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Effect of Environmental Conditions in Milk Production Under Small-Scale and Semi-Extensive Conditions in Kosovo

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1. Introduction

During the war in 1998-99, farmers in Kosovo lost 200,000 cattle, or approximately half the national cattle population (Kodderitzsch & Veillerette, 1999). After the war the Food and Agriculture Organization (FAO) and the World Bank implemented a joint cattle-restocking project in Kosovo as part of the Emergency Farm Restocking (FAO/WB/EFR) project, to improve the nutrition and food security of poor households affected by the conflict. The project was started in October 2000 lasting till 2003, importing around 4500 cattle of the Simmental (S), Brown Swiss (BS) and Tyrol Grey (TG) breeds, in three project phases. The cattle were distributed to six municipalities (Deqan, Skenderaj, Glllogoc, Klina, Vushtrri, and Peja) that had suffered the greatest losses to their livestock. The cattle were given to the households who had lost all their animals during the war, such that these could restart livestock production activities. Moreover, the project contributed to upgrade the national cattle population in Kosovo.

1.1. Review of the literature

The literature review is made up of four parts. Part one offers a general description about the rural communities and agro-ecological factors in Kosovo, part two describes cattle production in Kosovo, part three provides brief information about the history of the three imported cattle breeds (S, BS, and TG), while part four describes the characteristics of analysed traits (i.e., milk production, growth rate, service period, non-return rate, body condition score, shape of lactation curve, and milk production efficiency), as well as giving an introduction to estimation of environmental sensitivity from variance components of the three breeds.

1.2. Rural communities and agro-ecological factors in Kosovo

Kosovo is located in southeast of Europe, with about 2 million inhabitants. The land area is 10,887 km², of which about 53% is cultivable. The climate in Kosovo is typically semi-continental, with average annual rainfall of 631 mm and average temperature of 11°C, for the last 20 years. At present, family sizes in rural Kosovo are large, with an average of 9.64 members. Farm sizes are small, about 55% ranging 1 – 3 Ha.

1.3. Cattle production in Kosovo

Cattle production is the most important segment of the economy in rural household in Kosovo. The cattle production includes various breeds and categories of cattle, in total around 320,000 heads. To date, cattle production in Kosovo can be clearly defined as an industry consisting of two sectors, the small-scale cattle farmers (about 95% of the national cattle population), mainly producing for home consumption (but also for market sale during some periods of the year), and commercial farmers (less than 5% of the national cattle population) producing solely for the market. The cattle production of Kosovo on small-scale farms has many characteristics typical for cattle production in developing countries, as it depends almost exclusively on the resources locally available on the farm and basically aims at fulfilling the households' own needs.

Normally, the cattle are kept in the barn from the second half of November until the end of April (winter period). Feeding with fresh-green feedstuffs usually starts in May. However, due to small size of land owned by the private farmers, cultivation of such feedstuffs is often fragmented in 4-5 plots, sometimes located at large walking distances from the house. The grazing period for cattle normally starts after the first harvest of grass, in June and lasts until November, i.e., for approximately six months (summer period). Small diversity of feed sources, limited resources for grazing, and other factors (i.e., small barns, poor hygiene, etc.) make intensive dairy production difficult and often unfavourable in such small-scale farms.

The cattle population in Kosovo mainly consists of dual-purpose breeds of widely different body sizes and production capacities (i.e., Busha, Simmental, Brown Swiss, Tyrol Grey, Holstein and their crosses). Through the aid operations foreign breeds (S, BS, and TG) were brought to Kosovo and allocated to small-scale farms.

1.4. History of imported cattle breeds (S, BS, and TG)

Although these breeds are characterized as dual-purpose, literature suggests clear differences (Simon & Buchenauer, 1993). The Simmental (Fleckvieh) is amongst the oldest and most widely distributed of all cattle breeds in the world. The origin of this breed is the Simme valley in the western part of Switzerland, from where the name derives. Today, this breed accounts for about 40–60 million cattle on all six continents and is known by a variety of names (i.e., “The Fleckvieh” in Germany, Austria and Switzerland; “Pie Rouge”, “Montbeliard”, and “Abondance” in France and “Pezzata Rossa” in Italy). The Simmental is known as a typical dual-purpose breed that combines characteristics of milk and beef, but

with somewhat different emphasis on traits in different sub-populations. Based on data from Germany and Austria, average milk yield in lactation is about 6500 kg (Cattle breeding in Austria, 2003; Rinder production in der Bundesrepublik Deutschland, 2001). Average growth rate of steers/bulls can amount to averages of 1400 g/day. The coloration of Simmental varies from yellowish brown to straw color and dark red, with white markings on the head, brisket, belly and legs. No current information is available to establish whether there are significant genetic and phenotypic differences between Simmental and local red and white cattle in Kosovo).

The Brown Swiss originates from "Braunvieh" cattle in Switzerland, which was well known for the dual-purpose characteristics. The Braunvieh cattle were brought to USA between 1869 and 1880, where the cattle-breeding program put more emphasis on milk (Zogg, 1997). Today, this breed has a variety of names (i.e., "Brown Swiss" in USA and Canada; "Braunvieh" in the German speaking countries; "Bruna Alpina" in Italy; "Brunedes Alpes" in France, and "Parda Suizo" in Spain and Latin America). Based on German and Austrian data average milk production in lactation is about 6700 kg (Cattle breeding in Austria, 2003; Rinder production in der Bundesrepublik Deutschland, 2001). Average growth rate of steers can amount to 1000–1200 g/day (Atlas der Nutztierassen, 1994; Gruter, 1997). The coloration of Brown Swiss consists of various shades of brown ranging from light brown with grey to very dark brown (Gruter, 1997; Herzog, 1997).

Tyrol Grey are grey cattle originating from Tyrol-Austria, where they are used in typical mountain farming under rough conditions. The milk yield of the breed is around 4700 kg in lactation (Cattle Breeding in Austria, 2003). On low feedlevels, the Tyrol Grey steers achieve an average growth rate of 1100 g /day (Atlas der Nutztierassen, 1994; Frickh, 1999). Tyrol Grey herds have a higher proportion of older cows (> 8 yrs), compared with Simmental and Brown Swiss, respectively (Wallnofer, 1999; Rinder production in der Bundesrepublik Deutschland, 2001), which may indicate good breed characteristics for functional traits.

1.5. Characteristics of analysed traits

After the importation of all three cattle breeds to Kosovo, there was both a need and a unique opportunity to compare the introduced breeds with respect to their suitability to the smallholder management system of Kosovo. Introduction of highly productive breeds of dairy cattle into an extensive environment will often lead to reduced milk production, as well as an increased risk of reproductive and metabolic disorders (Calus & Veerkamp, 2003; Cienfuegos-Rivas et al., 1999; Horan et al., 2005). Thus, breeds well adapted to the environmental conditions in Western Europe may be poorly suited to the more extensive Kosovo environment.

One way to identify the most appropriate cattle breed for Kosovo would be to rely on a profit approach, requiring measurement of all traits affecting profit. Alternatively, one could choose to select the breed that is best fitted to the local environment as measured by some indicator traits (e.g., milk production, interval from calving to first insemination, body condition score, shape of lactation curve, estimated milk production efficiency, and environmental sensitivity). The traits that were included in this analysis are productive

traits (milk yield and calf growth rate) with major influence on income (Haile-Mariam et al., 2003), fertility performance (i.e., interval from calving to first insemination and nonreturn rate) affecting costs of production (Stott et al., 1999), and body condition score, which is a useful tool for assessing energy status of the cow (Lowman et al., 1976; Edmonson et al., 1989). The breeds were also compared with respect to the shape of the lactation curves, efficiency of milk production, and environmental sensitivity, estimated through heterogeneity of variance components.

