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Measuring the genetic impacts on 305 day Lactation production and performance by crossbreeding with Holstein-Friesian

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1. INTRODUCTION

Production of beef and milk is increasingly becoming an important economic sector because of the increased population in the world and the greater interest and need for these products. Therefore selection is vital to ensure early maturing and productive animals are bred and farmed correctly. Since the middle of the nineteenth century to the middle of the twentieth century, the predominant genotype of cattle in Vojvodina was Serbian Fleckvieh Cattle. In the late sixties and early seventies, both in the world and in Hungary there was a big increased interest in continental European cattle breeds, such as Black-and-white Lowland Cattle, Danish Red and the Rotbunt cattle of Dutch origin and also the Jersey and Simmental (Fleckvieh) breeds. In the mid-seventies, serious shift in the development of dairy-type cattle in Vojvodina has occurred. But nowadays, we are witnessing that Holstein crosses are required for improvement of other local breeds (McAllister 2002), and because of that reason there were exemplary initiatives in Serbia to improve the local Fleckvieh with Holstein-Friesian (Perišić, 2008). There were 660 high quality pregnant Holstein-Friesian heifers imported and reared at PIK-Bečej and organized work on the genetic improvement of cattle in the population in Vojvodina was planned. There was an introduction of Black-and-white Holstein genes into the Serbian Fleckvieh breed with the aim being achieving 75% Holstein genetics to improve milk yields and production. This program was implemented in Vojvodina, by the same methods as in some European countries (Germany, Netherlands, France, etc.); by crossing the pure Holstein-Friesian breed into the existing breeds. As a result of specific work in an organized breeding program, maintaining the same herd sizes, relatively satisfactory genetic and phenotypic progress was achieved. In addition there was a complete change achieved in genetic make-up in the requested type of cows in the herds with only a small number of Holstein-Friesian females being imported. A grading-up program is one which includes a series of back crossing in order to transmit new, specific or improved genes into a population from another gene pool in order to replace the genes of the original population with different genes to achieve better performances from the animals and more managable profitable farms. One of the aims of this crossing is to exploit a very mysterious phenomenon called "heterosis". **Heterosis** refers to the phenomenon that progeny of diverse varieties of a species or crosses between species exhibit greater biomass, speed of development, and fertility than both parents. From the second progeny generation, the level of this advantage will be influenced by a recombination effect due to the new rearrangement of the parental genes in the offspring.

During recent years, however milk pricing in most markets has placed greater emphasis on the solids in milk rather than the fluid, which resulted in the Holstein breed having less of a competitive advantage compared with other breeds (Heins, 2006). The aim of this paper was to present a long-standing work on the improvement of Serbian Fleckvieh cattle with the Holstein-Friesian breed in the controlled environment of the farm.

2. OBJECTIVE

The aim of this paper was to present results on the long-standing work on the improvement of Serbian Fleckvieh cattle by using imported Holstein-Friesian genetics in the controlled environment of the farm.

The aim of this study was to estimate the 305 day Lactation milk production and non additive genetic effects (recombination and heterosis) of cows with different proportions of Holstein-Friesian genes, obtained from the Serbian Fleckvieh (SF) and the Holstein-Friesian (HF) crossbreeding program in Vojvodina. Upgrading of local breeds with the Holstein-Friesian breed in Vojvodina started in 1971 and continued 2008. Six genotypes of cows (F_1, R_1, R_2, R_3, R_4, R_5) were obtained with increasing percentage of Holstein genes, in order to attain purebred Holstein cows.

This section is of particular interest to me as I am from a dairy farm and we have done alot of cross breeding in the last number of years, and I am very intrigued by the differences between Hungary and Ireland. I would also like to work in the dairy industry in the coming years.

The Holstein Friesian is a very useful breed for heterosis as it has high milk production traits. When crossing with the various other dairy breeds there is huge potential for improvement in many areas such as the milk fat, milk protein, milk yield, fertility, udder health and calving ease.

3. LITERATURE REVIEW

3.1 305 day Lactation and performance in dairy cows

The Holstein Friesian when crossed with the Guernsey was found to have between 5-8% heterosis for production traits and 12.8% for inseminations per pregnancy and 9.4% for days open. There is a lot of room here to exploit the heterosis effects for fertility. McAllister et al. (1994) found that when crossing the Holstein Friesian and the Ayrshire 20% heterosis was achieved for net return. This would encourage farmers to cross other dairy breeds with the Holstein Friesian instead of using the pure Holstein Friesian cow despite its superiority for production traits (Blottner et al., 2011).

When breeding pure Holstein Friesians, it has been found that the decline in fertility was a major cause for concern. Also reduced cow health and increased inbreeding might be contributing to reproductive decline in Holsteins (Lucy, 2001). In a report by Touchberry (1992), it was found that over all lactations more purebreds died on farms than crossbreds. This indicates that purebreds are more susceptible to disease, sickness and reproductive difficulties than the Holstein and Guernsey crossbred cows. Crossbreeding has been shown to increase herd life when comparing the pure Holstein cow with the Guernsey and Holstein crossbred cow, during the first lactation 31% of pure Holstein cows were removed from the herd compared with 15% of the Holstein and Guernsey crossbreds. When calving was compared the crossbred was superior again. 85.1% of Holstein and Guernsey crossbred cows calved once and 80.3% calved twice compared to the purebred Holstein and Guernsey cows where 71.9% calved at least once and 64.5% calved twice (Heins et al., 2006).

