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Evaluation of the relationship between main type traits and longevity in Hungarian Simmental cows

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SUMMARY

The Hungarian Simmental cattle is a dual-purpose breed, having good milk and meat production characteristics. Simmental cows have some other important traits, for example, a longer productive life. The longevity or productive life is the time period between first calving and culling. The conformation contributes to productive life, reproduction, and milk production.

The aims of this study were to analyze the longevity of Hungarian Simmental dual-purpose cows, to evaluate the effects of the size of the herd, age at first calving, main type traits (frame, musculature, feet and legs, mammary system), and combination of main type traits (frame and musculature, feet and legs and mammary system).

*Animal, age at first calving, herd*calving, musculature, the mammary system as well as the combination of mammary system and feet and legs were significant effects on longevity. The highest risk ratio was observed for cows first calved after 31 months. The risk of culling increased with increasing scores of musculature and decreasing scores of the mammary system. The highest risk ratio was estimated in category 11 (lower scores of mammary system with lower scores of feet and legs). In this case, the risk ratio was 36% higher than the reference group.*

Keywords: *Hungarian Simmental cows, longevity, main type traits, survival analysis*

INTRODUCTION

The Hungarian Simmental cattle is a dual-purpose breed, having good milk and meat production. Simmental cows have some other important traits such as good conformation, high and long-term fertility, excellent mothering ability, and longevity.

The longevity or productive life is an essential functional trait in the selection of cattle. Longevity is included with the weight of 8% within the selection index of the Hungarian dual-purpose Simmental population. Longevity is the time period between first calving and culling (Hu et al., 2021). The longevity is in relation to profitability, a longer productive life increases the profits and decreases the replacement costs (Van Arendonk, 1991). Furthermore, a longer productive life decreases the methane emission and the environmental footprint of the milk industry (Dallago et al., 2021). The longevity of dairy cows was less than 2.7 lactations (Hu et al., 2021), while the theoretical herd life (the time period between birth to culling) could be approximately 20 years (Najafabadi et al., 2016). The longevity of Hungarian Simmental cows was 2.7 in 2012 (Bedő, 2014). According to Bene and Balaskó (2015), the number of completed lactations was 2.7 for Hungarian Holstein-Friesian cows. The longevity of beef cows was higher than it was estimated for dairy cows. Based on the results of Dákay et al. (2005), the longevity values were 8.95, 9.08, 8.28, 7.81, 7.91, 10.79, 5.55 years for Hungarian Grey, Hereford, Aberdeen Angus, Limousin, Charolais, Simmental x Hereford F_1, Simmental x Limousin F_1 cows. Zsuppán et al. (2010) reported, that the longevity was 6.32 years for Hungarian Simmental beef cows.

The heritability of longevity is low. Hu et al. (2021) reported heritability values in the range from 0.01 to 0.30. Based on Raguž et al. (2014) and Strapáková et al. (2019), the heritability values were 0.07 and 0.05 for Croatian and Slovak Simmental cattle, while Vukasinovic et al. (2001) and Zsuppán et al. (2010) found higher values of heritability (0.19; 0.35) for Swiss dual-purpose Simmental and Hungarian Simmental beef cattle. Bene and Balaskó (2015) reported reasonably higher heritability (0.61) for Hungarian Holstein-Friesian cows.

The conformation contributes to productive life, reproduction, and milk production (Schneider et al., 2003). Several authors observed a strong relationship between udder traits, feet and legs traits, and longevity for Simmental cattle (Canji et al., 2008; Strapák et al., 2010). Canji et al. (2008) reported, besides the mammary system and feet and legs, the body frame was the most important main type trait on Slovak Simmental cows' longevity. Berta and Béri (2011) found the connection between dairy character, body capacity and longevity of the Hungarian Holstein-Friesian population.