In dairy cattle breeding, the largest emphasis in selection of most breeds has been for increased production, because this improves feed efficiency, i.e., feed cost per unit of milk produced (e.g., Svendsen et al., 1994). The logic is that increased milk production will “dilute” feed requirements over more units of milk, primarily the maintenance requirement, and thus improve efficiency of production.

Selection for greater milk production will lead to an increasing nutritional demand, primarily energetic, that has to be met by: 1) increasing the feed intake, 2) by body tissue mobilisation or by 3) partitioning from other traits. It is generally accepted that the genetically correlated response in feed intake when selection is on production ($r_g = 0.46 - 0.65$; Veerkamp, 1998) is not large enough to cover the additional requirements (energy) due to increased production (Van Arendonk et al., 1989, 1991; Veerkamp & Thompson, 1999). This is also so as there is little evidence for genetic variance for the rate of efficiency at converting nutrients into milk (Blake & Custodio, 1984; Gibson, 1986; Svendsen et al., 1993; Veerkamp & Emmans, 1995; Zamani et al., 2011).

In consequence, selection for increased milk production will lead to a larger negative energy balance (Gallo et al., 1996; Veerkamp et al., 2000, 2001), especially when selecting for a peaked lactation curve in early lactation, increasing the level of non-esterified fatty acids, impairing the glucose synthesis (Overton et al., 1999; Rukkwamsuk, 1999), enhancing the risk of ketosis and for the fatty-liver syndrome (Baird, 1982; DeVries & Veerkamp, 2000; Loeffler et al., 1999). Further, the large negative energy balance will reduce fertility (Butler & Smith, 1989; Nebel & McGilliard, 1993; Senatore et al., 1996; Domecq et al., 1997; Rukkwamsuk, 1999; Buckley et al., 2003) and may increase the risk of mastitis and milk fever. Direct selection against a negative energy balance, being the difference between what is consumed and the requirements for yield and maintenance, relies on measuring feed intake, and is therefore difficult to select for (Collard et al., 2000). An alternative is to base selection on the body condition score, that can be used to monitor energy balance during the lactation (Wildman et al., 1982). Pryce et al. (2000, 2001), and Dechow et al. (2001, 2002) have reported a genetic relationship to fertility, e.g., that improved body condition scoring was genetically correlated with a shorter interval from calving to first insemination, i.e., the service period, being strongly determined by the energy balance (e.g., Van der Lende, (1998), cows coming into heat when the energy balance becomes positive. However, non-return rate is physiologically more strongly related to early embryonic death (Van der Lende, 1998).

From this, one should expect a negative genetic correlation between milk production and the interval from calving to first insemination, e.g. found by Andersen-Ranberg et al. (2005a), but also to other traits that depend on available resources, primarily energy, i.e.,

ketosis, other aspects of fertility as retained placenta, clinical mastitis, and also milk fever, as also demonstrated by Heringstad et al. (2005). These latter traits, together with service period, make up a group of traits that can be denoted as metabolic health. To this group a part of fertility aspects, also belong the fatty-liver syndrome, displaced abomasum, animal behaviour and disease resistance.

Despite the negative genetic correlation between milk production and metabolic health, Heringstad et al. (2005) also showed genetic progress for all the examined traits, resulting from field recording, on large daughter groups, and with considerable weighting of both trait groups to the breeding goal. This is a rather different result than what is expected from one-sided selection for increased milk production, indicating that different partitioning between traits results as a consequence of selection. Another way of demonstrating differences in partitioning would be through breed comparison, for which the comparison of amongst others the Norwegian Red with Holstein in Ireland can be used as an example, the latter considered one-sided selected for increased milk production. Results of Buckley et al. (2000, 2003) again indicate rather different partitioning between breeds for different traits, e.g. for body condition score and milk production. Hence, to improve the partitioning between traits in the Holstein, an alternative to this Nordic scheme would be to rely on selecting for an improved energy balance directly, as measured by the body condition score. Differences in genetics, management practice and environment cause variation in the shape of the lactation curves, both within and between cattle breeds (e.g. Grossman et al., 1986; Ray et al., 1992; Tekerli et al., 2000; Dillon et al., 2003). Some studies indicate that dairy cows having a flatter lactation curve tend to be more persistent than those with a steeper curve (Ferris et al., 1983; Grossman et al., 1986; Tekerli et al., 2000). Further, a flatter lactation curve may also reduce incidence rates of metabolic disorders and reproductive problems that originate from physiological stress due to high milk production (Pryce et al., 1997; Dekkers et al., 1998).

When comparing breeds for milk production efficiency, one way is to only consider feed requirements for maintenance against milk production, the former being closely associated with the body weight of the cow (W), through the metabolic body weight ($\hat{W}^{0.75}$) (McDonald et al., 1995). The considerable differences that are known to exist between the breeds for body size and those observed for milk production should therefore be taken into account. Lately, it was observed that the high producing breeds may be more sensitive to the variable environment, between e.g. from farm to farm or from day to day, introducing a genotype by environment interaction (Calus & Veerkamp, 2003; Dillon et al., 2003, Hayes et al., 2003), which also may affect the level of production during the course of lactation. The interaction can be tested by calculating variance components both between and within cows of each breed, on a test-day basis. The logic is that a larger variance component for a breed indicates larger environmental sensitivity, i.e., genotype by environment interaction (Lynch & Walsh, 1998).

1.6. Aim of the review

The overall objective of this review was to possibly identify the most appropriate cattle breed for Kosovo. As these breeds differ both with respect to breed characteristics and

breeding goals (Dillon et al., 2003), the different breeds may respond differently to different environments (Falconer & Mackay, 1996; Lynch & Walsh, 1998; Bourdon, 2000). Three sub-goals were identified, first, to compare production, fertility and body condition score of the three imported breeds under the small-scale farming system in Kosovo. Secondly, the goal was to compare the three breeds for their shape of lactation curve and milk production efficiency, and thirdly, to compare variance components for daily milk yield both between and within cows of the different breeds, to possibly identify environmental sensitivity, i.e., genotype by environment interaction (Veerkamp et al., 1995).

2. Materials and methods

2.1. Description of project

The project was carried out from October 2000 till June 2003, and cattle were imported during the years 2000 – 2002; S and BS cows the first year, and S and TG the last two years.

Import phase	Simmental		Brown Swiss		Tyrol Grey	
	Heifers	Bulls	Heifers	Bulls	Heifers	Bulls
2000	1749	32	678	13	-	-
2001	1182	25	-	-	199	10
2002	532	10	-	-	60	2
Total	3463	67	678	13	259	12

Table 1. Number of imported heifers and bulls of Simmental, Brown Swiss and Tyrol Grey in three importation phases.

The total number of imports were 3463, 678, and 259 heifers of S, BS, and TG, respectively. S and BS were from Germany and Austria, while TG was imported from Austria. At importation, heifers were 4-7 months pregnant (Table 1).

The cows were donated to farms (one per farm) that had suffered the greatest losses to their livestock during the war. The farms were distributed in 228 villages, with an average of approximately 20 donated cows per village. For animals imported in the first year, calving was mainly from December till end of May (about 60% in January and February). In the third year, calving was between August and December (more than 50% in October and November). After calving the heifers were re-mated to a bull of the same breed, mainly by use of artificial insemination (A.I.) (56%), but also by natural mating to imported bulls (44%).

