

Comparative study on production, reproduction and functional traits between Fleckvieh and Braunvieh cattle

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Objective: Aim of the current comparative study was to evaluate production outputs, reproduction efficiency and functional traits in dual-purpose Fleckvieh and Braunvieh cows, reared under temperate European conditions.

Methods: A data-set from 414 Fleckvieh and 42 Braunvieh cows and 799 lactations was analysed. ID tag number, milk yield per milking session, number of steps/interval and milk conductivity were recorded and collected daily using Afimilk 3.076 A-DU software (Afimilk Ltd., Kibbutz, Israel). Production and milk quality data were taken from the results of the official performance recordings and the reproductive outputs of cows were recorded by the research stations veterinarians. Comparisons between the two genotypes were carried out using the one way analysis of variance protocol, with categorical factor being considered the breed of cows. All the statistical inferences were carried out using Statistica software (StatSoft Inc., Tulsa, OK, USA).

Results: Fleckvieh cows significantly outperformed ($p \leq 0.05$) the Braunvieh herd, with average milk yields of $5,252.1 \pm 35.79$ kg and $4,897.6 \pm 128.94$ kg, respectively. Age at first calving was significantly ($p \leq 0.01$) influenced by the breed, with Fleckvieh heifers being more precocious (32.8 ± 0.29 mo) compared to those of Braunvieh breed (35.7 ± 0.84 mo). Reproduction efficiency as defined by the number of inseminations per gestation, calving interval, dystocia, days dry and days open, was not influenced by genotype ($p > 0.05$). Incidences of sub-clinical mastitis, clinical mastitis, lameness and abortions were not influenced by the breed factor ($p > 0.05$). Stayability of cows was significantly ($p \leq 0.001$) influenced by genotype, with Braunvieh cows having an average age at culling of 117.88 ± 11.78 months compared to 90.88 ± 2.89 months in Fleckvieh.

Conclusion: Overall, results have shown that genotype significantly influenced milk yield, age at first calving and longevity.

Keywords: Animal Welfare; Cattle; Fertility; Mastitis; Milk Yield; Selection

INTRODUCTION

Milk yield per cow has more than doubled in the previous 40 years and many cows now produce more than 20,000 kg of milk per lactation. In the last 70 years most of the selection programmes for cattle have been focused solely on the genetic improvement of production traits, such as milk yield and growth rates. Subsequent to the negative genetic correlations between milk yield, reproduction efficiency and fitness traits, a significant decline in many functional traits has been observed in cattle [1], particularly in highly specialized Holstein Friesian, Brown Swiss and Jersey breeds. However, selection for a broader set of novel and 'greener' traits, which to include both economically relevant aspects of production and animal welfare related issues, such as health, longevity, feed efficiency, methane emissions and functional traits, is becoming more widespread. Therefore, both stakeholders and animal scientists realized that high productivity cannot be solely improved without a more integrated approach on animal performance and welfare [2].

The inclusion of functional traits in genetic improvement programmes is important for the long-term development of the cattle industry. In order to develop feasible total merit indices and to introduce new selection traits in the genetic improvement programmes, there is a need for up-to-date information on a wide range of relevant traits that have economical and animal welfare implications [1]. The main drawback on introducing functional traits into breeding programmes is the general low genetic additive variance, with heritability estimates of 0.02 to 0.09 for clinical mastitis [3], 0.01 to 0.07 for fertility-related diseases [4] and 0.02 to 0.04 for lameness [5].

The worldwide population of cattle is estimated to 1.4 billion animals, of which 159 million (11%) are found in Europe and Central Asia [6]. Romania is among the top ten countries in the EU regarding the cattle population with 2,022,400 heads [7], and a breed structure of 30.96% Romanian Spotted (Fleckvieh), 20.28% Romanian Black and White (Holstein-Friesian), and 13.58% Romanian Brown (Braunvieh).

To the best of our knowledge, no other comparative study concerning the production outputs, reproduction efficiency and health traits of Fleckvieh and Braunvieh breeds under European rearing conditions exists up to this moment.

Aim of the current comparative study was to evaluate production outputs, reproduction efficiency and functional traits in dual-purpose Fleckvieh and Braunvieh cows, reared under temperate European conditions.

MATERIALS AND METHODS

Animals and general management

The study was carried out at the Research and Development Station for Bovine Arad (46°10'36"N 21°18'4"E) Romania (altitude of site 107 m), where purebred dual-purpose Fleckvieh and Braunvieh cows, managed under identical conditions, were included in the research herd.