The aims of this study were to analyze the longevity of Hungarian Simmental dual-purpose cows, to evaluate the effects of the size of the herd, age at first calving, main type traits (frame, musculature, feet and legs, mammary system), and combinations of main type traits (frame and musculature, feet and legs and mammary system) by survival analysis method. Several pieces of research examined the effect of single traits on longevity, but these studies did not estimate the interaction effect of traits. This approach gives information about the joint impacts of main type traits on longevity.

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MATERIALS AND METHODS

The dataset contained information of 6,867 Hungarian Simmental cows, 1,689 cows (25%) were still in production at the time of data collection. The cows were born between 1997 and 2016 and the first calving was after 2000. The records were collected by the Association of Hungarian Simmental Breeder's. The pedigree file contained 26,190 cattle. Longevity was evaluated from the number of lactations.

In the model the number of lactation was the dependent variable, the animal was the random effect as well as the herd*calving year was the time-dependent covariate. The model has contained the fixed effect of size of the herd (number of annual calving is under 20; number of annual calving is between 20–50; number of annual calving is over 50). The further fix effects were the age at first calving (≤25 months, 26 months, 27 months, 28 months, 29 months, 30 months, ≥31 months), the main type traits (frame, musculature, feet and legs, mammary system) and combinations of main type traits.

Main type traits were judged on first-parity cows. Scores of main type traits were on a 1–9 scale. The scale was divided into three groups: 1–3 denoted as 1, 4–6 denoted as 2, finally, 7–9 denoted as 3. The combinations of main type traits were created based on principal component analysis and cluster analysis. The following combinations of main type traits were evaluated in our analysis based on our previous study (Török et al., 2021):

1. frame-musculature,
2. mammary system-feet and legs.

The dataset was created using Microsoft Office Excel and Microsoft Office Access. Relationship among factors (size of herd, herd*year, age at first calving, main type traits, combinations of main type traits) and longevity were evaluated using the Weibull model in the Survival Kit program (Mészáros et al., 2013).

RESULTS AND DISCUSSION

In *Table 1* descriptive statistics for some factors are shown. Based on our results, the average longevity was 3.23 and the average age at first calving was 28.07 months. In contrast, Jovanovac and Raguž (2011) reported a longer productive life (3.96 years) and earlier age at first calving (26.25 months) for Croatian Simmental cows. The productive life was 3.88 years for Slovak Simmental cow (Strapák et al., 2010). The means of main type traits scores varied between 5.09 for musculature and 5.67 for the frame. The standard deviation of musculature was the lowest.

Table 1: **Descriptive statistics of the analyzed factors (n=8868)**

Factors	Mean	SD	Min	Max
Longevity (number of lactations)	3.23	1.71	1	12
Age at first calving (months)	28.07	2.05	22	34
Musculature	5.09	1.11	1	9
Frame	5.67	1.20	1	9
Feet and legs	5.49	1.43	1	9
Mammary system	5.14	1.63	1	9

Significant effects of factors were presented in *Table 2.* Animal, age at first calving, herd*calving year, musculature, mammary system, and combination of mammary system and feet and legs were significant impacts on longevity. The effect of herd*calving year might be the result of the different environmental impacts of calving years within herds. According to Canji et al. (2008) and Strapák et al. (2010), the frame, the feet and legs, and the mammary system were an effect on the longevity of Slovak Simmental cattle. Based on several studies, the most important type traits were the mammary system and the feet and legs (Zavadilová and Stipková, 2009; Caraviello et al., 2004).