2.2. Data recording

Data were from the FAO/WB/EFR project in Kosovo. The cattle were monitored for a period of 14-16 months, and the database that was built holds information from several sources, i.e., farmer, contracted veterinarians and project staff. The data consisted of eartag number, breed, year of importation, village of donation, birth date, different events (i.e., mortality date and dates of different diseases (mastitis, metabolic disorders, ketosis, etc.), calving date, milk production (monthly test-day milk yield), calf data (i.e., calf sex, weaning date and

hearth-girth circumference at birth, 3 and 10 months of age), fertility information (insemination dates till third mating, non-return, and whether mating was natural or by A.I. (mating type)), body condition score (i.e., subjective, within one week after calving and within one week after first insemination, respectively), as well as socio-economic data (i.e., household headed by a female, size of land, size of the family, existence of members within the family older than 65 years of age, existence of members within the family younger than 12 years of age, whether the family had cows before the donated one, and sex of beneficiary). The farmers recorded the milk yield themselves and were trained for detection and recording of different events as well as date of mating, (natural mating). The project staff recorded heart-girth data as well as body condition score, and also socioeconomic data. The contracted veterinarians were responsible for recording the information on fertility by A.I.

In some farms the data were partially or completely missing, which might be explained by lack of recording practice. Unreliable data (e.g., daily milk production smaller than 3 kg or larger than 50 kg, the first and last record for one cow being either observed earlier or later than, respectively, 30 and 280 days in milk, 1st insemination before 20 days postpartum) and data deriving from incomplete lactations (254) were excluded from the final dataset, which was the basis for the statistical analyses included in this study.

2.3. A comparison of the productive, reproductive and body condition score traits

2.3.1. Milk production

Daily milk production was measured as the average of the yield in the morning and evening on a monthly basis. From the first 10 test-day records, the average over 305 days in milk in the first lactation was calculated, for analysis. Only cows having all 10 records were included (Table 2).

Traits	Simmental			Brown Swiss			Tyrol Grey		
	N	X	SD	N	X	SD	N	X	SD
AMY305	1900	11.96	2.68	444	12.69	2.84	172	10.82	1.89
BWC	328	39.45	2.68	73	38.15	2.34	73	32.59	2.01
GRC3	281	0.86	0.16	62	0.74	0.10	68	0.65	0.08
GRC10	254	0.96	0.16	59	0.76	0.09	66	0.72	0.07
SP	3179	102.33	47.35	582	119.37	50.23	242	97.02	40.23
NRR	3261	0.46	0.52	623	0.33	0.53	244	0.52	0.57
BCSC	791	3.28	0.34	200	3.21	0.33	118	3.24	0.29
BCSS	791	2.52	0.34	200	2.35	0.34	118	2.62	0.30

¹AMY305 = Average milk yield over first 305 days of first lactation (kg/day); BWC = Birth weight of calf (kg); GRC3 = Growth rate of calf over first 3 months of age (kg/day); GRC10 = Growth rate of calf over first 10 months of age (kg/day); SP = Service period (days); NRR = Non-return rate at first insemination (%); BCSC = Body condition score, within one week after calving (1-5); BCSS = Body condition score, within one week after service (1-5).

Table 2. Number of records (N), mean (X) and standard deviation (SD) for each trait and breed.

2.3.2. Calf growth rate

Calf body weights were estimated based on hearth-girth circumference at birth, at 3 months (weaning), and at 10 months of age, and used for calculation of calf growth rates from birth until 3 and 10 months of age, respectively (Table 2). These two later traits were analyzed as well as birth weight of calf.

2.3.3. Fertility

The interval from calving to first insemination, i.e., the service period was analysed as well as the non-return rate at first insemination, coded 1 if a cow did not return to service after the first insemination and 0, otherwise (Table 2).

2.3.4. Body condition score

In Table 2, the body condition was scored at the loin, pelvis and tail head within one week after calving, and within one week after first insemination. The scoring was from 1 (very thin) to 5 (very fat) (Edmonson et al., 1989). The traits described above were exposed to an analysis of variance, using the PROC GLM procedure (SAS Institute Inc., 1999) of the SAS-package. Generally, in order to estimate a possible breed effect, on the different traits: 305 days milk yield, birth weight of calf, calf growth rates until 3 and 10 months of age, service period, non-return rate, and body condition scores, at calving and at mating), univariate fixed effect models were used. The final model was chosen using backward elimination by removing non-significant ($P \geq .05$) explanatory variables from the model, one at a time. Several socio-economic indicators were recorded and tested as explanatory variables. These were; gender of household head, farmland area, number of family members, existence of family members above 65 years of age, existence of family member below 12 years of age, gender of the beneficiary, and whether or not the family had owned a cow before the donated one. For all traits, the effects of importation phase x village and month of calving were included. Age at first insemination and mating type were only considered for non-return rate, while sex of calf was included for weight and growth traits, respectively. To estimate for a possible breed x ration effect on the formerly described traits, information on feeding was recorded in 166 randomly chosen farms, and used in a separate analysis.

2.4. Lactation Curves and production efficiency

In this study, milk yield test-day records for cows in first lactation of the three breeds (S, BS and TG) were used in a statistical analysis with a linear model aimed at comparing lactation curves and milk production efficiency of the three breeds.

The applied model was used:

$$Y_{ijklmn} = BLM_i + PV_j + CM_k + HHF_l + c_m + e_{ijklmn}$$

where:

Y_{ijklmn} = milk yield record n of cow m in breed-lactation month class i , importation phase-village class j , calving month k , and gender effect of owner class l ;

BLM_i = fixed effect of first-lactation breed-lactation month class i , in 30 classes from 3 breeds and 10 months;

PV_j = fixed effect of phase-village class j , in 176 classes, from 3 phases and 99 villages;

CM_k = fixed effect of calving month k , in 12 classes;

HHF_l = fixed effect of gender of owner l , in 2 classes;

c_m = random effect of cow m : $\sim (0, \sigma_c^2)$, σ_c^2 being the cow variance; and

e_{ijklmn} = random residual term: $\sim N(0, \sigma_e^2)$, with σ_e^2 denoting the residual variance.

As in previous study, data were restricted to cows having 10 monthly test-day milk yield records in first lactation. In total, 25,160 records from 2516 cows were included in the analysis (Table 3).

Breed	Cows in project	Cows in analysis	Test-day records
S	3463	1900	19.000
BS	678	444	4440
TG	259	172	1720
Total	4400	2516	25,160

Table 3. Number of cows and number of test-day records for milk yields over the first 10 months of lactation (305 days) in cows of Simmental (S), Brown Swiss (BS) and Tyrol Grey (TG) breed.

To compare milk production efficiency of the three breeds, average body weight of each breed was derived, using measure of hearth-girth circumference. Body weight records were available for 102, 64 and 47 cows of S, BS and TG, respectively. The S cows weighed on average 572 kg, while the BS and TG were on average 533 kg and 445 kg, respectively. Based on the estimated average body weight (W) for each breed, average metabolic body weights were estimated as $\hat{W}^{0.75}$ (McDonald et al., 1995).

The statistical analyses were conducted using the PROC MIXED procedure of the SAS software package (SAS Institute Inc., 1999). All effects that had shown a significant effect ($P < 0.05$) on 305 days milk yield were considered in the analysis: Breed, importation phase x village, calving month, and whether the household was headed by a female or not. With the aim of modelling lactation curves of the different breeds, a breed x lactation month effect replaced the main effect of breed. As cows had repeated records during the lactation, a random cow effect was included, while the other effects were considered as fixed. From the monthly least-squares mean of daily milk yield (LSM_{DMY}), metabolic body weight per kg of milk per month was calculated as $\hat{W}^{0.75} / LSM_{DMY}$.