The Fleckvieh and Braunvieh (national names Bălțată Românească and Brună de Maramureș, respectively) herds have been selected predominantly for the increase of milk yield starting from 1981. Reproductive failure and udder-related problems were the criteria normally used to define which cows would be culled. However, in some cases, health and age were also considered. Cows taken in the study were between 1st and 11th lactation, with age and parity balanced within the breeds and representing a diverse sampling of genetic lines (Austrian, German, Swiss, and Romanian).

All animals were included in the Official Performance and Recording Scheme, being registered as nucleus reference breeding herds, which produce and disseminate tested bulls for the national Artificial Insemination Stations. A data-set from 414 Fleckvieh and 42 Braunvieh cows and 799 lactations was analyzed for the estimation of the effects that breed has on production and reproduction outputs and functional related traits.

Cows were milked twice per day in a 'herringbone' milking parlour (2 sides×14 units). The milking parlour was equipped with AfiMilk 3.076 A-DU software (Afimilk Ltd., Kibbutz, Israel). Furthermore, all cows were fitted with AfiTag (Afimilk Ltd., Israel) pedometers for oestrous and lameness detection.

Cows were kept on deep straw bedding, with a space allowance of 9 m² in the resting area and free access to water and outside paddocks. They received a daily feed ration of 15 kg of green alfalfa and 15 kg of green fodder, 12 kg corn silage, 6 kg of alfalfa hay and 6 kg of concentrates starting spring till late autumn, and a ration of 15 kg alfalfa silage and 25 kg of corn silage, 6 kg of alfalfa hay and 6 kg of concentrates during winter. Cows were fed twice per day, and had a feeding space allowance of 70 to 75 cm/head. Cows were housed in groups of 40 to 50 animals, according to lactation stage and productivity, regardless on their breed.

The research activities were performed in accordance with the European Union's Directive for animal experimentation [8]. Use of animals and the procedures performed in this study were approved by the Scientific and Ethics Committee of the Research and Development Station for Bovine Arad belonging to the Academy for Agricultural and Forestry Sciences, Decision no. 51.

Data collection and statistical analysis

ID tag number, milk yield per milking session, number of steps/interval and milk conductivity were recorded and collected daily using AfiMilk 3.076 A-DU software (Afimilk Ltd., Israel) and hardware fitted in the milking parlour during three consecutive years (01.01.2013 to 31.12.2015). Production and milk quality data (milk production, fat yield and percentage, protein yield and percentage, and the somatic cell count) were taken from the results of the official performance recordings, according to the standardized ICAR method [9]. The alternative milking AM/PM at 28-days interval protocol was used for this purpose. Milk yield was standardized for normal lactation (305 days) and mature equivalent (cow's parity) using correction coefficients [10]. Thresholds of >200,000 to 1,000,000 cells/mL and >1,000,000 cells/mL were considered for sub-clinical mastitis and mastitis, respectively [11].

Reproductive outputs of cows (number of inseminations per gestation, dystocia incidence, calving interval, days dry and days open) were recorded by the research stations veterinarians.

Comparisons between the two genotypes were carried out using the one way analysis of variance protocol, with categorical factor being considered the breed of cows. All the statistical inferences were carried out using Statistica software (StatSoft Inc., Tulsa, OK, USA) [12]. Decisions about the acceptance or rejection of statistical hypothesis have been made at the 0.05 level of significance.

RESULTS AND DISCUSSION

Fleckvieh cows significantly outperformed ($p \leq 0.05$) the Braunvieh herd, with average milk yields of 5,252.1 kg and 4,897.6 kg, respectively (Table 1). Production levels for both Fleckvieh and Braunvieh genotypes are consistent with those previously reported by Anton et al [13] and Pilarczyk et al [14] for dual-purpose European breeds. However, given the better performance of the Fleckvieh breed (+353.5 kg) we could estimate that on identical housing and feeding conditions, the farm returns are higher with 91.55 EUR/year/cow, compared to Braunvieh cows (0.259 EUR/kg of milk) [15].

Milk fat and protein percentages were not influenced ($p > 0.05$) by genotype during the current research trial. Both milk fat and protein levels were inferior to previous estimates for the two breeds [16]. Cecchinato et al [17] found significant breed disparities concerning the heritability for milk protein and fat between Brown Swiss cows (0.33) compared with Simmental cows (0.18). These results suggest that selection for fat and protein in Braunvieh breed should result in better phenotypic responses for the traits, to compensate for the lower milking ability in order for the breed to become competitive.

