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Original Paper

Estimation the Breeding Value for Calving Score Using a Threshold Model, in Limousine Breed

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The study was the aim to estimate breeding value and heritability for calving score using a threshold model for population from Limousine breed. Data consisted of records of 2,432 calves of Limousine breed from Romanian Breeding Association for beef cattle. The mean for calving score was 1.134 ±0.007. The breeding values for calving score for calves were between -0.2375 and 0.5354 at the first iteration and at six iterations the breeding values for calving scores for calves ranged between -0.1832 and 0.4880 The heritability for calving score was 0.141 in population of Limousine breed. The threshold model was adequate due to better accounting for total variability for calving score.

Keywords: calving score, breeding value, threshold model, meat breeds

1 Introduction

Calving ease is a reproduction trait with economic importance in Limousine breed. Calf health and survival are important for profitability of beef farms. Cortes et al. (2015) reported that the sustainability of agriculture is given by raising beef cows. Limousine is a breed from France used for beef production. This breed has a superior meat quality. Limousine had spread in Europe, U.S.A. and Australia. Limousine is a breed well adapted to environmental conditions, resistant to diseases. It is a precocious breed, the age of the first calving being around 2.5 years old, it is a breed with good longevity, good fecundity and fertility. Limousine breed had spread in Romania. The breed are the following features: high meat production, good quality of meat, a good percentage of unassisted calving. For threshold traits the phenotypes of animals are divided in few categories. Threshold procedure is adequate for genetic evaluation of animals for calving ease. Those who developed threshold in animal breeding were: Gianola (1982), Gianola and Foulley (1983) and Harville and Mee (1984). The threshold model was used by many authors to estimate the genetic parameters for calving ease (Varona et al., 1999; Ramirez-Valverde et al., 2001; Kizilkaya et al., 2003; Hansen et al., 2004). Calving ease is a trait with low heritability. Fries and Ruvinsky (1999) observed that calving ease is influenced by the size of calf and pelvic area of dam. Gullstrand (2017) reported that the main factors which determined difficulty calving are related with size of calf and dam. Benet et al. (2021) proposed the selection of the best cattle for calving ease. In the present study it is followed the estimation of the breeding values and heritability for calving score in Limousine breed using a threshold model.

2 Materials and Methods

The data from 2,432 Limousine calves in the year 2021 were used in this study. The pedigree covered 4,978 animals: 2,432 calves, 135 bulls and 2411 dams from Romanian Breeding Association for Beef cattle. The data collection procedure: the data were recorded by the farmers and sent to Romanian Breeding Association for beef cattle. The data were received from Romanian Breeding Association for Beef cattle. The R Project for

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Statistical Computing is used. R 4.1.2 is a software for statistical computing. The data were processed with R 4.1.2 software for compute genetic parameters and breeding values. Difficult calving is calving with major human intervention with the correction of the calf's position, without caesarean section. The number of progenies per sire was between 5 and 103. In our study were three categories of calving: 1-is easy calving, 2 is calving with assistance and 3 is difficulty calving. The calves were born in 2021 year. The model used is threshold model described as follows:

$$\lambda_{ijkl} = f(t)_i + S_j + H_k + a_l + e_{ijkl} \text{ (Grosu et al., 2013,)}$$

where: λ_{ijkl} – underlying liability value for calf; $f(t)_i$ – a function of the probabilities of calving score of the calf to be in different categories; S_j – sex of calf; H_K – a herd effect; a_l – calf additive genetic effect; e_{ijkl} – residual error effect

In matrix notation as:

$$\lambda = \mathbf{F}_t + X_b + Z_u + e$$

where: λ – the vector of unobserved liabilities of each calf; t – the vector of m^{-1} thresholds; b – the vector of fixed effects in the model; u – the vector of random effects, including random animal additive genetic effects; e – the vector of random residuals, assumed to have mean 0 and variance of 1; **F** – matrix of probabilities of a calf being in the different categories resulting in a function of the unknown thresholds; X, Z = are the usual design matrices of a linear model

The relative breeding value is:

$$BV\% = 100 + 12\left(\frac{BV_{abs} - average\ BV_{abs}}{\sigma BV_{abs}}\right)$$

where: $BV\%$ – relative breeding value; BV_{abs} – absolute breeding value; σBV_{abs} = standard deviation of absolute breeding values

The number of iterations was six. The equations of the model must be solved iteratively. The values of the matrices and vectors change with each iteration of the system. After six iterations were obtained the converged solutions.