2.5. Estimation of environmental conditions on milk production for dairy breeds comparison using random regression models

In this study were utilized the same data as in previous one. Here, daily milk yield was analyzed with seven different models, consisting of both repeatability and random regression test-day models.

All models had the following general characteristics:

$$DMY_{ijklmn} = BLM_{ij} + PV_k + CM_l + HHF_m + \sum_{p=0}^q r_{pn} Z_p(j) + e_{ijklmn}$$

where:

DMY_{ijklmn} = daily milk yield of cow n , of breed i , in lactation month j , importation phase village class k , calving month l , and gender effect of household head class m ;

BLM_{ij} = fixed effect of breed · lactation month class ij , in 30 classes (3 breeds and 10 lactation months);

PV_k = fixed effect of phase village class k , in 176 classes (3 phases and 99 villages);

CM_l = fixed effect of calving month l , in 12 classes;

HHF_m = fixed effect of gender of household head class m , in 2 classes;

$Z(j)_p$ = p^{th} order orthogonal polynomial of lactation month j ;

r_{pn} = p^{th} order random regression coefficient of cow n ; and

e_{ijklmn} = random residual.

The following models were specified:

REP1 = initial repeatability model with $q = 0$, assuming homogeneous cow and residual variances;

REP2 = extension of REP1, with heterogeneous residual variance for each month of lactation;

REP3 = extension of REP2, with heterogeneous cow variance per breed;

REP4 = extension of REP2, with heterogeneous residual variance per breed · lactation month class;

REP5 = combination of REP3 and REP4, with heterogeneous cow variance per breed, and heterogeneous residual variance per breed · lactation month class;

RR1 = extension of REP5 with $q = 1$ (1st order random regression of cow effects); and

RR2 = extension of RR1, with $q = 2$ (2nd order random regression of cow effects).

Initially, yield records (Table 3) were analyzed using a repeatability test-day model similar to the statistical model in the second study. Subsequently, this model was extended to allow heterogeneous cow and residual variances for the different breeds, and random regression models of varying orders were tested. The models were compared using a likelihood-ratio test statistics and Akaike information criterion (Akaike, 1973).

$$LR = 2[\ln RL(j) - \ln RL(i)] \sim \chi_{v_j - v_i}^2 \quad (1)$$

The likelihood-ratio test statistics (**LR**) for two models i and j , with the restricted model i nested within the model j , was presented in Equation 1: where $\ln RL(i)$ and $\ln RL(j)$ are the $\ln RL$ values of the models to be compared, and v_i and v_j are the corresponding number of (co)variance components in the models.

$$AIC = 2[\ln RL(i) - \ln RL(0) - (v_i - v_0)] \quad (2)$$

Models were also compared on Akaike information criterion (AIC) (Akaike, 1973), favoring models with fewer parameters (Equation 2): where $\ln RL(0)$ and v_0 are, respectively, the \ln restricted likelihood and number of (co)variance components of the base model (i.e., REP1). For all likelihood-based criteria, the model with the largest values was considered as having the best fit. The ASREML software (Gilmour et al., 1999) was used in all statistical analyses.

To determine whether breed differences in size of variance components could be attributed to scale effects (Falconer and Mackay, 1996), the coefficient of variation (**CV**) was calculated for each breed as follows:

$$CV = \frac{\sigma}{\bar{y}} \times 100 \quad (3)$$

where σ is the square root of the estimated variance component for a specific month of lactation in the preferred model, and \bar{y} is the corresponding estimate for BLM_{ij} (Equation 3).

3. Main results

3.1. A comparison of the productive, reproductive and body condition score traits

The breeds differed significantly with respect to milk production ($P < 0.0013$; Table 4). The BS yielded the highest average daily milk production, followed by S and TG, the least-squares means being less with by 0.59 and 2.72, respectively (Table 6).

Month of calving had a clear significant effect on milk yield ($P < 0.0001$; Table 4), with the highest milk yield obtained during the winter period.

Service period was affected by calving month ($P < 0.0001$; Table 4), favoring the cows that calved during spring period. Cows from households headed by a man produced more milk (0.42 kg) than cows in households headed by a female ($P < 0.0051$; Table 4). Significant breed differences ($P < 0.0001$) were found for weight of calf at birth and growth rates until 3 and 10 months of age, respectively (Table 4). The S calves had both the highest birth weight and the highest growth rate, compared with BS and TG (Table 6).

Sex of the calf showed a significant effect on birth weight and growth rate traits ($P < 0.0001$), with males having the largest values for all breeds (Table 4).

In Table 5, significant breed differences were found for service period ($P < 0.0001$), the least-squares mean being longest for S (125 days), followed by BS (114 days) and TG (97 days) presented in Table 6.

Traits	Breed	Importation phase x village	Calving month	Age - 1 st insemination in 1 st lactation	Sex of calf	Method of insemination	HHF	SL	SF	FM>65	FM<12	FCBD	SB
AMY305	<.0013	<.0001	<.0001	-	-	-	<.0051	NS	NS	NS	NS	NS	NS
BWC	<.0001	NS	NS	-	<.0001	-	NS	NS	NS	NS	NS	NS	NS
GRC3	<.0001	NS	NS	-	<.0001	-	NS	NS	NS	NS	NS	NS	NS
GRC10	<.0001	NS	NS	-	<.0001	-	NS	NS	NS	NS	NS	NS	NS
SP	<.0001	<.0001	<.0001	-	-	-	<.0366	NS	NS	NS	NS	NS	NS
NRR	<.0048	<.0001	NS	NS	-	<.0001	<.0191	NS	NS	NS	NS	NS	NS
BCSC	NS	<.0056	NS	-	-	-	NS	NS	NS	NS	NS	NS	NS
BCSS	<.0059	<.0129	NS	-	-	-	NS	NS	NS	NS	NS	NS	NS

¹NS = Not significant, i.e. level of significance ≥ 0.05 ;

²Breed = (Simmental, Brown Swiss, or Tyrol Grey); Importation phase x village = (1,2 or 3) x (1, . . . , 228)); Calving month = (1, . . . , 12); Age-1st insemination in 1st lactation = (months 22, . . . , 45); Sex of calf = (female or male); Method of insemination = (artificial or natural); HHF = (household headed by a female (yes or otherwise); SL = (Size of land (<1 Ha, 1 Ha \leq - <2.5 Ha, and \geq 2.5 Ha); SF = (size of the family (< 7, 7 – 11 and \geq 12); FM>65 = (members within the family older than 65 years of age (yes or otherwise); FM<12 = (members within the family younger than 12 years of age (yes or otherwise); FCBD = (family had cows before donated one (yes or otherwise); and SB = (sex of beneficiary (female or male). ³AMY305 = Average milk yield over first 305 days of first lactation (kg/day); BWC = Birth weight of calf (kg); GRC3 = Growth rate of calf over first 3 months of age (kg/day); GRC10 = Growth rate of calf over first 10 months of age (kg/day); SP = Service period (days); NRR = Non-return rate at first insemination (%/100); BCSC = Body condition score within, one week after calving (1-5); BCSS = Body condition score, within one week after service (1-5).

Table 4. Level of significance for effects model to affect various trait in analyses of a breed effect.

The cows managed in households headed by a female had shorter service period (4 days) than cows in households headed by a man ($P < 0.0366$; Table 4).