Given the unbalance size of the two experimental groups (10× in Fleckvieh vs Braunvieh) the potential statistical differences between the two breeds were difficult to detect for some of the studied traits. This might have happened because of the higher variability (standard error of the mean) detected in Braunvieh cows. To tackle this issue we have analysed the datasets for three consecutive years, while feeding, housing and milking technologies of the cows were identical cows, irrespective of their breed.

Somatic cells count (SCC) was not influenced by genotype ($p > 0.05$), with averages of 229.4 and 194.3 cells×1,000/mL in Fleckvieh and Braunvieh breed, respectively. Unexpectedly, the average SCC values for the Fleckvieh cows was above the threshold for the sub-clinical mastitis (>200 cells×1,000/mL). It is obvious that the amplitude of the somatic cell data is very high in both breeds, as well as variation. For example, the variation coefficient for this trait was 175.5% for Fleckvieh and 141.8% for Braunvieh. Taking into consideration this within breed variation the small difference between breeds (35.1×1,000 cells/mL) was not significant ($p > 0.05$). When the median was calculated, the results showed that dataset is skewed for both breeds. Thus, the median was 112×1,000 cells/mL for Fleckvieh and 96×1,000 cells/mL for Braunvieh. Both values were twice lower than the respective breed average. Very frequently the raw data regarding the somatic cell count is logarithmically transformed in order to reduce the

variance. In this case when the SCC data was transformed the following means were obtained: 11.62 ± 0.0412 for Fleckvieh and 11.50 ± 0.167 for Braunvieh. Medians were 11.626 and 11.471, respectively. These results showed that there was small difference between breeds regarding the somatic cell count in individual milk of cows per lactation.

Breeding for mastitis resistance is becoming increasingly important because of its effect on farm economy and animal welfare (lower productivity, discarded milk, lower selling prices, higher culling rates and higher veterinary costs). Furthermore, the unfavourable genetic correlations between milk production and mastitis are well known. The SCC has been already included in the total merit index, having a relative weight of 9.7% for the Austrian and German Fleckvieh [4], and an estimated heritability ranging between 0.07 and 0.17 [18,19].

The lifetime productivity of the cows commences from the onset of puberty and will be influenced by subsequent critical events including age at first calving, duration of the postpartum interval for each successive calving, conception rates and number of lactations. Puberty in heifers is mainly a consequence of the interactive effects of genetics and nutrition. Early onset of puberty is essential to achieving the first lactation and for shortening the non-productive period. In our study, age at first calving was significantly ($p \leq 0.01$) influenced by the breed, with Fleckvieh heifers being more precocious (-2.9 months) compared to those of Braunvieh breed (Table 1). Results are consistent with those reported by Diskin and Kenny [20] on the genetic effects on heifer puberty and subsequent reproduction outputs. Heritability estimates for age at puberty in Fleckvieh and Braunvieh breeds are in general considered to be moderate to high, with values of up to 0.40 [21], thus making this criterion suitable to selection. Given the significant breed disparities and economic implications of the trait, it is recommended for the industry to focus selection on reproductive precocity in the Romanian Braunvieh breed.

Generally, reproduction outputs in Fleckvieh and Braunvieh cows were not influenced ($p > 0.05$) by breed (Table 2). Data for the number of inseminations, calving intervals, days dry and days open in the two studied herds are in accordance with those previously reported [21,22] for European dairy and dual-purpose breeds. Reproduction efficiency relevance in dual-purpose breeds was demonstrated by Fuerst and Gredler [21] who reported that in Austria 24% of the culling rates are the result of poor fertility. Economic losses caused by poor fertility is of major concern to dairy industries around the world, with better herd management

Table 1. Averages (\pm SEM) for production yield related traits in Fleckvieh and Braunvieh cows

| Breed/trait | Milk yield (kg) | Fat (%) | Protein (%) | SCC (cells×1,000/mL) | Age at first calving (mo) |
|-------------|----------------------|-----------------|-----------------|----------------------|---------------------------|
| Fleckvieh | 5,252.1 \pm 35.79 | 3.93 \pm 0.01 | 3.29 \pm 0.01 | 229.4 \pm 14.69 | 32.8 \pm 0.29 |
| Braunvieh | 4,897.6 \pm 128.94 | 3.97 \pm 0.07 | 3.24 \pm 0.03 | 194.3 \pm 39.77 | 35.7 \pm 0.84 |
| p-value | 0.0149 | 0.5969 | 0.2264 | 0.5521 | 0.0030 |

SEM, standard error of the mean; SCC, somatic cells count.

