ANALYSIS OF LONGEVITY IN HOLSTEIN AND MONTBELIARDE CATTLE BREEDS

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Abstract

This study aimed at estimating the heritability and breeding values for the productive herd life in Holstein and Montbeliarde cows using a survival model. Data was analysed by means proportional hazard model. The experiment was done inside the experimental herd of the institute. The average productive longevity was 854 days for Holstein (125 cows), and 1434 days for Montbeliarde (36 cows), respectively. The heritability values for longevity in cattle populations were 0.099 for Holstein, and 0.097 for Montbeliarde, respectively. Similarly, the breeding values for productive longevity of the studied cattle ranged from -0.319 to 0.127 months for Holstein, and from -0.140 to 0.130 months for Montbeliarde, respectively. Even though this trait is difficult to improve, longevity is recommended to be included in cattle breeding programs in Romania from its utility point of view.

Key words: *breeding value, heritability, cattle, survival model*

INTRODUCTION

Nowadays, there is a growing interest to include longevity in the selection objective. The improvement of cow's lifetime performance could be achieved by including longevity as trait in dairy cattle breeding programs. This is translated in a refined farmers' ability to carefully decide towards slaughtering, rendering the cows exhibiting good health and welfare to be eliminated from the selection process. As such, reduced replacements costs, and implicitly reduced production costs are obtained by improving longevity. The statistical tools available for the evaluation of longevity include the use of generalized linear models, random regression models, threshold models, as well as survival analysis (Imbayarwo-Chikosi et al., 2015). Some of the advantages offered by the survival analysis over the use of linear models include a better estimation of heritability values, along with an increased precision in estimating the productive life differences between animals with similar survivability levels (Al-Samurai et al., 2014). Generally, cattle evaluation employing proportional hazard models are parametric Weibull models (Imbayarwo-Chikosi et al., 2015). The objective of the present study was to assess the longevity trait herds of two cattle breeds, Holstein and Montbeliarde, by estimating the associated heritability and breeding values.

MATERIAL AND METHOD

The research activities comply with the European Union Directive 2010/63. The cattle were reared in intensive breeding system in the experimental farm of our institute. The pedigree data for Holstein population consisted of 252 animals: 102 cows, 25 bulls and 125 cows with performances, whereas for Montbeliarde population the data consisted of 92 animals: 35 cows, 21 bulls and 36 cows with performances. Data were recorded for the reproductive and productive performances of cows. Among the cows with performances, 42 cows from Holstein breed and 19 cows from Montbeliarde breed had censored data.

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The manuscript was received: 30.09.2022
Accepted for publication: 13.12.2022

Censored data are represented by the absence of age records at the time of culling, while uncensored data are accompanied by the age records at the time of culling. Cows' culling was employed due to the reproduction, health, productivity and management issues. Data were collected between the years 2008-2018 for Holstein cows and between the years 2011-2018 for Montbeliarde cows. The average of test-day milk yield in productive life of Holstein cattle was 23.17 kg, and 22.32 kg for Montbeliarde cows, respectively. Milk production was assessed on 3 levels (high, medium and low) and the season effect comprised 4 levels. The average age at first calving was 31.5 months in Holstein cattle population and 34 months in Montbeliarde cattle population. All animals were raised under similar conditions.

Statistical analysis. The proportional hazard model was assessed using the R software (done by Grosu, 2013, 2019):

$$S_t = exp^{-(\lambda t)^{\rho}}$$

where "λ" is the calculated scale parameter and "ρ" is the calculated shape parameter (Dorner, 1999).

"ρ" was 1.16 for Holstein and 1.28 for Montbeliarde and "λ" was 0.0239 for Holstein and 0.0198 for Montbeliarde.