For non-return rate, significant breed differences were estimated ($P < 0.0048$), from significant differences in leastsquares mean between S and BS (Table 6). S had the highest success rate on conceiving at first insemination (53%), followed by BS (44%) and TG (40%) (Table 6).

In Table 5, the method of insemination significantly affected non-return rate ($P < 0.0001$), with about 57% success for natural service compared with 34% in artificial insemination.

Whether the household was headed by a man or a woman also significantly affected the non-return rate ($P < 0.0191$), with female headed households being better than those headed by a man (Table 4).

No significant differences between breeds ($P > 0.1701$) were found for body condition score at calving (Table 4).

However, significant breed differences were found one week after insemination ($P < 0.0059$; Table 4), from significant least-squares mean differences between S and BS (Table 6). The TG

cows showed the smallest reduction of least-squares mean for body condition score, compared to S and BS (Table 6).

Traits	Breed × Ration	Importation phase	Village	Calving month	Age- 1 st insemination in 1 st lactation	Method of service
AMY305	<.0750	<.0298	<.8570	NS	-	-
SP	<.0011	<.7863	<.3386	NS	-	-
NRR	<.5992	<.5611	<.3974	NS	NS	NS
BCSC	<.1329	<.2183	<.2741	NS	-	-
BCSS	<.0017	<.2497	<.2245	NS	-	-

¹NS = Not significant, i.e. level of significance ≥ 0.05 .

²Breed x ration = (Simmental, Brown Swiss or Tyrol Grey x forage and concentrate or only forage); Importation phase = (1,2, or 3); Village = (1, . . . , 64); Calving month = (1, . . . , 12); Age-1stinsemination in 1stlactation = (months 22, . . . , 45); Method of service = (artificial or natural).

³AMY305 = Average milk yield over first 305 days of first lactation (kg/day); SP = Service period (days); NRR = Non-return rate at first insemination (%/100); BCSC = Body condition score, within one week after calving (1-5); BCSS = Body condition score, within one week after service (1-5).

Table 5. Level of significance for effects modeled to affect various trait) in analyses of a breed x ration effects.

Traits	Simmental		Brown Swiss		Tyrol Grey		S vs. BS	S vs. TG	BS vs. TG
	LSM	SE	LSM	SE	LSM	SE			
AMY305	11.76	0.26	12.35	0.29	9.63	0.92	< .0037	< .0270	< .0058
BWC	39.24	0.17	37.96	0.31	32.39	0.31	< .0002	< .0001	< .0001
GRC3	0.87	0.01	0.74	0.02	0.65	0.02	< .0001	< .0001	< .0004
GRC10	0.96	0.01	0.78	0.02	0.72	0.02	< .0001	< .0001	< .0026
SP	125.29	4.13	113.79	4.67	97.07	9.88	< .0001	< .0035	< .2282
NRR	0.53	0.02	0.44	0.03	0.40	0.11	< .0023	< .2355	< .7374
BCSC	3.28	0.02	3.21	0.04	3.14	0.17	< .0611	< .4552	< .7415
BCSS	2.54	0.03	2.40	0.05	2.54	0.19	< .0014	< 1.0000	< .4937

Table 6. Estimates of least-squares mean (LSM), their standard error (SE) and level of significance on the test of differences in least-squares mean between Simmental (S), Brown Swiss (BS), and Tyrol Grey (TG), for various traits 1). 1) AMY305 = Average milk yield over first 305 days of first lactation (kg/day); BWC = Birth weight of calf (kg); GRC3 = Growth rate of calf over first 3 months of age (kg/day); GRC10 = Growth rate of calf over first 10 months of age (kg/day); SP = Service period (days); NRR = Non-return rate at first insemination (%/100); BCSC = Body condition score within one week after calving (1-5); BCSS = Body condition score within one week after service (1-5).

The breed x ration effect was significant ($P < 0.0011$ and $P < 0.0017$) for service period and for body condition scoring at insemination, respectively (Table 5). Within the same breed differences in least-squares means between rations, on body condition scoring at service, was reduced for both S and BS, on the ration without concentrate, and significantly ($P < 0.0012$ and $P < 0.0444$), respectively (Table 6).

Village effects, nested within importation year had a highly significant effect on milk yield, service period, non-return rate and body condition score, at calving and at service, respectively (Table 4).

3.2. Lactation curves and production efficiency

The results from the Figure 1 show that estimated cow variance was twice as high as the estimated residual variance. However, it also should consider that allocating one cow per farm, the estimate also contains the effect of farm.

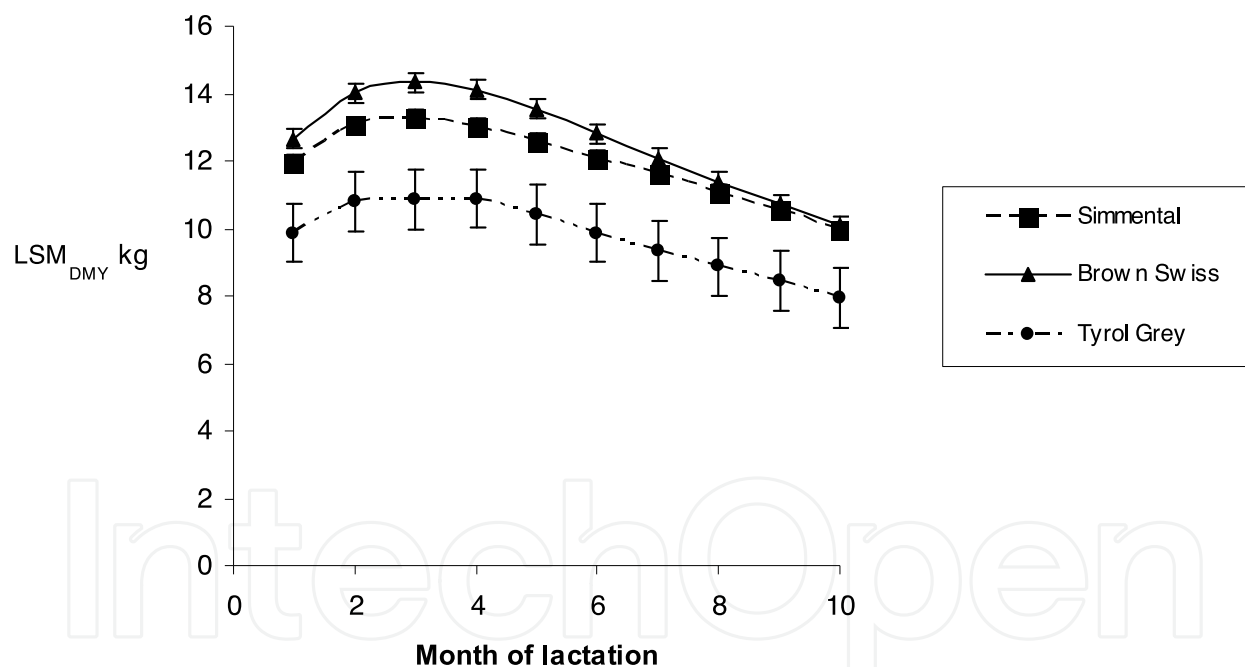


Figure 1. Least-squares mean of daily milk yield (LSM_{DMY}) by lactation month for Simmental, Brown Swiss and Tyrol Grey cows in Kosovo.

