they had significantly (p<0.01) higher milk yield and lower protein content. According to results obtained by Heins and Hansen (2012),

TABLE 1. Descriptive statistical analysis of the milk traits in standard (305 days) and full lactation for Holstein Friesian and F1 crossbred (HF x NRF) cows

Traits	HF (n=401)					HF x NRF (n=57)				
	mean	SD	CV	MIN	MAX	mean	SD	CV	MIN	MAX
M 305	8278.00	1750.03	21.14	2720.70	14206.90	8672.29	1826.57	21.06	4980.00	14102.70
M Lac	9057.94	2293.76	25.32	2720.70	16610.90	9358.98	2287.80	24.45	4980.00	16497.10
SF	343.10	77.30	22.53	120.90	637.40	378.32	71.95	19.02	225.70	541.10
LF	377.04	99.13	26.29	120.90	738.20	409.02	87.88	21.49	225.70	630.70
SP	274.20	52.60	19.18	97.80	447.40	291.26	53.61	18.41	172.00	421.50
LP	301.90	72.64	24.06	97.80	531.70	315.66	69.26	21.94	172.00	494.10
SFP	4.17	0.51	12.34	2.58	5.65	4.40	0.45	10.28	3.44	5.38
LFP	4.19	0.51	12.10	2.58	5.60	4.42	0.44	9.88	3.60	5.38
SPP	3.33	0.22	6.51	2.76	4.18	3.38	0.21	6.26	2.99	4.03
LPP	3.35	0.22	6.57	2.79	4.18	3.40	0.21	6.25	2.99	4.03
DIM	329.90	47.77	14.48	250.00	471.00	325.59	49.54	15.22	253.00	461.00

M 305 = milk yield (kg) in standard lactation; M Lac = milk yield (kg) in full lactation; SF = fat yield (kg) in standard lactation; LF = Fat yield (kg) in full lactation; SP = protein yield (kg) in standard lactation; LP = protein yield (kg) in full lactation; SFP = percentage value of the fat (%) in standard lactation; LFP = percentage value of the fat (%) in full lactation; SPP = percentage value of the protein (%) in standard lactation; LPP = percentage value of the protein (%) in full lactation; DIM = days in milk

TABLE 2. Least Squares Means of the milk traits for Holstein Friesian and crossbred (HF x NRF) cows

Traits	HF	HF x NRF	Difference[1]	P-value
M 305	8190.91	8652.58	-461.67	Ns[2]
M Lac	8755.45	9127.34	-371.89	Ns[2]
SF	342.42	381.58	-39.16	<0.001
LF	367.03	402.89	-35.86	<0.01
SP	270.72	289.47	-18.75	<0.05
LP	290.77	306.33	-15,56	Ns[2]
SFP	4.20	4.49	-0.29	<0.001
LFP	4.22	4.46	-0.24	<0.001
SPP	3.32	3.37	-0.05	Ns[2]
LPP	3.34	3.38	-0.04	Ns[2]

[1] difference = difference in the means of the two groups; [2]Ns = not significant, P>0.05; M 305 = milk yield (kg) in standard lactation; M Lac = milk yield (kg) in full lactation; SF = fat yield (kg) in standard lactation; LF = Fat yield (kg) in full lactation; SP = protein yield (kg) in standard lactation; LP = protein yield (kg) in full lactation; SFP = percentage value of the fat (%) in standard lactation; LFP = percentage value of the fat (%) in full lactation; SPP percentage value of the protein (%) in standard lactation; LPP = percentage value of the protein (%) in full lactation

crossbreeds of HF with Normand, Montbeliard and Scandinavian Red, had higher values of fat percentage across the five lactations comparing to pure Holstein from +0.11 to +0.15 %. As for fat plus protein (kg) in 305 days the same authors mentioned that crossbreeds had 3 to 10 % lower values comparing to HF. Opposite results were obtained by Ezra et al. (2016), who state that Holsteins were higher for milk, fat and protein production comparing to crossbreeds in F1 generations. Ezra et al. (2016) also confirmed a slightly higher concentration (%) for fat and protein of the F1 crosses comparing to pure Holstein, which agrees with the results of this research.