The Jersey and Holstein Friesian crossbred cows were able to consume similar quantities of Dry Matter compared to the purebred Holstein Friesian cows when fed high concentrates. This was also the case when offered lower concentrate feed. Heins et al. (2008a) found that during the first 21 weeks of lactation there was no difference between the intakes where as Xue et al. (2011) reported higher intake for the Jersey and Holstein Friesian crossbred cows compared to the pure Holstein Friesian cow. Prendiville et al. (2009) reported that for herbage intakes, the pure Holstein cow had an intake of 16.9kg of Dry Matter per cow per day and the Holstein and Jersey crossbred cow had an intake of 16.2kg of Dry Matter per cow per day. The Holstein Friesian had a lower intake of Dry Matter per 100kg however, 3.39kg of Dry Matter compared to 3.63kg of Dry Matter for the Holstein and Jersey cow (Vance et al., 2012).

The lifetime profit was estimated in 352 cows (66 Normande x Holstein, 166 Moltbeliarde x Holstein, 90 Scandinavian Red x Holstein) over a 4 year period. The milk price was $0.3411/kg of milk. The value of calves was $250 for heifers and $100 for bulls. The replacement cost was $1200 per cow. These figures were taken as an average throughout the study (Heins et al., 2012).

Heterosis for longevity was examined in a Danish experiment. When crossbreeding it was found that there was recombination gain for longevity. In New Zealand it was found that heterosis heterosis for survival from the first to fifth lactation was more than twice as high compared to the survival rates for the first two lactations. The heterosis for overall longevity is 10 to 15% (M.K. Sorensen et al., 2008).

3.2 What is milk fat made up of?

Bovine milk fat is made up of a wide range of fatty acids. The fatty acids can be roughly divided into saturated and unsaturated Fatty Acids. The fatty acid composition can differ between different cows (Stoop et al., 2008). Mele et al. (2009) reported heritability's for individual Fatty Acids in milk of the Holstein Friesians (HF) ranging from 0.03 to 0.17 and stoop et al (2008) reported heritability's for individual FA in milk of Dutch HF ranging from 0.22 to 0.71. This indicates that a considerable part of variation of FA composition is due to genetics. Some farmers nowadays are breeding to breeding to improve the Fatty Acid composition of milk (Stoop et al., 2008; Eijndhoven et al., 2013).

Average cow milk fat contains 70% saturated fatty acids, 25% monounsaturated fatty acids and 5% polyunsaturated fatty acids. The Jersey contains a saturated fraction of higher nutritional quality than the Holstein Friesian cow.

In Figure 1 below when a mean production performance measuring the milk fat % it was found that the Jersey had 5.33% in its milk. The Holstein Friesian had 3.96% in its milk and the F1 progeny had a % of 4.75% (Prendiville et al., 2009).

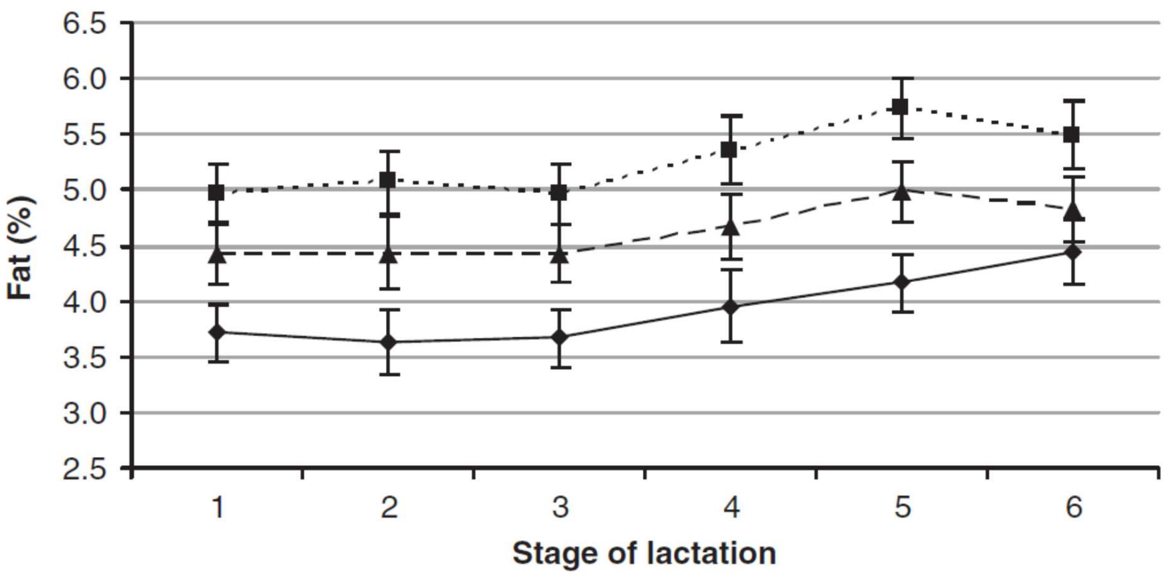

Figure 1: **Milk fat yield of Holstein-Friesian (__♦__) Jersey (- - -■- - -) and JerseyxHolstein-Friesian (_ _▲_ _) through the six stages of lactation (Prendiville et al., 2009)**

The Brown Swiss had a milk fat of 4.18%. When crossed with the Holstein Friesian the F1 progeny had a milk fat of 4.16% from the results from a crossbreeding experiment with Brown Swiss and Holstein (Freyer et al., 2008).