Table 2: **Significant effects of different factors impacting longevity**

Factors		Sign.
Random effect	**Animal**	*
Fix effect	Size of herd	n.s.
	Age at first calving	*
Time-dependent covariate	**Herd*calving year**	*
Main type traits	Frame	n.s.
	Musculature	*
	Feet and legs	n.s.
	Mammary system	*
Combinations of main type traits	Frame-musculature	n.s.
	Mammary system-feet and legs	*

*: P<0.05

Figure 1 shows the effect of age at first calving on the relative culling risk. The highest risk of culling was observed in cows having their first calving after 31 months, with about 40% more risk ratio compared with the reference group (age at first calving: 27 months). The lowest risk ratio was evaluated in cows having first calving under 25 months. Most cows had their first calving at 27 and 28 months. According to Potočnik et

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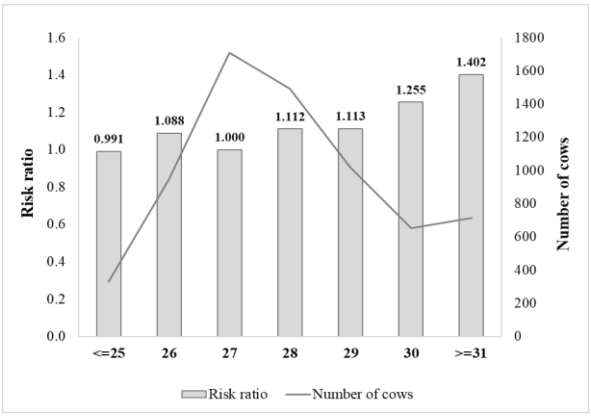
al. (2010), relative culling risk increases with the increase of age at first calving for Slovenian Simmental cattle. Based on Cielava et al. (2017) findings, the later age at first calving leads to reduces reproductive performance and it might be the main reason for decreased longevity. The later age at first calving might be a signal of low fertility or other health problems. Jovanovac et al. (2013) reported that the later age at first calving leads to a lower risk of culling for Croatian Simmental cows. The reason of the different tendency of risk ratios might be originated in the different environmental and technological conditions.

Figure 1: **Effect of age at first calving on the relative culling risk**



The relationship between musculature and culling risk was shown in *Figure 2*. Description of musculature at the hind haunch analogous to the EUROP system (Tanzler et al., 2015). The lowest risk ratio was estimated for category 1 (scores: 1,2,3) as well as the highest risk ratio was observed for category 3 (scores 7,8,9). So, the increasing score of musculature increased the relative culling risk. The musculature and meat production were in close relation. Between meat production and milk production there were a negative correlation. The higher musculature score might result lower milk production and therefore increases voluntary culling risk. Our estimation was in line with Jovanovac and Raguž (2011), as they recognized cows with higher scores for the musculature were at higher risk of culling than the lower scores for Croatian Simmental cattle. In contrast, Strapáková et al. (2021) reported lower culling risk for cows having a higher score of musculature for Slovak Simmental cattle. This contradiction among the reported risk ratios might be the result of differences among selection decisions across countries.

To calculate mammary system score, contributions from linear traits (fore and rear udder length, central ligament, udder depth, fore udder attachment, front and rear teat placement, teat thickness, and teat length) were weighted according to their effect on longevity (Tanzler et al., 2015). *Figure 3* shows the effect of the mammary system on longevity. The risk of culling increased with increasing scores of the mammary system. The highest risk of culling was evaluated for category 1 (scores: 1,2,3), the risk ratio 32% higher than the reference group (where the risk ratio=1.000). The higher scores of the mammary system have a more favorable effect on longevity. Most of the cows were average mammary system scores (category 2). Sewalem et al. (2004) reported the mammary system was the second most important trait on longevity. The low scores of the mammary system resulted a higher risk ratio compared to the higher mammary system scores.