Conception rate for the F1 crosses was 1.58 % better in comparison to HF cows. The number of inseminations per pregnancy (2.36: 2.79; Table 3.) was slightly better and also the duration of the days open (110.90: 133.10; Table 3.) were shorter for 22 days in F1 crosses than in HF cows, which can be supported by the results of Ezra et al. (2016), who reported a significantly (p<0.001) better fertility in all three parities of the F1 crosses when compared to pure Holstein cows. Higher conception rates of F1 crosses (Swedish Red, Norwegian Red or Scandinavian Reds with Holstein) in comparison to pure Holstein cows were also established in researches of Heins and Hansen (2012), Malchiodi et al. (2014), Buckley et al. (2014) and Ezra et al. (2016). Heins and Hansen (2012) reported a lower value

TABLE 3. Fertility traits for the Holstein Friesian (HF) and F1 crossbred (HF x NRF) cows

Traits	HF x NRF (n = 120)	HF (n = 255)	Difference[1]
Conception rate, %	33.44	31.86	+1.58
Insemination per pregnancy, n	2.36	2.79	-0.43
Days open, days	110.90	133.10	-22.2

[1] difference = difference between two groups (HF x NRF; HF)

of SCC and better fertility traits of Scandinavian Reds and Holstein crossbreed in comparison to pure HF. Ferris et al. (2014) point out that crossbreeding Norwegian Red with Holsteins in Norway resulted in developing cows with improved calving ease, fewer stillbirths, reduced SCC, and improved fertility and longevity. Also, in this research a lower number of SCC in HF x NRF was recorded in comparison to HF cows in full lactation (4.29: 4.58).

For the health traits, F1 crosses cows were slightly better in comparison to Holstein Friesian cows. For example, HF x NRF crosses had almost 12 % less mastitis prevalence per cow, and from 0.5 to 4.8 % less cases of ketosis, displaced abomasum
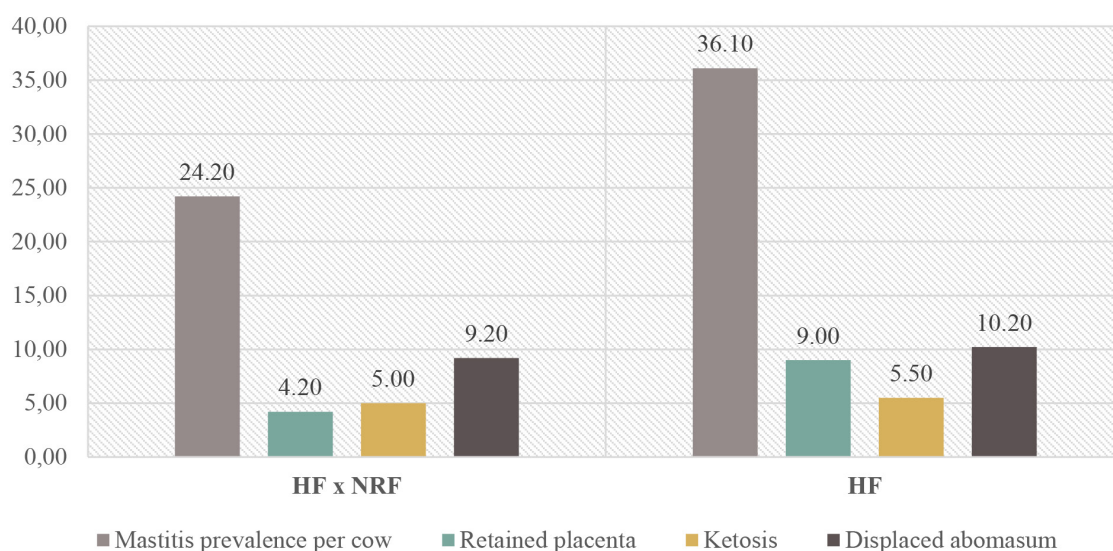

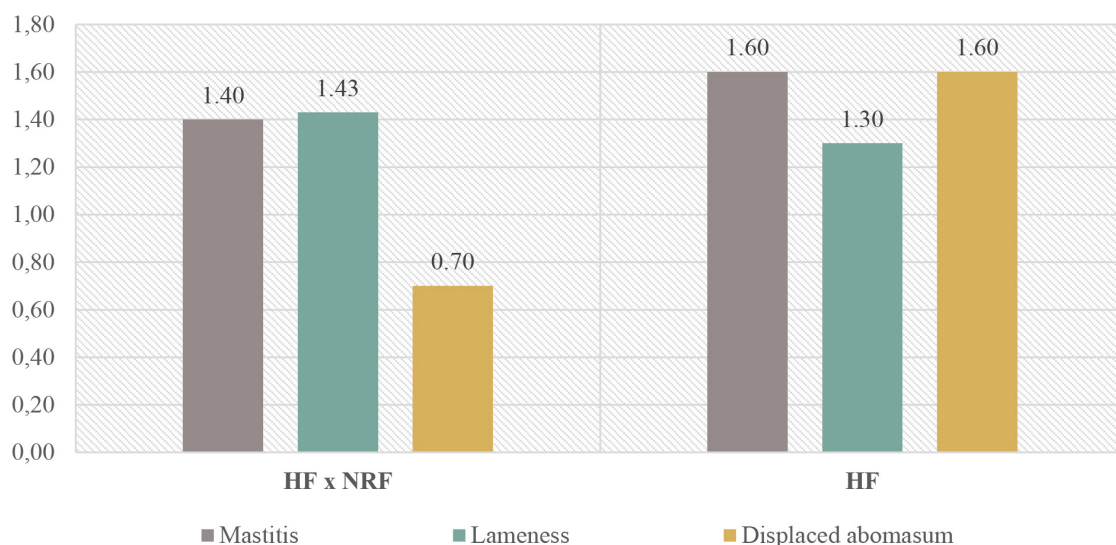**FIGURE 1.** Prevalence of health disorders Holstein Friesian (HF) and F1 crosses (HF x NRF) cows