3.3. Uses of milk fat

Figure 3 below shows us that in an experiment Sixty-Four grazing cows (32 Holstein (H) and 32 Montbeliarde (M) cows) in the declining phase of lactation were divided in to two groups that were milked either once or twice a day. The full fat milk was collected during 24 hours from the cows and was processed into Cantel cheese. Once daily milking leads to changes in the major and minor constituents of milk as it changes the mammary permeability of the cow (Davis et al., 1999). Once daily milking also increases milk fat by 2.8g/l and this value was consistent in both breeds (Remond and Pomles 2005). The Cheddar cheese yield (CY) is calculated by the Van Slyke equation (Coggins 1991) the equation is as follows: CY=(0.93MF+0.80P-0.1) x 1.09/(1 – desired M/100), where MF, P and M is milk fat content, protein content and cheese moisture content, respectively. The Montbeliarde had a higher cheese yield than the Holstein. Data was also collected from 1.88 million Holstein and 68,916 Jersey cows in the United States. The average milk yield and fat was 29.1kg and 3.8% for the Holstein. For the Jersey it was an average milk yield of 20.9kg and a milk fat % of 4.8%. The Holstein had a cheese yield of 2.9 kg per day while the Jersey had a yield of 2.6kg per day (Capper et al., 2009). The jersey therefore needs a greater supporting population due to the reduced yield (see Figure 3).

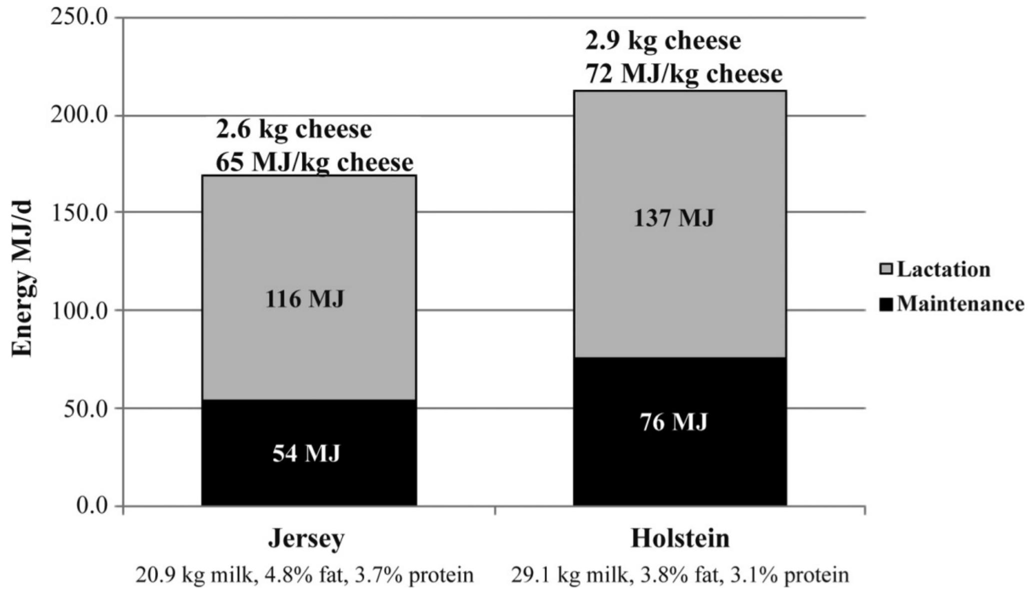

Figure 3: **The effect of breed type, milk yield, milk composition, and relative proportion of daily energy used for maintenance versus lactation on energy use (and thus natural resource use) per kilogram of cheese (Capper et al., 2009)**

3.4. Improvements gained in the milk fat percentage by using heterosis

Crossing is advantageous in dairy cattle. The main reasons for crossing are to utilize the different additive genetic levels between breeds to generate offspring of higher economic value caused by a new combination of additive components. This can also be referred to as "specific combining abilities" (Falconer and Mackey., 1996). Crossing purebred dairy cattle also results in heterosis. The crossbred animals are more robust and economically efficient compared to the parental breeds. (Christensen and Pedersen., 1998; Maki-Tanila., 2007) Sorensen et al., (2008) reported a substantial heterosis increase of up to 18% for the productive life when comparing crossbred and purebred cows. It was also seen that when using a 3 breed rotational cross heterosis for economic traits was greater than 21% (Heins et al., 2012).

The purebred Holstein has higher milk yield than other dairy breeds but increased selection of the Holstein for milk production has led to reduced reproductive efficiency, extended calving interval and increased health problems and decreased productive life(Gonzalez-Recio et al., 2004, 2006) (Blottner et al., 2011).

In the Holstein Friesian heterosis is now very useful as we can try to eliminate unwanted side effects in health, fertility and metabolism. Despite the advantages of selection within purebreds, a purebred dairy cow is unlikely to meet all the criteria of milk producers (Schuler et al. 2001)

In Brazil for example the Holstein Friesian sire is crossed with the Zebu dam. Novaes (1992) and Stock et al. (1995) demonstrated the economic feasibility of these crosses when kept in a proper grazing and management system. The milk fat % was only measured for the first lactation and was 4.1% (Cardoso et al., 1998).

For the first five lactations fertility, somatic cell score, milk yield and milk fat production was calculated for the following crosses ; Holstein x Normande, Holstein x Montbeliarde and Scandinavian Red x Holstein. The Scandinavian Red is a mix of the Norwegian Red and the Swedish Red. The Normande x Holstein, Montbeliarde x Holstein and Scandinavian Red cows had fewer days to the first breeding, enhanced first service conception rates, higher pregnancy rates and 12 to 26 fewer days open than the Holstein cows during the first five lactations. The avoidance of crossing comes with the fear of having a reduced production compared to the purebred Holstein. (Weigal and Barlass, 2003). Dechow et al. (2007) found that the Brown Swiss x Holstein has a higher milk fat % and similar yield when compared to the Holstein. From the first to the fifth lactation Walsh et al. (2006) found that Normande x Holstein crossbreds had similar milk production when compared to the pure Holstein and this was the case for the Montbeliarde cross. Swalve et al. (2008) found that the Brown Swiss x Holstein cross and Swedish Red x Holstein cross had higher fat production during the #first lactation. McDowell and McDaniel (1968) reported that there was no significant difference between the pure Holstein and the Ayrshire x Holstein and Brown Swiss x Holstein for milk revenue or income over feed cost during the first lactation. It was found that the crossbreds were more profitable when mortality and health treatments were taken into account. For 305 day Lactation production the Montbeliarde x Holstein and Scandinavian Red x Holstein cows had significantly higher 305 day Lactation milk volume than the pure Holstein cow. The Normande x Holstein, Montbeliarde x Holstein and Scandinavian Red x Holstein cows had significantly greater 305 day Lactation fat and lifetime protein when compared to the pure Holstein. Crossbreds have greater survival in herds than purebred animals and this is demonstrated by their greater lifetime profitability (Heins and Hansen., 2006).