The hazard function was expressed as follows:

$$h(t) = \rho\lambda(\lambda\rho)^{\rho-1}$$

The risk factors were modelled as a linear model (Grosu et al., 2013):

$$\eta_i = X_i' * b + Z_i' * u$$

where "b" are fixed factors, and "u" are random factors.

$$S(t, \eta_i) = exp^{-t^{\rho}} exp^{\eta i}$$

For $\eta = \rho ln(\lambda)$, and

$$h(t, \eta_i) = \rho t^{\rho-1} exp^{\eta i} = h_0(t) exp^{\eta i}$$

where "$h_0(t)$" describes the basic hazard function when $\eta = 0$

$$\eta_i = X_i' * \hat{b} + Z_i' * \hat{u}$$

$$q_i = exp^{\rho ln(t)}$$

$$r_{ii} = q_i exp^{\eta i}$$

$$Y_i = w_i - q_i exp^{\eta i} + r_{ii}\eta_i$$

w_i =1 for the uncensored dataset, while w_i =0 for the censored dataset

The mixed model equations were:

$$\begin{pmatrix} X'RX & X'RZ \\ Z'RX & Z'RZ + G^{-1} \end{pmatrix} \begin{pmatrix} \hat{b} \\ \hat{u} \end{pmatrix} = \begin{pmatrix} X'y \\ Z'y \end{pmatrix}$$

where "X" includes X_i', "Z" includes Z_i', "R" describes the diagonal matrix, the diagonals are equal to $r_{ii,}$ and y represents a vector of Y_i

$$\eta_i = b_j + h_k + a_i$$

RESULTS AND DISCUSSIONS

In the survival model in our study, the production level was set as a fixed effect. The milk production had a significant effect on Holstein and Montbeliarde cows' longevity. Similarly, Kern et al. (2016) have shown that in Brazilian Holstein the environmental factors (milk production, regional effects) influence the longevity of cows. In this context, Olechnowicz et al. (2016) have shown that the reproduction and production traits influence longevity. Age at first calving determines the fertility and length cows' productive life (Zolkiewski et al., 2018). In the Holstein population, the age at first calving was 31.7 months, whereas in the Montbeliarde population it reached 34 months. Abadia et al. (2016) reported higher culling risks in Mexican Holstein when cows calve early, before 24 months of age, which may be related to the lower body weight of cows. In our study, the average test-day milk yield for the productive life registered 23.27 kg for Holstein cows, and 22.32 kg for Montbeliarde population, respectively. Similar findings were reported by Litwinczuk et al. (2016), who obtained the average test-day milk yield of 18.5 kg in Polish Holstein-Friesian cows. Remmik et al. (2020) reported that a longer first calving interval leads to higher lifetime milk production in Estonian Holstein cattle. The productive longevity in Holstein and Montbeliarde cows' population in our study was 854 days (28 months) for Holstein and 1434 days (47 months) for Montbeliarde cows. Holstein herd had lower productive life than the Montbeliarde herd. The average productive longevity was between 28 and 36 months. Other findings showed that the productive longevity in Brazilian Holstein was 952±497.10 days (Kern et al. 2014). Zolkiewski et al. (2018) have shown that Montbeliarde cows had 5.31 lactations, high lifetime yield of milk and its constituents. These authors had shown that Montbeliarde cows were culled due to poor yield and udder