Figure 2: **Effect of musculature on relative culling risk**

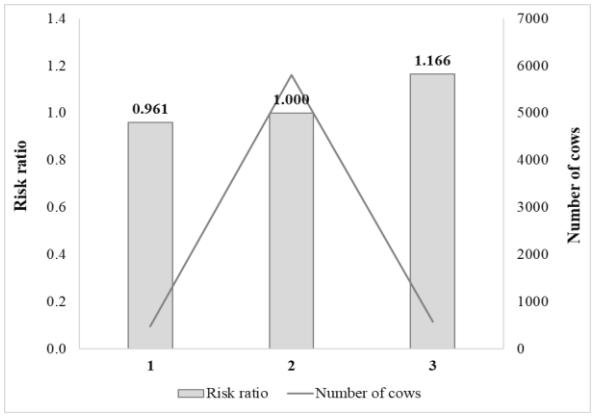
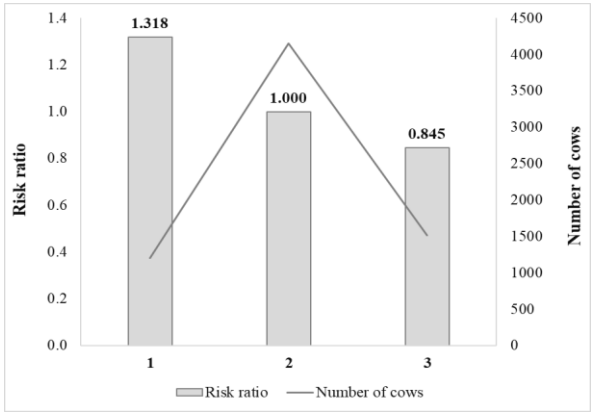


Figure 3: **Effect of the mammary system on relative culling risk**



The relationship between the combination of mammary system and feet and legs and relative culling risk was shown in *Figure 4*. The highest risk ratio was observed for class 1–1. The cows having lower scores of mammary system with lower scores of feet and legs had a higher risk of culling than the risk ratio of the reference group (category 2–2). In this case, the risk ratio was 36% higher than the reference group. The second culling risk was estimated in category 1–2 (lower scores of mammary system and average scores of feet and legs) and the third in category 1–3 (lower scores of mammary system and higher scores of feet and legs). The risk ratio was higher in the case of lower scores of the mammary system (1–1, 1–2, 1–3). The lowest risk ratio was evaluated in category 3–1 (higher scores of mammary system and lower scores of feet and legs), but in this class the number of cows was low. The

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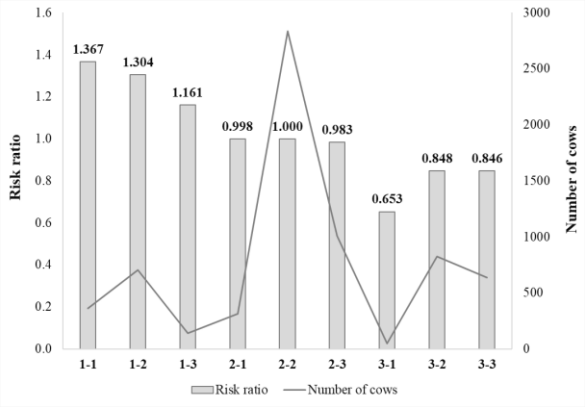
increasing score of the mammary system decreased the relative risk ratio. The tendency of risk ratios was similar for lower scores of the mammary system (1–1, 1–2, 1–3), average scores of the mammary system (2–2, 2–3), and lowest scores of the mammary system (3–2, 3–3) subclasses. The risk ratio had decreased with increasing of feet and legs scores in case of low mammary system scores whereas risk ratios were quite similar for average and above average mammary system scores independently from feet and leg scores.

Figure 4: **The effect of the combination of mammary system and feet and legs on the relative culling risk**



CONCLUSIONS

The evaluation of the relationship between main type traits, combinations of main type traits, and longevity using the survival analysis method was focused on in our study. Animal, age at first calving and herd*calving were significant impacts on longevity. The lowest risk ratio was evaluated in cows having first calving under 25 months. The highest risk ratio was observed for cows first calved after 31 months. The most important type traits were the musculature and mammary system. The risk of culling increased with an increasing score of musculature and the relative culling risk increased with decreasing scores of the mammary system. From the two combinations of main type traits, the most important combination was the combination of mammary system and feet and legs. Cows having a lower score of mammary system with the lower score of feet and legs had the highest risk of culling.

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