The Jersey cows when compared to the Holstein Friesian show a large amount of genetic diversity (Basedow, 1998). Sewalem et al. (2006) reported higher somatic cell counts for Jersey cows when compared to the Holstein (212,000 and 167,000 cells/ml, respectively). When crossing the Jersey and Holstein Friesian the F1 cow had a milk fat % of 4.79% which is greater than the purebred Holstein (4.00%) and less than the purebred Jersey (5.40%). The Jersey Holstein F1 cow has a genotype very well suited to grazing systems. Prendiville et al. (2009) obtained estimates regarding the DMI or the Holstein, Jersey and their cross and compared them finding that the Jersey has the superior intake capacity and production efficiency compared to the Holstein. (Penno., 1998; Lopez-Villalobes et al., 2000; Buckley et al., 2005; Prendiville et al., 2010).

When the Jersey cow is crossed with the Holstein Friesian there is improved health and fertility and longevity when compared to the pure Holstein. When crossing the Holstein Friesian and the Jersey significant improvements in the fertility were noted (Auldist et al., 2007). There is a significant difference between the Holstein Friesian and the Jersey for somatic cell score as (Heins et al.2008b; Prendiville et al. 2010b) discovered in their study. It was found that the lighter Holstein Friesian x Jersey was able to compete with Holstein Friesian cows within the medium input grazing system but they were not able to exhibit as large a milk production. When the DMI was measured there was no significant difference. The Holstein Friesian took in 5,813kg and the Holstein Friesian x Jersey took in 5,559kg for the entire lactation (Vance et al., 2012).

The Holstein Friesian and Jersey x Holstein Friesian dairy cows were compared when fed a low concentrate, medium concentrate and a high concentrate diet. The milk fat yield was highest in the high concentrate diet at a figure of 280kg per lactation. The milk fat was lowest for the low concentrate diet at a figure of 238kg pre lactation (Vance et al., 2012).

Hollon and Branton (1975) found that there was a decrease in the still birth rate for Brown Swiss sired crossbreds compared to the Holstein sire and Holstein dam. Heins et al. (2006) discovered that Brown Swiss sired calves and Scandinavian sired calves had less calving difficulty than Holstein sired calves and they reported that calves from the Scandinavian Red sire had less calving difficulty then the Holstein sired calves. Mc Dowell et al. (1970) found significant differences in the number of days open when comparing the pure Holstein and the Brown Swiss x Holstein during the first few lactation (Blottner et al.,2011).

Van Randen and Sanders (2003) found that the Brown Swiss sire x Holstein had almost identical fat and protein yields to the pure Holstein and also found the Brown Swiss sire x Holstein to be more economically competitive. As the lactation number increased heterosis for fat plus protein increased. The fat plus protein was different between the Brown Swiss and Holstein for the first and second lactation but not for higher lactations. Brown Swiss x Holstein had a lower somatic cell score when compared to the pure Holstein. The Brown Swiss is a viable choice for cross breeding (Dechow et al., 2007).

In Kenya the Sahiwal was crossed with the Friesian and the cross was compared to the Brown Swiss x Sahiwal x Friesian. The Friesian x Sahiwal is inferior when having to rear replacements. It was concluded that the first cross is best suited to dairy production in the tropics (Kahi et al., 1999).

In a study to examine calving difficulty and still births between pure Holstein and Holstein crosses it was found that claves with the pure Holstein sire had a higher incidence of still births compared to those sired by breeds other than the Holstein. With Montbeliarde x Holstein, Scandinavian Red x Holstein and Normande x Holstein crossbreds less calving difficulties were observed (Heins et al., 2012)

Heterosis for milk production was 21.6% and for fat production it was 18.8% as was found by Fohrman et al. (1954) and Touchberry et al. (1992). In a study of crossbreeding the Holstein and Guernsey's it was found that the pure Holstein was superior for milk production but the Holstein Guernsey cross had an advantage for income per lactation. Income was reported by

Touchberry (1992) to be 11.4% better for crossbreds than the average purebred. In a cross between the Ayrshire and the Holstein 20% heterosis was reported for lifetime performance (McAllister et al. 1994). There was no great difference between the Ayrshire and Holstein for milk yield but there was a significant difference for milk fat (Heins et al., 2012).

3.5. Non genetic factors influencing the milk fat percentage

3.5.1. Environmental factors

Environmental stress was seen to have a big effect on the productivity of dairy cattle. It is an accepted notion that breeds from warmer areas have a greater capacity for adaptation to the local environment that those from more temperate regions (Berman, 2011).
The difference between feeding in the summer and winter has an effect on the milk fat %. The milk fat % is higher in winter when fed silage (4.36%) compared with the summer months when the cows are fed fresh pasture (4.26%). In the study the milk fat % difference could also be due to the stage of lactation. The difference in milk fat can be attributed to differences in the diet between the seasons rather than genetic differences (Duchemin et al., 2013).

3.5.2. Dietary factors

In dairy management it's well known that the diet influences the milk composition. The feed conversion is the most important factor. The energy and protein are the most important dietary factors. Regarding fat content, increasing the energy supply has no effect or may slightly decrease the milk fat % (Gorden and Forbes 1970; Friggens et al., 1995; Brun-Lafleur et al., 2013).

