Influence of Farm Size on Estimated Breeding Values and Selection Indices in Romanian Spotted Cows

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Abstract

Researches were carried out on 3186 lactations obtained from Romanian Spotted cows raised in farms from Bihor County that were enrolled in official performance control scheme. According to the number of milking cows (farm size), farms were divided into three categories small (n≤10 cows), middle (n=11 to 25 cows) and large (n>25 cows). The influence of the farm size on five selection indices (global, for milk, for fitness, for reproduction and for functionality) and eight estimated breeding values (milk yield, milk fat yield, milk protein yield, age at first calving, inseminations per gestation, calving ease, longevity and somatic cell count) was determined by using One-way ANOVA. Reference population had an average ME milk production of 6028 kg with 3.67% fat and 3.28% protein, calved for the first time at 29 months and 14 days, had an average calving interval of 389 days and days dry of 51 days. Generally, the farm size had a significant influence on selection indices ($p<0.05$). Selection indices and estimated breeding values were similar between small and middle farms. Global selection index and selection index for milk were significantly higher ($p<0.05$) in large farms compared to small and middle size farms, while selection indices for fitness, reproduction and functional were higher ($p<0.05$) in small and middle farms compared to large farms. Estimated breeding values differed among farms according to their size ($p<0.05$), being higher for milk yield and somatic cell count in large farms, while in small and middle farms, the values for reproduction and longevity were higher than in large farms.

Keywords: cows, estimated breeding values, farm size, fitness, functionality, milk yield, reproduction, Romanian Spotted, selection indices.

1. Introduction

Molecular genetic studies have identified many chromosome regions with potentially important major genes for economic traits. Use of DNA markers for genetic improvement is currently limited by lack of precision in marker location. Discovery of major genes will be accelerated by the availability of the bovine genome sequence, comparative genome maps and genome sequences across species, and increased use of breed crosses in molecular studies. As major genes are identified, their effects will be incorporated into genetic evaluations and selection indexes [1].

The inclusion of genomic information into genetic evaluations has been proved to benefit traits associated with welfare and sustainable production. Cow welfare traits remain complex and suitable phenotypes are not always easy to measure or readily available for genetic evaluations [2].

Average relative emphasis for production, durability, and health and reproduction, across 15 countries, was 59.5, 28, and 12.5%, respectively. The main difference between selection indices in various countries was the relative emphasis on production [3].

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Fertility traits in heifers and older cows were not the same genetically (genetic correlations in general were smaller than 0.9). Genetic correlations (both direct and maternal) among traits indicated that different traits measured different aspects of reproductive performance of a dairy cow. These traits could be used jointly in a fertility index to allow for selection for better fertility of dairy cattle [4].
Fertility EBV were correlated unfavourably with EBV of milk production traits but favourably with udder health and longevity. Integrating fertility traits into a total merit selection index can halt or reverse the decline of fertility and improve the longevity of dairy cattle [5].
Very low correlations of EBV for daughter reproductive traits with predicted transmitting ability for yield indicate that, in order to improve daughter fertility, fertility must be incorporated in sire selection decisions [6].
Quantitative trait loci have been associated to the reproductive complex. Most important traits, including reproduction traits are regulated by a multitude of genes and environmental factors in a complex relationship, however. Genomic selection might therefore be important in future breeding programmes. Information on single nucleotide polymorphism has already been introduced in the selection programmes of some countries [7].
Success of first insemination showed slightly higher heritability than non-return rate but the two traits are genetically correlated. Based on this result, both two could be used for early indicator for evaluate the capacity of cows to conceive [8].
Genotype x environment interactions were found for fertility traits across different herds in Denmark [9]. Statistically significant genotype x environment interactions were observed for number of inseminations per conception in heifers, non-return rate within 56 d after the first insemination in heifers, and interval from calving to insemination [10].
Some authors suggest that a high SCC in the prepartum period may advance parturition by increasing PGF2α and decreasing progesterone and that the first ovulation in the postpartum period was affected by a high SCC [11].
Does with a high EBV for SCC had a higher prevalence of any intramammary infection and were more likely to have an intramammary infection due to a major pathogen than does with a low EBV SCC. Thus, selection for EBV SCC is likely to result in a lower SCC and also lower prevalence of intramammary infection [12].
Conformation traits, milk production traits, reproductive traits, and health traits may be used as indicators to select and breed the longevity of dairy cows [13].
The study was carried out to find out how the farm size had an influence on the selection indices and estimated breeding values of Romanian Spotted cows reared in Bihor County.