The lactation curve was consistently higher for BS than for S, the latter dominating the curve for TG (Figure 1). The milk production efficiency here is defined as milk yield per unit bodyweight. The lactation curve for TG cows tended to be less peaked than those for S and BS cows. BS cows tend to produce milk more efficiently throughout lactation compared to S and TG, the two latter being rather similar in this respect (Figure 2).

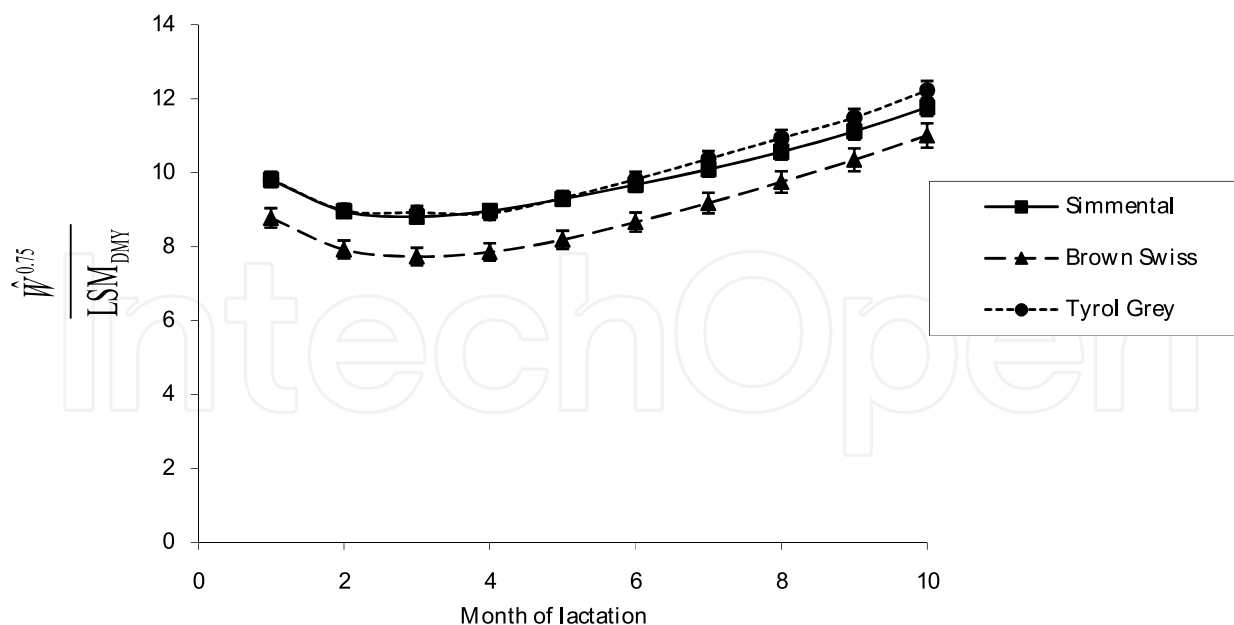


Figure 2. Ratio of metabolic body weight on daily milk yield ($\frac{\hat{W}^{0.75}}{LSM_{DMY}}$), LSM_{DMY} being least-squares mean of daily milk yield, by lactation month for Simmental, Brown Swiss and Tyrol Grey cows in Kosovo

3.3. Estimation of environmental conditions on milk production for dairy breeds comparison using random regression models

In the Table 7 are presented the repeatability (REP) and random regression (RR) test-day models and their estimates for ln of restricted likelihood (lnRL), Akaike information criterion (AIC), likelihood-ratio test statistics (LR), and level of significance (P), when comparing to the reduced model. In order to describe the statistical analyses of daily milk yield, seven models in total were developed. First model considered the homogenous cow and residual variances. Second model, was developed consisting of homogenous and heterogeneous cow and residual variances, respectively, the latter by month of lactation.

Full model	LnRL	AIC	Reduced model	LR	P
REP1	-26685	0	-	-	-
REP2	-24150	5053	REP1	5071	< 0.01
REP3	-24129	5090	REP2	41	< 0.01
REP4	-23553	6207	REP2	1194	< 0.01
REP5	-23536	6236	REP4	32	< 0.01
RR1	-19862	13572	REP5	7348	< 0.01
RR2	-17415	18448	RR1	4894	< 0.01

Table 7. Repeatability (REP) and random regression (RR) test-day models and their estimates for ln of restricted likelihood (lnRL), Akaike information criterion (AIC), likelihood-ratio test statistics (LR), and level of significance (P), when comparing to the reduced model.

Third model was based on heterogeneous cow and residual variances, by breed and month of lactation, respectively.

Fourth model described the homogenous and heterogeneous cow and residual variances, respectively, the latter by breed · lactation month. Model five showed the heterogeneous cow and residual variances, by breed and breed · lactation month, respectively.

Model six explains the first-order random regression of cow effects, assuming heterogeneous cow and residual variances, by breed and breed · lactation month, respectively, while the model seven considered the second-order random regression of cow effects, assuming heterogeneous cow and residual variances, by breed and breed · lactation month, respectively.

A second-order random regression model was preferred for statistical analysis of daily milk yield.

Generally, residual variances were largest in the first half of lactation and diminished towards the end, for all breeds (Table 7).

The rank order of breeds for the cow variance was observed for the residual variance (Figure 3). For BS the residual variance ranked from 1.62 in the beginning to 0.16 kg²/d at the end of lactation, while for S and TG cows the residual variance was 1.04 and 0.38 kg²/d milk in the beginning and 0.16 and 0.15 kg²/d at the end of the lactation (Figure 4).