Feeding an increased amount of fat in the diet has been shown to have varied results on milk fat production. Different fats can cause a different response in the milk fat %. (Weiss and Pinos-Rodriguez, 2009). Feeding tallow, oilseeds and other Ca salts reduced the milk fat. Feeding Megalac and prilled fat increased the milk fat %. An increase in Mg and C18:0 caused a decrease in the milk fat % also (Rabiee et al., 2012).

In Figure 2 below it can be seen that the as the milk fat % gets higher the FCM yield also gets higher. The slope is constantly increasing when the milk fat % is increased.

The high moisture content of the diet had a tendency to decrease the milk fat %. Feeding high concentrations of starch was also seen to decrease the milk fat %.

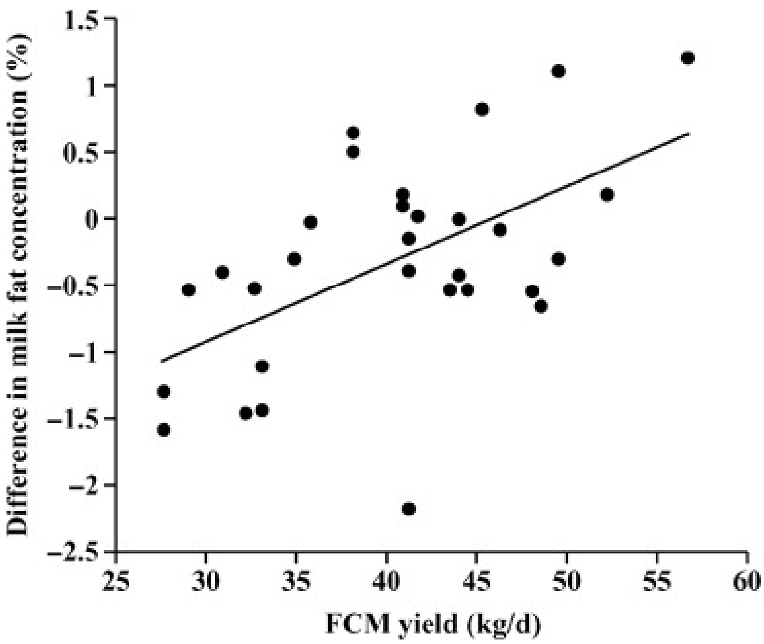

Figure 2: **Relationship between preliminary period 3.5% FCM yield and difference in milk fat concentration (n = 30). Difference in milk fat concentration is calculated as milk fat concentration during high moisture corn grain treatment minus milk fat concentration during dry ground corn grain treatment, adjusted for the effect of period (R^2 = 0.32; *P* = 0.001). Preliminary period fluid milk yield was positively related to difference in milk fat concentration (R^2 = 0.25; *P* < 0.01) (Bradford et al., 2004).**

4. MATERIAL AND METHODS

The results of the upgrading program were obtained from two direfent cattle farms in Vojvodina, which started in the years 1971 and 1975 by crossing the native Serbian Fleckvieh (SF) cows with diferent bulls of the Holstein-Friesian (HF) breed imported from the USA and Canada. The whole process lasted 35 years until 2008 when it concluded, and the six cow genotypes (F1, R1, R2, R3, R4, R5) with varying proportions of the Holstein-Friesian genetics were obtained, in order to get the required pure Holstein cows. Cows of F1 generation were obtained by mating Serbian Fleckvieh cows to Holstein bulls, which obtained calves with 50% Holstein genes. Each of the following generations was mated with Holstein-Friesian sires by using straws of AI semen purchased abroad. The grading-up process was continued until we obtained Holstein-Friesian cow whose blood had over 99% Holstein. As a result of the many years of crossing, the cows of the following genotypes and proportion1 of Holstein genes was obtained: R1 with 75% HF genes, R2 with 87.5% HF genes, R3 with 93.75% HF genes, R4 with 96.88% HF genes, R5 with 98.44% HF genes, in order to obtain the last generation of HF cows with 100 % (>99%) proportion of HF genes.

For the estimation of the nonadditive crossing effects the Dickerson-model (Dickerson, 1969) was applied. The realised heterosis (h^R) is the deviation of the real performance from a theoretical value which is estimated as the sum of the results of the blood proportion *x* the performance of the pure breeds being present at a given genotype (genetic composition: $p_{si}p_{dj} + p_{pi}p_{sj}$ where, p_{si} = Holstein-Friesian sire's gene proportion, p_{sj} = Serbian Fleckvieh sire's gene proportion, p_{di} = Holstein-Friesian dam's gene proportion, p_{dj} = Serbian Fleckvieh dam's gene proportion). The relative heterosis (h^r) represents, as a percentual value, the level of the previous realised heterosis. The additive component of the realised heterosis (defined as individual heterosis,h^I) has linear association with the degree of heterozygosity. It is made by the consecutive bisection from the heterosis appeared in the F_1 genotype. The

recombination (r^I) is intended to characterize the distance of the realised heterosis from its additive component.
The data base of this evaluation came from the Agricultural and Industrial Combine of Bečej and of Senta, where the grading-up breeding program was started in 1972 (Gavrilović, 1981). The following eight genotypes were distinguished: 1. 100.00% Serbian Fleckvieh (SF), 2. 50.00% Holstein-Friesian (HF) blood proportion (F1), 3. 75.00% HF (R1), 4. 87.50% HF (R2), 5. 93.75% HF (R3), 6. 96.88% HF (R4), 7. 98.44% HF (R5), and 8. 100.00% HF.