The model included the fixed effects: the sex and the herd. The sex has two levels: female and male. The levels of effect herd were 131. The sex was included in the model because the birth weight was influenced by the sex of calve and the calving was influenced by the weight of calve, the males calves had higher birth weight. The herd was included as fix effect because in different herds the feeding levels for cattle were different. A low nutrient diet increased difficult calving in heifers because the heifers are smaller with smaller pelvic areas. The feeding level influenced also the birth weight of calves. The fraction of animals in the first category was (0.8696 = 2,115/2,432 (from category one-unassisted calving) and in the first two categories 0.9954 = 2,421/2,432 (2,415 calves from category one and 306 calves from category two). From the category with calving score one (unnassisted calving) the mean of birth weight of calves was 38.57 kg with the minimum and maximum limits between 20 and 62 kg, for the category with calving score two (calving with assistance) the mean of birth weight was 39.59 kg with limits between 17 and 55 kg. From category three (difficult calving) were 11 calves with the mean birth weight of 45.54 kg and the limits between 25 and 54 kg.

In model were included only two fixed effects because for more fixed effects increased the complexity and computing time and was difficult to obtained results and it is necessary a performant computer.

The minimum number of descendants per sire was five. The cows with difficult calving were in the first parity. From all calves, 1,261 calves were females and 1,171 were males. Calving score is a trait that it is not distributed normally.

The calves from cows with difficult calving were 7 males and 4 females. 9 calves from difficult calving had the birth weight between 45 and 54 kg.

The mean for birth weight for females calves was 37.99 Pkg and for males calves was 39.52 kg. The average of calves/herd was 18.56.

The mean for age of dams of calves from our study was 4.9 years.

3 Results and Discussions

The average performance for calving ease score and birth weight are presented in table 1.

The results obtained in our study were similarly with the results from literature for calving score and birth weight. Cady and Burnside (1982) presented the average dystocia score in Holstein breed and ranged between 1.103 in August to 1.156 in February. Gutierrez et al. (2007) obtained the mean of calving ease was 1.64 in Asturiana de los Valles beef cattle breed.

The proportions of calves were 86,96% for score 1 (unassisted calving), 12.58% for score 2 (assisted calving)

Table 1 The average performance for calving ease score and birth weight

Breed	Traits	Mean and standard error	Standard deviation	Variation coefficient
Limousine	calving score	1.134 ±0.007	0.354	31.21
	birth weight	38.731 ±0.112	5.561	14.36
		females		
	calving score	1.113 ±0.009	0.327	29.37
	birth weight	37.996 ±0.144	5.136	13.51
		males		
	calving score	1.158 ±0.011	0.381	32.89
	birth weight	39.522 ±0.171	5.885	14.89

and 0.45% for score 3 (difficult calving). The mean percentage unassisted calving score was high 72% in Charolais heifers (Mujibi and Crews, 2009). The mean of birth weight in our study is close to the value obtained by Shi et al. (1993) in Limousine breed. The age of dam influenced the calving ease. The calving difficulty were presented in the first calving of cows because the cows are smaller at first parturition. The breeding value for the best 10 calves and for the 10 lowest calves for calving score were shown in table 2. The relative breeding values for the best calves for first iteration were from 119 to 127 and for lowest calves were from 39 to 56. The relative breeding values for the best calves for six iterations were from 119 to 193. Estimating breeding values observed the genetic potential of the cow for calving ease. The calves with low breeding value are the best because the calves had score 1 – easy calving. Silvestre et al. (2019) obtained the mean of the breeding values for bulls estimated with different models were between 64 and 122. Table 3 show the heritability for calving score. The Limousine breed had lower frequencies of difficulties at calving from beef breeds (Vaxa, 2017). The heritability for calving ease is different in beef breeds. The heritability for calving ease (0.141) was low in present study as well as the heritability reported by Phocas and Lalöe (2004) in Limousine breed, 0.10 direct heritability and 0.08 maternal heritability for calving difficulty score. The direct and maternal heritability were for Charolais 0.13 and 0.12, for Blonde d'Aquitaine 0.09 and 0.08 and for Maine-Anjou 0.09 and 0.09 for calving difficulty score (Phocas and Lalöe, 2004). Vostry et al. (2014) reported direct heritability for calving ease in Charolais breed with different models between 0.096 to 0.226 and maternal heritability between 0.060 to 0.104. Gullstrand (2017) showed different heritability for calving difficulty obtained by different authors. Luo et al. (2002) obtained the heritability for calving ease 0.26 and 0.17 for first and second parities in Canadian Holstein. Erikson et al. (2004a) reported direct heritability for calving difficulty score for Charolais and Herford breeds between 0.11–0.16 and