2. Materials and methods

Study was carried out on a total of 3168 lactations obtained from Romanian Spotted cows, reared in Bihor County, Romania. Only lactations completed in years 2019 and 2020 were taken into account.
Data was taken from the annual performance report, published by the organization that is managing the herd book for Romanian Spotted breed, Simmental type, for years 2018/2019 and 2019/2020.
Farms were divided into three categories, by the number of animals (farm size), as follows:

- Small farms, having 1 to 10 cows (n=130), with a total of 876 lactations, and an average size of 6.7 cows;
- Middle farms, having 11 to 25 cows (n=93), with a total of 1352 lactations, and an average size of 14.5 cows;
- Large farms, having over 25 cows (n=14), with a total of 940 lactations, and an average size of 67.1 cows.

From the records, data regarding the 5 selection indices, as well as 8 of the estimated breeding values calculated for Romanian spotted cows from Bihor County was taken.
The five section indices (SI) were:

- Global selection index

$$SI_{Global} = 50\%SI_{Milk} + 20\%SI_{Meat} + 30\%SI_{Fitness}$$

- Milk selection index

$$SI_{Milk} = 60\%EBV_{Milk} + 20\%EBV_{Fat} + 20\%EBV_{Protein}$$

- Fitness selection index

$$SI_{Fitness} = 33\%EBV_{Conformation} + 34\%SI_{Reproduction} + 33\%SI_{Functionality}$$

- Reproduction selection index

$$SI_{Reproduction} = 40\%EBV_{DaysOpen} + 30\%EBV_{AFC} + 15\%EBV_{IG} + 15\%EBV_{CE}$$

- Functionality selection index

$$SI_{Functionality} = 15\%EBV_{Longevity} + 85\%EBV_{SCC}$$

The eight estimated breeding values (EBVs) that were used to calculate the selection indices were as follows:

- EBV for milk yield (kg): EBV_{Milk}
- EBV for milk fat yield (kg): EBV_{Fat}
- EBV for milk protein yield (kg): $EBV_{Protein}$
- EBV for age at first calving: EBV_{AFC}
- EBV for number of inseminations per gestation: EBV_{IG}
- EBV for calving ease: EBV_{CE}
- EBV for longevity: $EBV_{Longevity}$
- EBV for somatic cell count: EBV_{SCC}

All EBVs and selection indices were expressed as relative EBV and SI (%).

In order to study the effect of farm size the mathematical model of One-Way ANOVA was employed. STATISTICA software was used [14].

$$Y_{ijk} = F_i + e_{ijk}$$

where:

Y_{ijk} was one of the 5 SI or 8 EBVs

F_i was farm size, with three levels: small (n=561), middle (n=855), and large (n=498)

e_{ijk} was the error variance.

3. Results and discussion

The reference values for milk production and reproduction indices, used to compute the EBVs and SI for Romanian spotted cows from Bihor County are presented in Table 1.

Values presented in Table 1, are averages for year 2019 for Romanian Spotted breed, for the whole cows that were under the performance control scheme in the herd book organisation.

A ME yield of 6028 kg milk with 3.67% fat and 3.28% protein represents a good milk yield for this breed. Also, the age at first calving at 29 months and half represents a very good precocity for milk production.