After examining the systemic records of each cow, the proportion of Holstein genes in the overall genotype, the crossing levels and the number of generations, then the 305 day Lactation quantity of milk and the amount and percentage of milk fat production was determined.
For the investigated traits the corrected value of the mean (LSM - Least Square Means) was computed by the multiple trait hierarchical linear model and Duncan's post-hoc test for statistically significant differences among genotypes was applied (StatSoft, Inc., 2011).

The population investigated contains 11,278 individuals of initial purebred Fleckvieh and Holstein-Friesian breeds as well as of the six intermediate crossed genotypes (born form 8 Fleckvieh and 388 Holstein-Friesian sires) from the last four decades (1971-2008).
The production was realized by the use of two housing systems: the closed-tied system as well as the open system (in stable with lying boxes and with adjoined paddock).
The mode of feeding was put into three regimes: 1. the traditional („green fodder-belt" based on alfalfa in summer, maize silage in winter, manual rationing, until the beginning of 1980-ies), 2. The transitional (monodietic feeding based on maize silage and concentrates from mixer wagon with additional manual rationing of hey, from the beginning of 1980-ies) as well as 3. the modern (Total Mix Ratio feeding based on maize silage, hay and concentrates, Diet feeder, from the middle of 1990-ies).

The investigated parameters (305 day Lactation milk yield, 305 day Lactation butterfat yield, 305 day Lactation average butterfat content) were analysed by the following multiple trait nested linear model:

$$Y_{ijklmnopqrs} = \mu + K_i + B_j + S_k + E_l + I_m + T_n + F_o + P_p(K_i) + A_q(K_i) + Z_r + X_s + \varepsilon_{ijklmnopqrs}$$

where:

$Y_{ijklmnopqrs}$ = investigated parameters,

μ = = overall mean,

K_i = genotype (n = 8),

B_j = sire's origin (n = 6; 1. = HF from Bečej, 2. = HF from Yugoslavia-Serbia, 3. = HF from the USA, 4. = HF from Canada, 5. = Fleckvieh from Yugoslavia-Serbia, 6. = Fleckvieh from abroad)

S_k = number of calving (n = 7; 1-6 = from 1 upto 6 per calving, 7 = with 7 calving or more),

E_l = year of calving (n = 38; 1971-2008),

I_m = season of calving (n= 2; 1 = April-September, 2 = October-March),

T_n = housing system (n = 2; 1. = tied, 2. = open),

F_o = feeding system (n = 3; 1. = by hand silage, concentrates and hey, 2. = mixer wagon + hey, 3. = TMR-monodietic),

P_p = service period (covariate, nested in genotype),

A_q = age at first calving (covariate, nested in genotype),

Z_r = sire's year of birth (n = 48, 1955-2002),

X_s = cow's year of birth (n = 39; 1968-2006),

$e_{ijklmnopqrs}$ = random residual.

As result, the Least Squares Mean (LSM) and the Standard Error of Mean (SEM) will be given. The differences among the genotypes will be proven by use of Duncan's post hoc test (StatSoft, Inc., 2011).

In the case of a grading-up breeding scheme there cannot be crossed sires with paternal heterosis. However, in the dairy production the crossbred stage of the dam contributes, as an environment, hardly to the individual performance, so the maternal heterosis is negligible. This is the reason that our investigation operates with the h^I only like it was in the processing of Egger-Danner (2005).

The realized percentage advantage of the intermediate genotypes was compared to the zero values of the Serbian Fleckvieh breed by use of a difference test (with known records and frequencies).

5. RESULTS AND DISCUSSION

5.1. 305 days Lactation milk production

Table 1 shows the adjusted mean (LSM) and the adjusted standard mean errors (SE_{LSM}) for the 305 days Lactation milk production of cows with different genotypes. It can be seen that the purebred Serbian Fleckvieh (SF) cows produced 3917 kg milk, while the improved cow generation R_5 with a share in Holstein genes of 98.44% had the highest 305 days Lactation milk production (5801 kg), followed by genotype R_4 with 5760 kg (96.87% HF genes), then by the pure Holsteins (HF) gained 5752 kg of milk and finally by the cows of genotype R_3 with 5712 kg (93.75% HF genes).

Among the mentioned genotypes of the cows (R_4, R_3 and R_5) there was no statistically significant difference (P>0.05) as compared to both purebreds (SF and HF) where a significant statistical difference (P <0.05) was observed. The largest heterosis (h^I) and realized heterosis (h^R) was recorded in cows of the F_1 generation (185.8 kg), while the increase in the proportion of genes of Holstein-Friesian cattle led to the decrease of additive component of heterosis from generation to generation by ½. The highest level of recombination (r^I = 72.4 kg) was recorded in cows with R_5 genotype which contained the proportion of Holstein genes from 98.44%, while the cows of genotype R_2 contained a proportion of 87.50% of HF genes had a negative recombination (-252.2 kg) and the least realized heterosis (h^R) of -205.7 kg. The smallest relative heterosis (h^r) for 305 days Lactation milk production - expressed as the percentile difference between the realized and expected production - appeared in the R_2 genotype (-3.7%), while cows of F_1 generation had the highest relative heterosis (3.8%). Similar results have been published by other authors (Lopez-Villalobos et al., 2000; Sørensen et al., 2008; Freyer et al., 2008), in their research which had the aim to blend their local cattle breeds with purebred Holsteins

Table 1: The 305-day lactation milk yield and heterosis realized the extent of the crossover degrees