Table 2. Averages (\pm SEM) for reproduction efficiency traits in Fleckvieh and Braunvieh cows

| Breed/trait | Inseminations per gestation | Calving interval (mo) | Dystocia incidence (%) | Days dry | Days open |
|-------------|-----------------------------|-----------------------|------------------------|------------------|-------------------|
| Fleckvieh | 1.78 \pm 0.03 | 385.8 \pm 1.65 | 15.70 \pm 1.79 | 73.37 \pm 0.63 | 122.0 \pm 4.11 |
| Braunvieh | 1.83 \pm 0.13 | 379.1 \pm 4.16 | 14.29 \pm 5.46 | 72.57 \pm 1.73 | 124.1 \pm 10.10 |
| p-value | 0.6596 | 0.2123 | 0.8100 | 0.3649 | 0.6163 |

SEM, standard error of the mean.

temporarily preventing the onset of diseases and reduced fertility. However, these result in increased production costs, and therefore a combination of better management and genetic selection for good health and fertility should be advisable as a long-term solution. The need for inclusion of health and fertility traits in selection programmes has been strengthened by several findings of an unfavourable genetic correlation with milk production traits [1].

Out of all the traits routinely used for evaluation of the reproduction efficiency in cattle, dystocia has the most important negative effects on the overall reproductive performance and functional longevity. In the current research, dystocia incidence was 15.70% and 14.29% in Fleckvieh and Braunvieh cows, respectively. Dystocia incidence for the two studied herds was within limits reported for dairy and dual-purpose breeds [23].

Functional traits such as calving ease, udder health, feet and legs, functional longevity and fertility have become more and more important when designing new selection strategies for cattle [1,2].

Sub-clinical mastitis (Table 3) had an average incidence of 24.63% in Fleckvieh and 27.08% in Braunvieh cows, with breed-related difference not being significant ($p > 0.05$). Results on the incidence of sub-clinical mastitis are in agreement with previous reports on dairy herds. The reduction in milk yield associated with sub-clinical mastitis has been estimated to 80 and 120 kg per lactation per two fold increase in SCC above 50,000 cells/mL in primiparous and multiparous cows, respectively [24].

Genotype of cows had no influence on the incidence rate of clinical mastitis, with occurrence rates of 4.12% and 2.08% in Fleckvieh and Braunvieh breed, respectively. Although the clinical mastitis incidence for the Fleckvieh breed was two-folded, compared to the Braunvieh, differences were not significant ($p > 0.05$). Hortet and Seegers [24] reported a yield loss per entire lactation due to clinical mastitis of 300 to 400 kg in multiparous cows and 200 to 300 kg in primiparous cows. Additionally to milk yield losses, the farm costs are increased by the cumulative effects of veterinary treatments, lower milk quality and higher culling rates.

Lameness incidence was not influenced ($p > 0.05$) by breed,

with 2.89% of the Fleckvieh and 4.76% of the Braunvieh cows being affected by clinical lameness (Table 3). Previous studies have shown the significant impact of lameness on milk production, with estimates of reduction in milk yields between 270 and 440 kg per lactation [25]. The prevalence of lameness in intensive dairy farms is high, up to 15% to 20% [26], values that are significantly higher compared to the results from current study.

Stayability of the cows was significantly ($p \leq 0.001$) influenced by breed, with Braunvieh cows having an average age at culling of 117.88 months (9.82 years) compared to 90.88 months (7.57 years) in Fleckvieh group. Previously published data regarding the stayability in European dual-purpose cows reported significant shorter longevity [27]. Higher longevity in the studied herd compared to that from commercial farms could be attributed to the general better feeding and management conditions in this research facility, with animals being looked after by two veterinarians and an equal number of technicians, which could have contributed to a better health management than occurring in commercial farms. Although the two studied breeds have shown a remarkable stayability, given the economic and animal welfare implications of the trait, especially in the Fleckvieh herd, stayability should be considered as a selection trait, given that for the Canadian Simmental heritability for stayability to second calving was estimated to 0.35 [27].