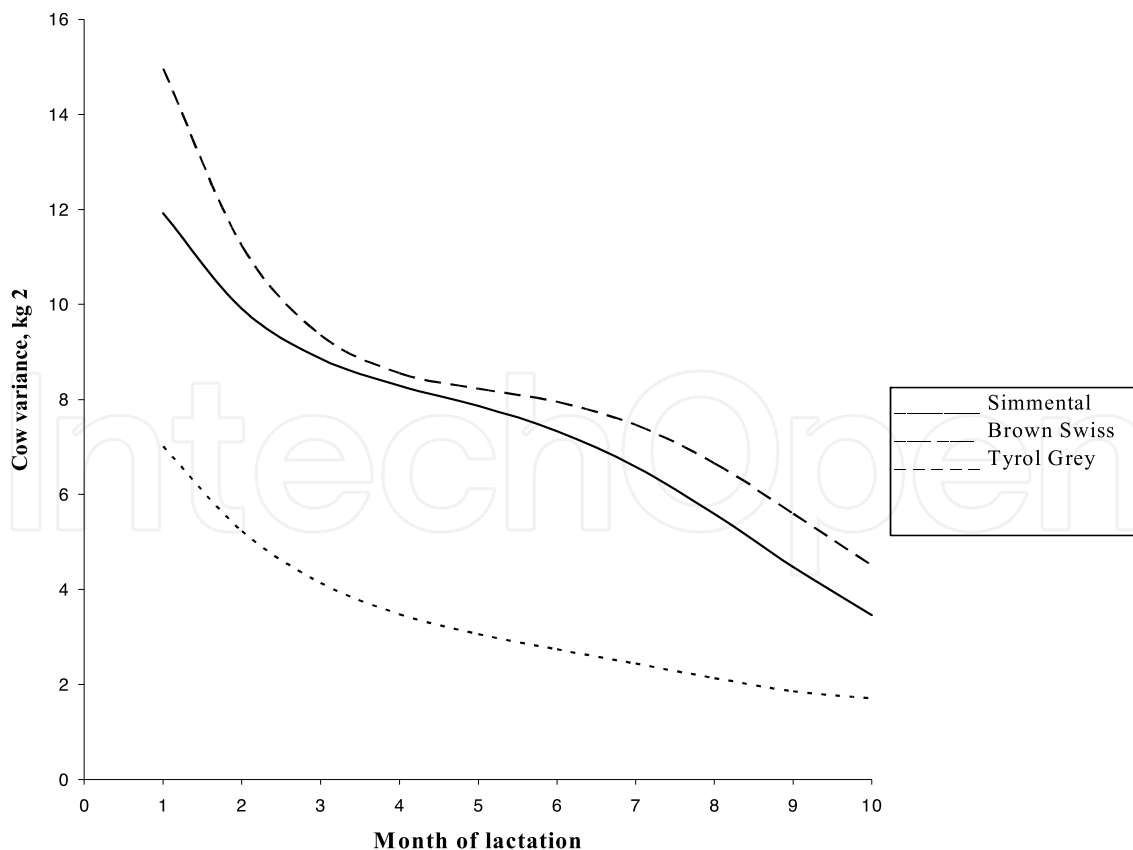


Figure 3. Trajectories of estimated cow variance by month of first lactation for Simmental, Brown Swiss and Tyrol Grey, using a second-order random regression model (RR2) for analysis.

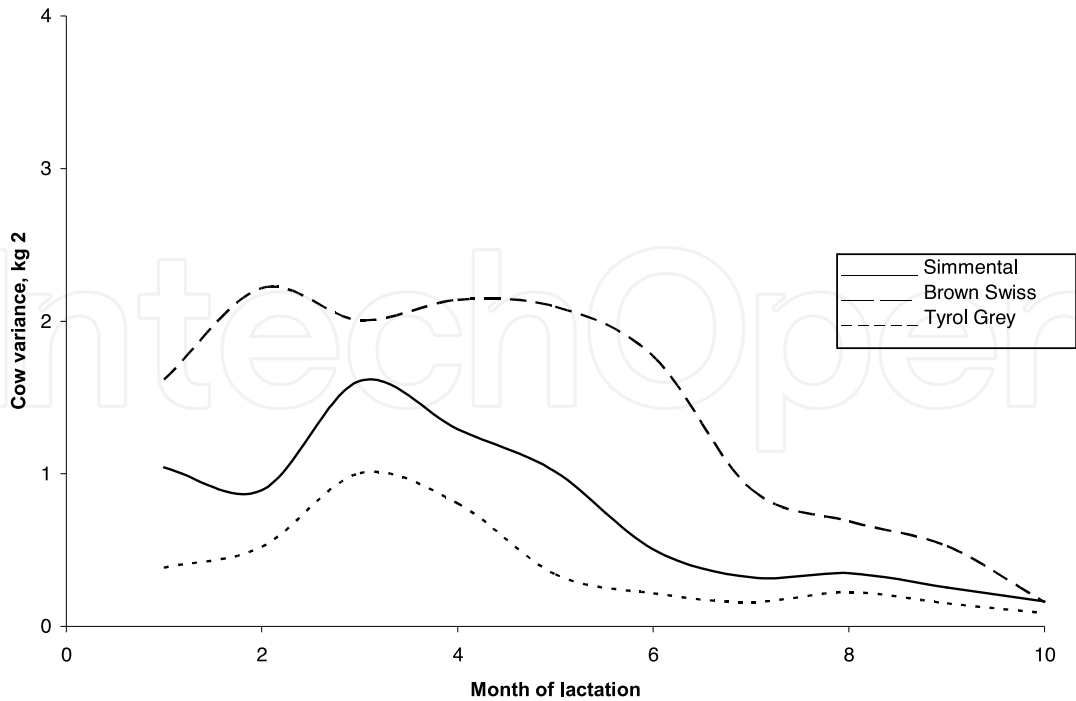


Figure 4. Trajectories of estimated residual variance by month of first lactation for Simmental, Brown Swiss and Tyrol Grey, using a second-order random regression model (RR2) for analysis.

Clear breed differences were observed also with respect to the coefficient of variation within breed (Figure 5), suggesting that scale effect alone might not explain the breed differences in size of the estimated variance components (Figure 6).

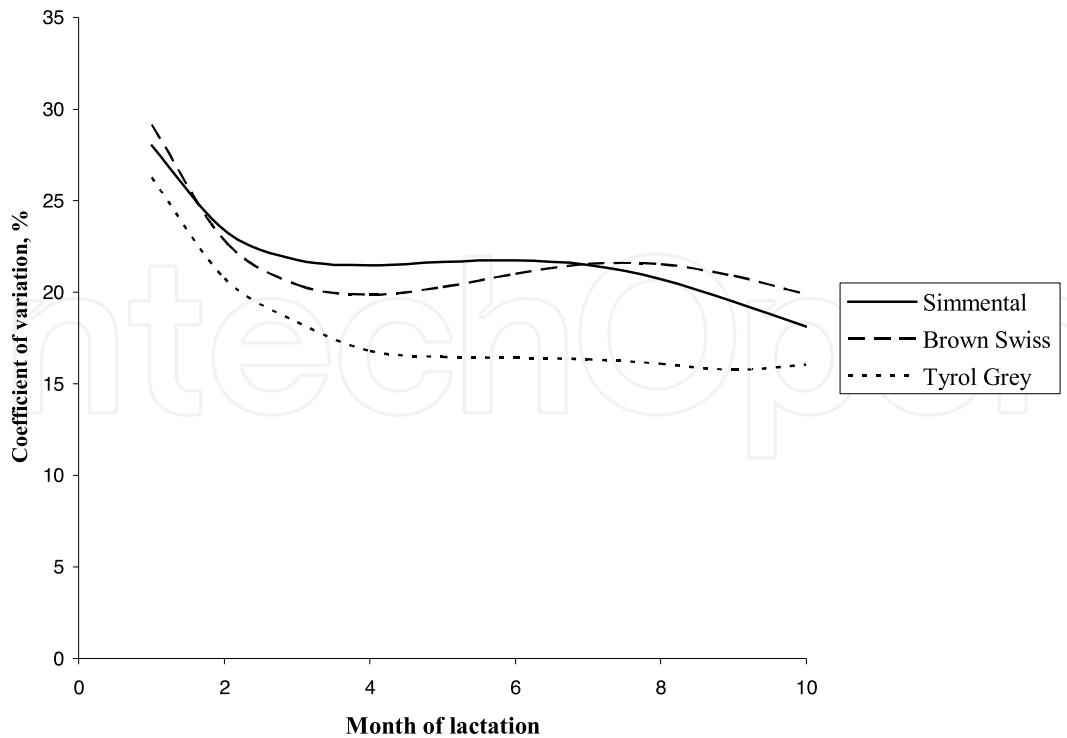


Figure 5. Trajectories of estimated coefficient of variation for cow effect by month of first lactation for Simmental, Brown Swiss and Tyrol Grey, using a second-order random regression model (RR2) for analysis.