FIGURE 2. Percentage representation of reasons for culling of Holstein Friesian (HF) and F1 crosses (HF x NRF) cows

or retained placenta, when compared to HF cows (5.00: 5.50; 9.20: 10.20; 4.20: 9.00; Figure 1.). As to the reasons of culling, presented in Figure 2, HF x NRF crosses had about 0.2 % less culled cows because of mastitis (1.40: 1.60), and 0.9 % less culled cows because of the displaced abomasum (0.70: 1.60) when compared to HF cows. Regarding the hoofs problem, F1 crosses had a slightly higher problem, which means that F1 crosses had approximately 0.13 % more culled cows because of hoofs problem comparing to Holstein Friesian cows.

According to a recent study conducted by Nemes et al. (2014) which referred to crossing Serbian Fleckvieh cows with Holstein bulls, good working organization and breeding work leads to the optimal gene recombination, and maintenance of the necessary variability for the purpose of continual positive success of selection on the observed properties. After many years of planned selection, Nemes et al. (2014) obtained a pure desired type of Holstein. Following their results and the results obtained in this study, it can be inferred that further planned pairing of HF and NRF would provide generations with an improving health and fertility traits.

Conclusions

The obtained results indicate that F1 crossbreeds of Holstein Friesian with Norwegian Red cows had better production, fertility and health traits comparing to pure Holstein Friesian cows. Better F1 crossbreeds' performance could be a result of the expression of the heterosis effect. The subject of further research should be focused on examining to what extent the heterosis effect will be pronounced in subsequent lactations and whether it will result in higher longevity. Also, it is extremely important to define adequate pairing schemes in order to achieve the highest possible heterosis effect.

Proizvodne razlike između Holstein Friesian i F1 križanaca Holstein Friesian i Norwegian Red krava

Sažetak

Cilj rada bio je usporediti proizvodna, zdravstvena i svojstava plodnosti krava Holstein Friesian (HF) pasmine i njegovih F1 križanaca sa Norwegian Red pasminom krava (HF x NRF F1). Za potrebe ovoga istraživanja korišteni su samo proizvodni podaci zaključenih prvih laktacija za ukupno 57 HF x NRF F1 križanaca i 401 HF krava, te za zdravstvena i svojstva plodnosti za 120 HF x NRF F1 križanaca i 255 HF krava. Značajnost razlika u proizvodnim svojstvima testirana je analizom varijance uporabom PROC GLM procedure u SAS-u. Proizvodnja mlijeka u obje laktacije (standardna 305 dana i puna laktacija) bila je veća kod HF x NRF F1 križanaca za približno 400 kg, ali bez utvrđene značajnosti. Proizvodna svojstva (mast i protein (kg i %)) izuzevši protein u punoj laktaciji, bili su značajno veći (p<0,001; p<0,05) kod HF x NRF F1 križanaca u usporedbi sa HF kravama. Gledajući svojstva plodnosti, HF x NRF F1 križanci su imali bolju koncepciju (+1,58 %), manji broj osjemenjivanja krava po uspješnoj bređosti (-0,43), te kraće trajanje servisnog razdoblja (-22,2) u usporedbi sa HF kravama. HF x NRF F1 križanci su imala bolja zdravstvena svojstva (izuzev problema sa papcima) komparabilno sa HF kravama, odnosno imali su manje krava s mastitisom (-11,9 %), ketozom (-0,5 %), zaostalom posteljicom (-4,8 %), te dislokacijom sirišta (-1,0 %). Obzirom da su rezultati dobiveni od krava sa završenom prvom laktacijom, potrebno je analizirati i podatke od narednih laktacija, kako bi se dobio puno jasniji uvid u istraživanu problematiku.

Ključne riječi: **proizvodna svojstva, zdravstvena svojstva, svojstva plodnosti, Holstein Friesian, Norwegian Red**

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