Abortion rates were 1.79% and 0.64% in Fleckvieh and Braunvieh cows, respectively, with abortion occurrence rates not being significantly influenced ($p > 0.05$) by the genotype. Murray [28] reports occurrence rates for abortions ranging between 3% and 10% in large dairy cattle farms, significantly higher figures compared to those from the current study.

Data on culling rates and reasons in Fleckvieh and Braunvieh cows are shown in Table 4. Generally, the culling rate and reasons for culling were not significantly influenced by the cow's breed ($p > 0.05$), although genotype-related disparities can be observed.

Average culling rates during the 3-year study were 19.8% in Fleckvieh cows and 28.5% for the Braunvieh group ($p > 0.05$). Similar culling rates were reported by Knaus [29] for dual-purpose

Table 3. Averages (\pm SEM) for functional traits in Fleckvieh and Braunvieh cows

| Breed/trait | Sub-clinical mastitis (%) | Clinical mastitis (%) | Lameness (%) | Stayability (mo) | Abortions (%) |
|-------------|---------------------------|-----------------------|-----------------|--------------------|-----------------|
| Fleckvieh | 24.63 \pm 0.15 | 4.12 \pm 0.72 | 2.89 \pm 0.82 | 90.88 \pm 2.89 | 1.79 \pm 0.40 |
| Braunvieh | 27.08 \pm 0.64 | 2.08 \pm 2.08 | 4.76 \pm 3.32 | 117.88 \pm 11.78 | 0.64 \pm 0.64 |
| p-value | 0.7035 | 0.4843 | 0.5058 | 0.0001 | 0.2910 |

SEM, standard error of the mean.

Table 4. Averages (\pm SEM) for culling rates and culling reasons in Fleckvieh and Braunvieh cows

| Breed/trait | Culling rate (%) | Cervicitis (%) | Infertility (%) | Cystic ovaries (%) | Udder related causes (%) |
|-------------|------------------|-----------------|-----------------|--------------------|--------------------------|
| Fleckvieh | 19.8 \pm 1.96 | 1.93 \pm 0.67 | 6.76 \pm 1.23 | 5.79 \pm 1.14 | 5.31 \pm 1.10 |
| Braunvieh | 28.5 \pm 7.05 | 4.76 \pm 3.32 | 9.52 \pm 4.58 | 7.14 \pm 4.02 | 9.52 \pm 4.58 |
| p-value | 0.1816 | 0.2337 | 0.5056 | 0.7254 | 0.2632 |

SEM, standard error of the mean.

cows.

Out of all culling reasons, infertility was most prominent in both breeds, affecting 6.78% and 9.52% of Fleckvieh and Braunvieh cows, respectively ($p > 0.05$). It was followed by udder-related causes, with 5.31% in Fleckvieh and 9.52% in Braunvieh herd ($p > 0.05$). Cystic ovaries was ranked the third reason for culling, with 5.79% and 7.14% in Fleckvieh and Braunvieh breed ($p > 0.05$), respectively. The overall culling reasons and motives pattern was similar to reports by Ahlman et al [30] on Swedish Red and Holstein dairy breeds.

Knowledge on the reasons for culling in cattle herds is important to both farmers and veterinarians, to be able to formulate proper health management plans and to identify problems that occur in the commercial farms, by setting-up up 'alarm' thresholds. It also helps in the decision making process regarding changes in reproductive management and/or choice of bull semen with high estimated breeding values for longevity and fitness traits.

Further studies, with more detailed information regarding the onset and causes of health disorders are needed to properly address genetic and environmental effects on cow productivity, in order to account for their influence on longevity. Phenotypic and genetic evaluation of fitness characteristics in dual-purpose cattle under a wide range of environments and production systems should be undertaken by researchers in collaboration with farmers' organizations, in order to define new selection indexes.

IMPLICATIONS

Comparison of the two dual-purpose breeds for their productive and reproductive outputs, as well as functional traits under European temperate conditions was considered necessary knowledge for the cattle industry. Further research on feed efficiency, growth performances, carcass, and meat quality under different rearing systems to effectively understand production efficiency in Fleckvieh and Braunvieh breeds would provide valuable information for the cattle sector in Europe and worldwide. Results suggest that genotype significantly influenced milk production, age at first calving and longevity. This may in turn result in different economic weight of the selection traits in the future breeding goals for Fleckvieh and Braunvieh breeds.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial

organization regarding the material discussed in the manuscript.

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