Table 1. Average values for milk production (n=76,568) and reproduction indices (n=9926) used as reference for computing the EBVs and SI

Trait	Value
Total milk production	
Days in milk	343
Milk yield (kg)	5914
Fat percentage (%)	3.68
Protein percentage (%)	3.29
Maturity equivalent milk production	
Milk yield (kg)	6028
Fat yield (kg	221
Fat percentage (%)	3.67
Protein yield (kg)	197
Protein percentage (%)	3.28
Reproduction indices	
Age at first calving (months and days)	29 and 14
Calving interval (days)	389
Days dry	51

Table 2 presents the averages and differences among the three farm size groups for selection indices.

Generally, farm size had a significant influence on the selection indices of Romanian Spotted cows from Bihor County. Thus, for the global selection index, the probability threshold was 0.009, for milk, fitness and reproduction selection indices the threshold was lower than 0.001, while for functionality selection index it was 0.01.

When comparing the selection indices of the cows from small farms to those of cows from middle farms, we see that the differences are small and were not statistically significant ($p>0.05$). There was one single exception, namely the reproduction selection index was significantly higher by 0.54 percentage points in cows from small farms ($p<0.05$).

Table 2. Averages, standard error of the mean and statistical significance for selection indices according to the farm size

Selection index	Farm size (average±SEM)			Differences and significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
Global (%)	100.03±0.0716	99.96±0.0571	100.30±0.1191	0.07 ns	-0.27*	-0.34**
Milk (%)	100.07±0.1364	100.06±0.1089	101.10±0.2269	0.02 ns	-1.02***	-1.04***
Fitness (%)	100.01±0.0545	99.83±0.0583	99.40±0.1198	0.18 ns	0.61***	0.43***
Reproduction (%)	100.06±0.1506	99.52±0.1663	98.29±0.2261	0.54*	1.76***	1.22***
Functionality (%)	99.96±0.1749	99.93±0.1171	99.36±0.1606	0.04 ns	0.60**	0.56**

ns = $p>0.05$, $p\leq0.05$*, $p<0.01$**, $p<0.001$***

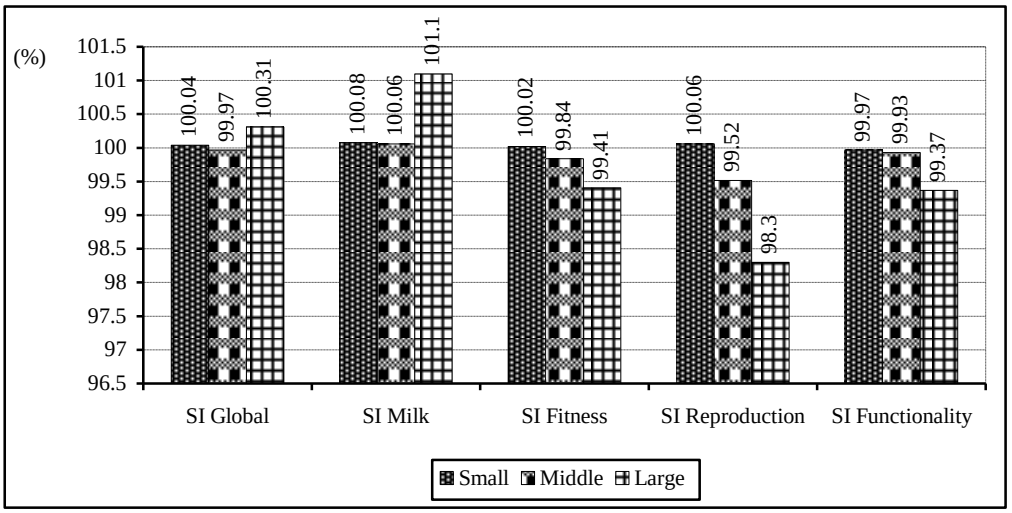

Figure 1. Selection indices in Romanian Spotted cows, by farm size

When comparing small and large farms, there was a statistical significance ($p<0.05$) for differences in all studied selection indices. Thus, the global, as well as the milk selection indices were higher in large farms than in small farms by 0.27 and 1.02 percentage points, respectively. Conversely, the fitness, reproduction and functionality selection indices were higher in small than in large farms by 0.61, 1.76 and 0.60 percentage points, respectively (Table 2 and Figure 1).