Table 2 The breeding value for Limousine calves for calving score

No.	Breeding values for the best calves at first iteration	Relative breeding value for the best calves at first iteration	Breeding value for the lowest calves at first iteration	Relative breeding value for the lowest calves at first iteration	Breeding values for the best calves at six iterations	Relative Breeding values for the best calves at six iterations	Breeding values for the lowest calves at six iterations	Relative breeding values for the lowest calves at six iteration
1	-0.2375	127	0.5354	39	-0.1832	123	0.4880	38
2	-0.2375	127	0.4795	45	-0.1832	123	0.4488	38
3	-0.2375	127	0.4549	48	-0.1832	123	0.4488	38
4	-0.2375	127	0.4549	48	-0.1832	123	0.4148	47
5	-0.1971	122	0.4549	48	-0.1548	119	0.3491	56
6	-0.1890	121	0.4467	49	-0.1545	119	0.3491	56
7	-0.1890	121	0.4467	49	-0.1545	119	0.3491	56
8	-0.1890	121	0.4018	54	-0.1545	119	0.3330	58
9	-0.1738	120	0.4018	54	-0.1545	119	0.3294	58
10	-0.1709	119	0.3836	56	-0.1545	119	0.3294	58

Table 3 The heritability of Limousine population for calving score

Trait	h^2 at first iteration	h^2 at six iterations
Calving score	0.141	0.141

Table 4 The phenotypic correlation and genotypic correlation between calving score and birth weight of Limousine population for calving score

Trait	Phenotypic correlation	Genotypic correlation
Calving score	0.086	0.127

maternal heritability 0.07 to 0.12 at first parity and 0.01 to 0.05 at later parities (Erikson, 2004b). Hickey et al., 2007 reported direct and maternal heritability 0.13 and 0.04 for calving difficulty in Holstein heifers. Wiggans et al. (2008) obtained heritability for calving ease 0.06 in first parity for sire effect and 0.03 for later parities. Cervantes et al. (2010) found the direct and maternal heritability in Asturiana de los Valles breed 0.325 and 0.066 and Gutierrez et al. (2007) obtained 0.19 and 0.14. Cervantes et al. (2010) reported that calving ease can represent a factor of calf survival. Albera (2006) obtained the direct and maternal heritability for Piemontese cattle breed 0.19 and 0.05. Jeyaruban et al. (2016) obtained direct heritabilities for calving difficulty were 0.22 for Limousine breed, 0.24 for Angus, 0.22 for Charolais, 0.31 for Hereford and 0.17 for Simmental breed. For minimize dystocia is necessary to control of both genetics and environment factors, the nutrition. The genetics and management are important factors in reducing the dystocia. Bennet et al. (2021) presented a selection strategy used by beef cattle breeders. In table 4 were presented the phenotypic and genotypic correlation between calving score and birth weight of calves. Calving score is a trait that is genetic corelated positive with birth weight. The genetic correlation between calving ease and birth weight was 0.127. The low heritability for calving score showing a high influence of environmental conditions over trait. The feeding of cows influenced the birth weight of calves.

The calves from Limousine breed have low birth weight which lead to minimum calving problems. A threshold model was used in France in genetic evaluation of cattle (Ducrocq, 2000), Italy (Canavesi, 2003) and USA (Wiggans et al., 2003). In present the Bayesian methods for threshold model was used by different authors because the distributed data were better analysed (Wang et al., 1997; Varona et al., 1999).

4 Conclusions

The relative breeding values for calving scores for the best calves were from 119 to 127 at first iteration and from 119 to 123 at six iterations. The cattle with high relative breeding value for calving score had easy calving. The selection of the best cattle for this trait is necessary for the studied population of Limousine breed. The heritability of calving score was low in population of Limousine breed. The threshold model was adequate due to better accounting for the total variability for calving score. The phenotypic and genotypic correlation between calving score were positive. Using the threshold model can be estimate the proportion of cattle which perform in each category for calving score. Applying the threshold model for calving score would increase the accuracy of selection in population of Limousine breed.

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