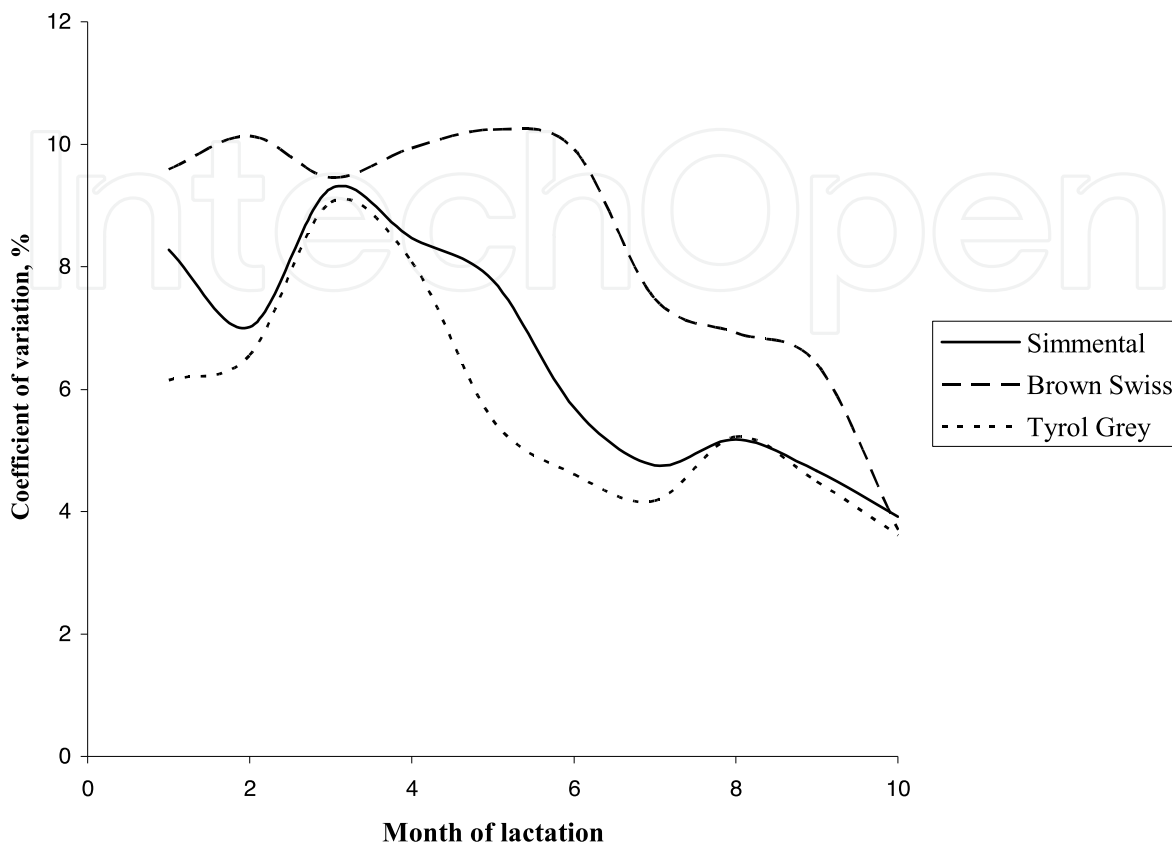


Figure 6. Trajectories of estimated coefficient of variation for residual effect by month of first lactation for Simmental, Brown Swiss and Tyrol Grey, using a second-order random regression model (RR2) for analysis.

4. General discussion

Cattle production in Kosovo is characterized by being predominately small-scale and semi-extensive. In this environment, focus in breed comparison should not only be on increased production (to improve feed efficiency), but also on how well the breeds are adapted to the local environment. An indication is given by studying the energy balance, here indirectly through measuring the body condition score and the length of the service period. It is also relevant to examine the pattern of the lactation curves for the breeds, for which a flatter curve should be favorable with respect to energy balance. The fit to the local environments was also studied through examination of genotype by environment interaction, e.g. through estimation of a breed \times ration effect. Another approach was through testing for heterogeneity of variance components for milk production for the different breeds. In conclusion, the choice of traits to record for the breed comparison was in large sound generally appropriate.

The analyses showed that BS cows had higher yields compared with S and TG. The production levels of the different breeds in Kosovo were lower than in the countries of origin, with the most pronounced reduction for the BS and S breeds (Cattle breeding in Austria, 2003; Rinder production in der Bundesrepublik Deutschland, 2001; Tiroler Grauvieh, 1999). The TG breed is a smaller breed with lower milk production, and therefore also with lower nutritional requirements. This might explain why the Kosovo results for this breed seem to fit better with their milk production potential in the country of origin.

When comparing the efficiency of breeds only on the bases of production, the large differences in body weight are not taken into account. Hence, the efficiency, as the metabolic body weight per kg of milk, was calculated throughout lactation. This measure should be proportional to the expected maintenance requirement, given that weight records were representative for the entire lactation and that feed requirement per kg of milk was the same for all three breeds. After correction for weight, it was found that BS was the most efficient, while now TG and S breeds produced milk with similar efficiencies.

With regard to the service period and body condition score, results from this study showed that TG cows had shorter service periods and less negative energy balance during lactation (less reduction of body condition score), compared with the S and BS breeds. An important goal of dairy cattle breeding programs is to achieve an approximately 12-month calving interval (Schmidt, 1989; Schultz-Rajalla and Frazer, 2003), and in this context; the TG breed was closest to fit with this recommendation. However, it should be noted that an unfavorable genetic relationship exists between days open and non-return rate (e.g., Andersen-Ranberg et al., 2005b) such that cows coming into heat early often have high embryonic loss and reduced success of conceiving (Averdunk et al. 1995; Van der Lende, 1998), which might explain the lower non-return rate estimated for TG, compared with the other breeds.

The finding of less negative energy balance for TG relative to the other two breeds was also supported by the pattern of the lactation curves, tending to be less peaked for TG than for other two breeds.

In addition, the fit to the local environment was examined more directly than through indirect measures of the energy balance, by calculating the genotype by environment interaction directly, i.e., a breed x ration effect. Although the material was rather limited, the results for body condition score indicated that S and BS were more sensitive to an extensive environment than TG.

Existence of genotype by environment interaction was also examined by calculating variance components for milk production both between and within cows of the different breeds, with a random regression test-day model. The larger estimates obtained for BS than for S, again being larger than those for TG, indicate that performance of BS

cows was more variable across the same range of physical environment than the two other breeds (breed and heifer were randomly allocated, one per farm), or from test-day to test-day. The smaller variance for TG implies reduced environmental sensitivity or greater phenotypic stability, relative to the two other breeds. In contrast, the largest variances for BS imply greater phenotypic plasticity that might be desirable for herds with an improved environment. However, for the majority of herds, under small-scale and semi-extensive conditions, these latter results point to the choice of TG amongst the breeds compared.

Currently, beef cattle production is almost non-existing in Kosovo. Hence, dual-purpose cattle breeds (S and TG) should have preference over more specialised milk breeds (BS). A significantly higher growth rate was found for S compared with TG. However, breeds with high growth rate and larger mature weight normally reach maturity later, and also require more intensive feeding than smaller breeds (Geay & Robelin, 1979; Arango et al., 2002).

Finally, it should be mentioned that many farmers are used to dealing with local cattle and their crossbreeds, which are smaller in size and produce a lower amount of milk. Hence, to explore their potential they should have been included in the experiment that preferably also could have been more balanced for the number of animals of each breed.

5. Conclusion

In small-scale and semi-extensive management as in Kosovo, robust dual-purpose cattle breeds for production of both milk and beef should be preferred over more specialized dairy breeds highly adapted to intensive production systems, requiring intensive feeding and good management practices.

Substantial breed differences were found for the trajectories of cow and residual variances as well as for their coefficients of variation at different stages of lactation, indicating more environmental sensitivity in the larger and more productive breeds; S and BS compared to TG. Furthermore, TG had a shorter service period and thus a shorter calving interval than the other two breeds, less body reserve losses, in addition to a less peaked lactation curve and a satisfactory milk production, also relative to their metabolic body weight.

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