Genotype*	Lactation Number	305-day milk yield kg LSM SEM	Expected additive dominance kg	expected heterosis, kg	Recombination combiner kg	Achieved heterosis, kg	Achieved relative heterosis, %
SF	721	3917[a] ± 108	-	-	-	-	-
F1	785	5020[b] ± 103	917,5	185,8	-	185,8	3,8
R1	825	5272[c] ± 100	1376,2	92,9	-113,9	-21,0	-0,4
R2	649	5317[d] ± 104	1605,5	46,5	-252,2	-205,7	-3,7
R3	782	5712[e] ± 102	1720,2	23,2	51,1	74,3	1,3
R4	2583	5760[f] ± 91	1777,5	11,6	53,5	65,1	1,1
R5	5561	5801[g] ± 89	1806,2	5,8	72,4	78,2	1,4
HF	20116	5752[f] ± 88	1834,9	-	-	-	-

* - Explanation of the model

5.2. 305 day Lactation milk fat production

The 305 day Lactation milk fat production (Table 2) among the genotypes from R_1 to R_5 did not show statistically significant difference (P> 0.05) which ranged from 176 -201 kg, while in comparison with the SF breed and F_1 generation they showed statistically proven differences (P<0.05). The purebred Holsteins had an average 305 day Lactation milk fat production of 201 kgs, without a significant statistical difference (P>0.05) when compared to cows of genotype from R_1 to R_5. With the increase in the proportion of genes of the Holstein-Friesian, the additive component of heterosis (h^I) was decreased. Positive values of the realised and relative heterosis effect on milk fat yield were observed in all genotypes. In cows of genotype F_1, with proportion of 50% Holstein genes recorded the highest realised (h^R= 6.07 kg) and relative (h^r= 3.6%) heterosis, while the cows of the genotype R_5 with the proportion of 98.44% Holstein genes had the least individual heterosis. Therefore the lowest realized heterosis, negative recombination, and relative heterosis was not able to be determined, which can be explained by the fact that it is already the sixth improved generation of cattle, where there is an advanced gene fixation and a reduced chance for recombination.

McAllister et al. (1994) recorded high relative heterosis in the 305 day Lactation milk production and milk fat production (16.5-20%, respectively) in their work about the Holstein x Ayrshire crossing, while Van Raden and Sanders (2003) studied the length of a productive life in the different dairy crossed progenies sired by the Holstein and estimated heterosis which was low (1.2%), which can be the result of the environmental factors (Bryant et al., 2007).

Table 2: The 305-day lactation fat and the degree of heterosis realized crossover degrees

Genotype *	Lactation Number	305 days fat, kg LSM SEM	Expected additive dominance,kg	expected heterosis, kg	Recombination combiner kg	Achieved heterosis, kg	Achieved relative heterosis, %
SZT	721	139,4[a] ± 3,46	-	-	-	-	-
F1	785	176,2[b] ± 3,29	30,78	6,07	-	6,07	3,6
R1	825	188,4[c] ± 3,22	46,18	3,04	-0,25	2,79	1,5
R2	649	189,5[d] ± 3,31	53,88	1,52	-5,31	-3,79	-2,0
R3	782	200,2[e] ± 3,25	57,73	0,76	2,33	3,06	1,6
R4	2583	201,3[f] ± 2,92	59,68	0,38	1,89	2,27	1,1
R5	5561	201,6[g] ± 2,85	60,62	0,19	1,37	1,56	0,8
HF	20116	201,0[f] ± 2,80	61,58	-	-	-	-

* - Explanation of the model

abcdefg - the different letters indicate a statistically proven to have different values ($p < 0.05$)

5.3.305 day Lactation milk fat percentage

The Table 3 shows the milk fat content by the genotypes, where we observed that SF cows had the highest percentage of milk fat (3.68%). The milk fat percentage decreased with the process of grading-up, so that the cow genotypes R_3, R_4, R_5 and HF had less than 3.5% milk fat. With the increase of the 305 day Lactation milk production from generation to generation the milk fat content is decreasing, as it was expected based on knowledge from the lactation performances, given that these traits are in negative genetic correlation (Vidović et al., 2013). Negative values of realised and expected heterosis effect on milk fat was observed in almost all genotypes, whereas the positive heterosis effect was only observed in the R_1 and R_2 genotype which is a typical consequence of the positive recombination in the early crossed generations.

Lopez-Villalobos et al. (2000) suggested that modern breeding methods, such as artificial insemination, embryo transfer, breeding programs such as TEAM or MOET, use sexed semen, reducing the number of bull lines leading to a reduction in genetic variability, resulting in an increase in the coefficient of inbreeding, while the rotational crossing of two or more breeds contributes to the manifestation of the effects of crossing and maintenance of genetic variability, which is important in maintaining the balance between production costs and future market requirements. When the crossed animals will be bred further (e.g. F_1 x F_1 mating, or grading-up is carried out), the breeders have to realise the loss in traits caused by nonadditive genetic impacts, namely by recombination, which could contradict the valued heterosis that is expected. This genetic effect may sometimes be greater than the expected heterosis effect, although in each case the effect is to be expected in reverse.
The success of the crossing requires a consistent and strict selection from the breeder.

Dickerson (1969) has shown that the maternal heterosis cancel out when the difference is taken between the crossbred and straight bred females mated to the sires of a different breed. Estimate of maternal heterosis in the beef production is applicable to any system of mating involving purebred bulls and either F_1 dams or crossbred females produced in terminal or rotational crossbreeding systems because its effects expressed in the calf are always present in approximately the same proportion to effects of individual heterosis expected. Alternative designs employing F_1 bulls may provide estimates of maternal heterosis without any effect of recombination but the results for reproduction are confounded with any effect of heterosis on the fertility of crossbred bulls.