When comparing the results from middle and large farms we can see that for all the selection indices the differences were statistically significant $9p<0.05$). Thus, the global and milk selection indices were higher in large than in middle farms, by 0.34 and 1.04 percentage points, respectively. Selection indices for fitness, reproduction and functionality were higher in middle than in large farms, by 0.43, 1.22 and 0.56 percentage points, respectively.

The global selection index has the same trend as the milk selection index because the latter makes 50% of the global selection index.

Table 3 presents the averages, differences and significance for relative estimated breeding values for milk production, by the farms size. Generally, farm size had a significant influence ($p<0.001$) on the relative EBVs for milk production in Romanian Spotted cows from Bihor County. Exception was the EBVs for milk between small and middle farms, where differences were small (between 0.0 and 0.04 percentage points) and non-significant ($p>0.05$).

When small farms were compared to large farms, one can see that for all three relative EBVs the differences were high and statistically significant ($p>0.001$). Thus, in cows reared in large farms the relative EBVs for milk yield, milk fat yield and milk protein yield were higher than those reared in small farms by 0.91, 1.23 and 1.16 percentage points, respectively.

Table 3. Averages, standard error of the mean and statistical significance for estimated breeding values for milk production according to the farm size

Estimated breeding value	Farm size (average±SEM)			Differences and significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
Milk yield (%)	100.11±0.1209	100.09±0.0983	101.02±0.2143	0.02 ^{ns}	-0.91***	-0.93***
Milk fat yield (%)	100.04±0.2059	100.06±0.1590	101.27±0.2954	-0.02 ^{ns}	-1.23***	-1.21***
Milk protein yield (%)	100.03±0.1594	99.99±0.1217	101.20±0.2423	0.04 ^{ns}	-1.16***	-1.21***

ns = $p>0.05$, $p\leq0.05$*, $p<0.01$**, $p<0.001$***

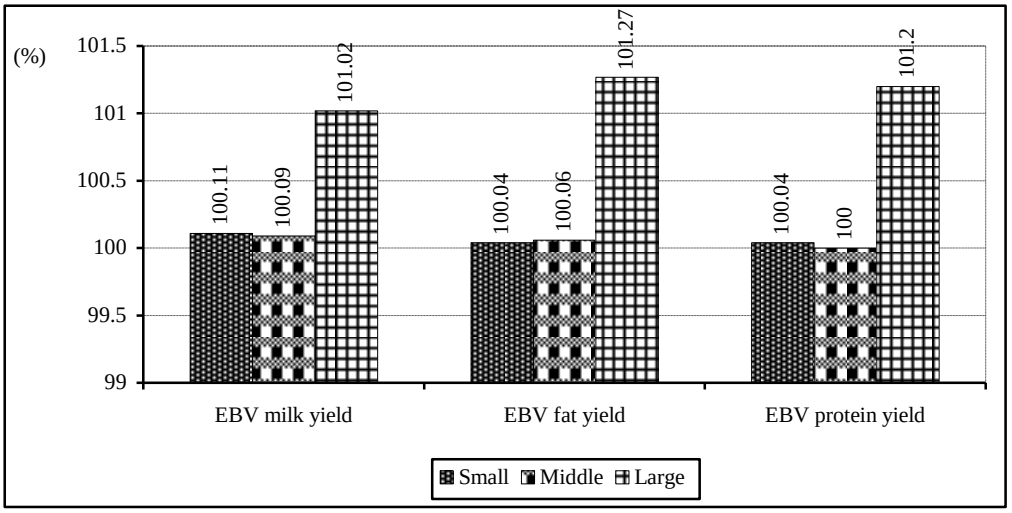

Figure 2. Relative estimated breeding values for milk production in Romanian Spotted cows, by farm size

Relative EBVs for milk production were significantly higher ($p<0.001$) in large farms than in middle farms. The EBVs for milk yield, milk fat yield and milk protein yield were higher in large farms by 0.93, 1.21 and 1.21 percentage points than in middle farms (Table 3, Figure 2).