disease. Walsh et al. (2008) reported that the median survival period after the first calving for the Holstein-Friesian cows was 695 days (1.9 lactations) and for Montbeliarde cows was 1023 days (2.8 lactations) in Ireland. Karslioglu Kara and Koyuncu (2018) observed that the longevity for Holstein from Turkey was 33.6 month. Valchev et al. (2020) obtained the productive life was 3.63 years. The heritability for longevity as productive life of Holstein cows' population was 0.099 and 0.097 for Montbeliarde cows. Varying heritability values measured for functional longevity have been reported by other authors in different cattle breeds. Shin et al. (2022) obtained the heritability of longevity for the first, second and the third parity was 0.020, 0.028 and 0.039 in Korean Holstein cows. The estimates of heritability for functional longevity in our study are within the ranges cited in the scientific literature, which are generally low. Similarly, Garcia-Ruiz et al. (2016) found longevity heritability values between 0.09 and 0.10 in Holstein cattle. Compared to our study, the heritability obtained for productive longevity was lower in other experiments. For example, Kern et al. (2014) obtained values of 0.05 and 0.07, Wiebelitz et al. (2014) found a range of 0.03-0.05 in German Holstein, followed by Zavadilova and Stipkova (2012) with 0.03-0.05 in Czech Holstein, Shabalina (2021) with 0.05 in German Holstein. Other authors obtained higher heritability for functional productive life than in the study herein: Kern et al. (2016) obtained 0.18 using the threshold model in Holstein cows in Brazil; Van Pelt (2017) reported a range of 0.115-0.149 in Holstein Friesian and Dutch Friesian; Sasaki et al. (2012) found 0.12 in Japanese Holstein; M'hamadi et al. (2010) estimated a value of 0.19 using Weibull proportional hazard model in Tunisian Holstein; Strapakova et al. (2014) reported a value of 0.13 in Slovak Holstein population on the original scale; and Imbayarwo-Chikosi et al. (2017) obtained a heritability value of 0.11 in South African Holstein. Accordingly, it has been observed that longevity heritability differs from one breed to another and from one population to another population in the same breed. The breeding value for longevity in Holstein and Montbeliarde populations was estimated using the Best Linear Unbiased Prediction BLUP-Survival Animal Model. The breeding values of the best 10 Holstein cows are shown in Table 1 and ranged from 0.092 month to 0.127 month. The average breeding value for productive longevity in Holstein cows from our study was -0.032, ranging from a minimum of -0.319 and a maximum of 0.127. The breeding value in Holstein sire ranged from -0.241 to 0.104, and registered an average of -0.013. Furthermore, we estimated an average relative breeding value in Holstein bulls of 98, ranging from 58 to 119.The estimated breeding values of the best 10 Montbeliarde cows are shown in Table 1 and ranged from 0.045 to 0.130 months. The average breeding value for productive longevity in Montbeliarde cows was -0.0016 with a minimum breeding value of -0.140 and a maximum of 0.130. The average breeding value in Montbeliarde sire was -0.001 ranging from -0.123 to 0.0943. The average relative breeding value in Montbeliarde bulls was 100. The breeding values for Montbeliarde bulls ranged from 71 to 122. The estimates for the cattle productive longevity breeding values in our study are within the ranges cited in the scientific literature, which are generally low. For instance, Garcia-Ruiz et al. (2016) reported in Holstein cattle the average breeding value for longevity of 1.06±2.89. For Canadian Holstein bull proofs, the average relative breeding value was 100, ranging from 85 to 115 (Van Doornaal, 2010). Strapakova et al. (2014) have shown that the breeding value of total bulls in Slovak Holstein population ranged from -0.78 to 0.8, highlighting the best 10 sires in herd with an average relative breeding value of 100±12.

Table 1 Longevity breeding values (months) for the best 10 Holstein and 10 Montbeliarde cows

No. cow	Breeding values for Holstein longevity	Breeding values for Montbeliarde longevity
1	0.1270	0.1302
2	0.1085	0.1180
3	0.1082	0.0952
4	0.1073	0.0920
5	0.1056	0.0905
6	0.1047	0.0652
7	0.1008	0.0642
8	0.0993	0.0530
9	0.0978	0.0511
10	0.0924	0.0456

Cows' productivity increases as the environment factors are improved (Van Amburgh and Soberon 2013). Shabalina et al. (2021) reported that the genetic correlations between length of productive life and stayability were high (0.77-0.94), the selection for stayability can determine the genetic improvement of longevity.

CONCLUSIONS

In the present study, we showed that the heritability for longevity estimated in Holstein and Montbeliarde cattle populations was low, which suggests that this attribute falls into the category of traits that are difficult to improve. Due the low predicted heritability, indirect selection is therefore important in order to improve longevity. By employing the survival analysis, the results obtained herein provide further insight with regard to the farm environmental conditions, the improvement of which may lead towards increased longevity in cattle. Therefore, longevity is a trait recommended to be included in cattle breeding programs in Romania.

ACKNOWLEDGEMENTS

This work was supported by funds from the National Research Projects 8.1.6 and 8.1.10 granted by the Romanian Ministry of Agriculture and Rural Development and Perform project 8 PFE/2021 and PN 19090201 funds from Ministry of Research, Innovation and Digitalization.

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