Table 3. The 305 day Lactation milk fat percentage and non additive genetic effect in different cow genotypes

Genotype	Proportion of Holstein-Gene, %	No. of Cows	Lactation Average Milk fat Content, % LSM SE$_{LSM}$	Additive Component of Heterosis, % (h^I)	Recombination, % (r^I)	Realised Heterosis, % (h^R)	Relative Heterosis, % (h^r)
SF	0.00	277	$3.68^{e} \pm 0.020$	-	-	-	0.0
F_1	50.00	254	$3.53^{c} \pm 0.020$	-0.053	-	-0.053	-1.48*
R_1	75.00	243	$3.58^{d} \pm 0.020$	-0.027	0.073	0.046	1.30
R_2	87.50	223	$3.55^{cd} \pm 0.019$	-0.013	0.051	0.038	1.08
R_3	93.75	265	$3.46^{a} \pm 0.018$	-0.007	-0.030	-0.037	-1.06
R_4	96.87	967	$3.43^{a} \pm 0.011$	-0.004	-0.059	-0.063	-1.80*
R_5	98.45	2053	$3.44^{a} \pm 0.010$	-0.002	-0.046	-0.048	-1.37*
HF	100	6996	$3.49^{b} \pm 0.008$	-	-	-	-

^{abcde} – different subscribed letters show significant differences (P<0.05)

* – number of subscribed stars show a significant difference from the Serbian Fleckvieh (* P<0.05)

6. CONCLUSIONS AND RECOMMENDATIONS

With the use of crossing Serbian Fleckvieh cows with Holstein bulls, we were able to manage after 38 years with a good working relationship, organization and breeding work to get pure Holstein-Friesians after six generations. There was a simultaneous increase in the number of cows, we carried out a satisfactory genetic and phenotypic improvement and total change in genetic composition and we came to the desired type of Holstein-Friesian. With the increase in the share of Holstein-Friesian genes bred from generation to generation with optimal zoo technical requirements and care. There has been an increase in the total quantity of milk, previously from 3917 kg in SF to 1834 kg in HF, but the milk fat decreased from 3.68% to 3.49% but there has been an increase in the total milk fat yield from 139.4 kg to 201 kg.

Research indicates that a planned crossing leads to the optimal gene recombination, which results in the increase in production and maintenance of the necessary variability for the purpose of continual positive success of selection on the observed properties. We can conclude after our experience in Vojvodina that the upgrading with Holstein-Friesian was successful.

There are relatively few examples in literatures in regards to the subject about the non-additive genetic impact on the 305 day Lactation performances of crossed dairy genotypes. The reasons we would like to enlighten:

- The data collection for the processing lasts for more decades, it is expensive, and the result is not well determinable,
- The market has a disinterested attitude to an individual with unknown producing-ability (with an unknown general- and special breeding value),
- The generations born differentiate in size, performance, and in demand from each other.

When the crossed animals will be bred further (e.g. F1 x F1 mating, or grading-up is carried out), the breeders have to count with losses in traits caused by recombination, namely by non-additive genetic impacts, which could contradict the valued heterosis that is expected (Nemes et al., 2011). Guba and Dohy (1979) pointed out that an undesirable, so called transgressive splitting can come into being on the course of crossing, which means the appearance of many minus variant individuals. The success of the crossing requires a consistent, strict selection from the breeder.

It is important that we evaluated six intermediate genotypes of upgrading, and the typical, advantageous recombination found in F1 persisted up to the R2 in regards to the fat content. Taking into consideration that the majority of the Serbian Fleckvieh in our investigation have produced in the 1970-ies, and the two third of the Holstein-Friesian purebred and crossed cows were sired by home raised bulls the performances reached in the 305 day Lactation production are accepted by us.

We can conclude after our experience in Vojvodina that the upgrading with Holstein-Friesian was successful, and the farms could continuously have utilized the positive heterosis manifested in the intermediate genotypes – even if at a decreasing extent.

In would recommend crossbreeding in Ireland with the Holstein Friesian as the resulting progeny have a large number of improvements as we saw in the literature section above.

7. SUMMARY

The aim of this study was to Measure the genetic impacts on 305 day Lactation production and performance by crossbreeding with Holstein-Friesian from cows with different proportions of Holstein-Friesian genes, obtained from the Serbian Fleckvieh (SF) and the Holstein-Friesian (HF) crossbreeding program in Vojvodina. The upgrading of local breeds with the Holstein-Friesian breed in Vojvodina started in 1971 and continued until 2008. Six genotypes of cows (F_1, R_1, R_2, R_3, R_4, R_5) were obtained with increasing percentage of Holstein genes, in order to attain purebred Holstein cows. Of all obtained genotypes, cows of genotype R_5 with a proportion of Holstein genes from 98.44 % had the highest 305 day Lactation milk production (5801kg), followed by cows R_4 with 5760 kg (96.87 % HF genes) and cows R_3 with 5712 kg (93.75 % HF genes). Finally the process of upgrading resulted in pure Holsteins with 5752 kg of milk. The 305 day Lactation production of milk fat did not show statistically significant difference (P>0.05) among the genotypes R_1 – R_5 which ranged from 46 to 60 kg. The pure Holstein cow obtained after six intermediate generations had the average 305 day Lactation milk fat production of 201 kg. With the increase in the proportion of Holstein-Friesian genes, the percentage of milk fat was decreased, so that the cows of genotypes R_3, R_4, R_5 and pure Holsteins, had less than 3.5 % milk fat.

In relation to the total milk yield, the highest realized heterosis effect was observed in the cows of F_1 generation (h^R_{F1}= 185.8 kg), while the lowest was observed in generation R_2 (h^R_{R2}= - 205.7 kg), where negative effect of recombination was also found (r^I_{R2}= - 252.2 kg). Positive values of the actual and relative of heterosis effect of the milk fat yield was observed in all genotypes, whereas the negative heterosis effect of the milk fat percentage was observed also in all genotypes, with the exception of R_1 and R_2 cows, in which the typical consequence of the positive recombination in the early crossed Holstein-generations was manifested.

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