Table 4 shows the averages, differences and significance for the relative estimated breeding values for reproduction traits in cows reared in the three farm size groups. Farms size had no significant influence ($p>0.05$) on the EBVs for age at first calving and calving ease.

Table 4. Averages, standard error of the mean and statistical significance for estimated breeding values for reproduction traits according to the farm size

Estimated breeding value	Farm size (average±SEM)			Differences and significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
Age at first calving (%)	102.33±1.5806	102.1±0.6905	102.10±0.6855	0.22 ^{ns}	0.24 ^{ns}	0.01 ^{ns}
Inseminations per gestation (%)	98.40±0.2068	98.02±0.1758	94.03±0.3798	0.38 ^{ns}	4.38***	4.00***
Calving ease (%)	99.98±0.0698	99.97±0.0776	99.95±0.1393	0.01 ^{ns}	0.03 ^{ns}	0.02 ^{ns}

ns = $p>0.05$, $p\leq0.05$*, $p<0.01$**, $p<0.001$***

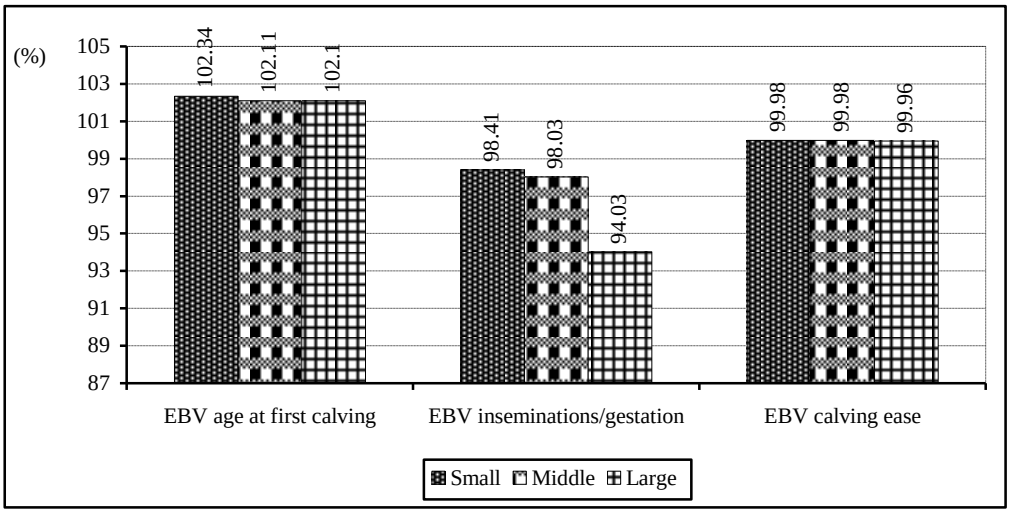

Figure 3. Relative estimated breeding values for reproduction traits in Romanian Spotted cows, by farm size

For the number of inseminations per gestation, the farm size had a significant effect (Table 4, Figure 3). Thus, in large farms cows needed more inseminations to obtain a gestation than in small and middle-sized farms. Relative EBVs were 4.38 and 4.00 percentage points in large farms compared to small and middle farms, respectively ($p<0.001$). There was no significant difference between small and middle farms regarding this trait ($p>0.05$).

Table 5 shows the averages, differences and significance for the relative estimated breeding values for functionality traits in cows reared in the three farm size groups. Generally, farm size had a significant influence ($p<0.05$) on the relative breeding values for Romanian Spotted cows' functionality.

Table 5. Averages, standard error of the mean and statistical significance for estimated breeding values for functionality traits according to the farm size

Estimated breeding value	Farm size (average±SEM)			Differences and significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
Longevity (%)	100.77±1.5839	103.03±1.0646	96.25±1.1537	-2.26 ^{ns}	4.52*	6.78***
Somatic cell count (%)	99.95±0.2050	99.87±0.1368	99.38±0.1820	0.08 ^{ns}	0.57*	0.50*

ns = $p>0.05$, $p\leq0.05$*, $p<0.01$**, $p<0.001$***

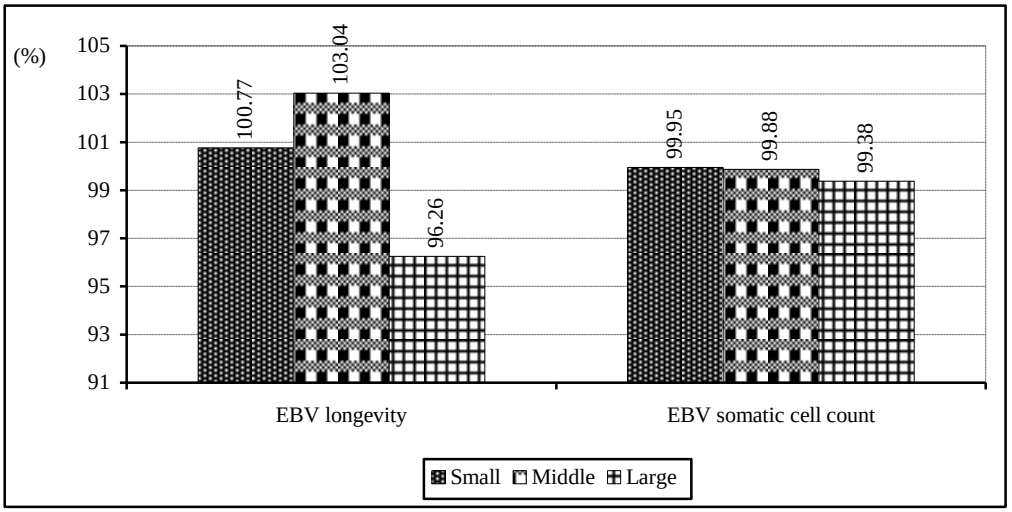

Figure 4. Relative estimated breeding values for functionality traits in Romanian Spotted cows, by farm size

Both EBVs for longevity and for somatic cell count were similar in cows reared in small and middle farms ($p>0.05$).

Cows reared in large farms had significant lower values for relative EBV for longevity than cows reared in small and middle farms (Table 5, Figure 4). Thus, compared to small farms the difference was 4.52 percentage points ($p<0.05$) and compared to middle farms the difference was 6.78 percentage points ($p<0.001$).

Even the differences for somatic cell count between small and middle farms on one hand and large farms on the other hand was low (0.57 and 0.050 percentage points, respectively), they reached the statistical significance level ($p<0.05$). Thus, we can state that cows in large farms had lower somatic cell count in milk than cows in small and middle farms.

4. Conclusions

Farm size had a significant influence on the studied selection indices and relative estimated breeding values, except for EBVs for age at first calving and for calving ease.

There were no significant differences for selection indices and relative EBVs between small and middle farms, except for reproduction selection index that was 0.54 percentage points higher in cows from small compared to middle farms.

Global selection index and that production and were significantly higher in large than in small and middle farms.
Selection indices for fitness, reproduction and functionality were significantly higher in small and middle than in large farms.
Relative estimated breeding values for milk production (milk, fat and protein yield) were significantly higher in large vs. small and middle farms.
Relative estimated breeding values for number of inseminations per gestation, longevity, and somatic cell count in milk were significantly higher in small and middle vs. large farms.

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