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Some factors affecting the longevity of Hungarian Simmental beef purposed cattle

A húshasznú magyartarka élettartamát befolyásoló néhány tényező értékelése

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ABSTRACT

The study aimed to assess the influence of herd size, age at first calving, year, month, season of first calving, and first calf sex on the longevity of Hungarian Simmental beef cattle using survival analysis. The data included 598 sires, 9,077 dams, and 14,165 cows, with longevity defined by the number of calvings. A Weibull proportional hazards model was applied to analyse functional longevity. Results indicated the lowest culling risk (20% less) in cows calving first ≤ 27 months of age compared to the reference (33< and ≤ 36 months). Cows first calving at 46< months showed a 37% higher culling risk. Medium-sized herds had the highest culling risk (23%) compared to the reference, while large herds had the lowest. Seasonally, spring and summer calving presented higher risks, and a slight increase in culling risk was observed for cows with male first calves (0.4% higher). Findings show that these factors significantly affect longevity, making them valuable considerations for herd management. The heritability for calving number was $h^2 = 0.20$, suggesting that it is a useful selection trait due to its low heritability and reliable measurability, supporting its role in longevity enhancement.

Keywords: beef cattle, culling, survival, weibull, longevity

ÖSSZEFOGLALÁS

Tanulmányunk célja az állományméret, az első elléskor betöltött életkor, az év, a hónap, az első ellés évszaka és az első borjú nemének a húshasznú magyartarka hosszú élettartamára gyakorolt hatásának értékelése volt. Az adatok 598 apára, 9077 anyára és 14165 tehénre terjedtek ki, a hosszú élettartamot az ellések száma alapján határoztuk meg. A hosszú élettartam elemzéséhez Weibull modellt alkalmaztuk. Az eredmények azt mutatták, hogy a selejtezés kockázata a 27 hónapos kor előtt először ellő tehenek esetében volt a legalacsonyabb, a referenciához (33< és ≤ 36 hónapos kor) képest 20%-kal kisebb. A 46 hónapos kort követően először ellő teheneknél 37%-kal magasabb volt a selejtezés kockázata. A közepes méretű állományoknál volt a legmagasabb a selejtezési kockázat (23%), míg a nagy állományoknál a legalacsonyabb. Szezonálisan a tavaszi és a nyári ellés magasabb kockázatot jelentett, míg az első elléskor bikaborjakat ellő tehenek esetében a selejtezési kockázat enyhe növekedése volt megfigyelhető (0,4%-kal magasabb). Az eredmények azt mutatják, hogy ezek a tényezők jelentősen befolyásolják a hosszú élettartamot, így értékes szempontok a tenyésztői munkában. Az elléssszám öröklődőképessége h^2 =0,20 volt, ami arra utal, hogy alacsony örökölhetősége mellett megbízható mérhetősége miatt hasznos lehet a beépítése a szelekciós modellbe, ami elősegíthetné a hosszú élettartam növelését.

Kulcsszavak: húsmarha, selejtezés, túlélés, weibull, hosszú élettartam

INTRODUCTION

The Simmental breed was named after the Simme Valley in Switzerland, where it was bred for the first time. Its colour ranges from light yellow to dark red, with a white head being the most common (Averdunk, 2002). The Hungarian Simmental cattle, at the end of the nineteenth century, were comprised of local breeds (Hungarian Grey) combined with Swiss cattle. Until the late 1970s, the Hungarian Simmental was the most popular breed in Hungary (Holló et al., 2012). Currently, the population is bred for both milk and meat production, accounting for around 50,000 cows in Hungary (Abella et al., 2023). As it produces milk and meat, the Hungarian Simmental cow is a dual-purpose breed, playing a vital part in Hungary's high-quality beef production (Hollo et al., 2008). The longevity or lifespan of a cow can be defined as the sequence of individual events that characterize its life, encompassing the non-productive phase until breeding and the productive phase. Total life is measured from birth until culling or the death of the cow (Sawa et al., 2010). According to Forabosco et al. (2004), the functional longevity of an animal is defined as its productive lifespan and is measured by the number of days between first calving until culling or death. Another option is measuring it based on the number of lactations/ calvings. The longevity of cows is recognized as a measure of how long they produce in a herd, governed by various characteristics, including productivity (Vollema, 1998; Neerhof et al., 2000; Dallago et al., 2024). Furthermore, in many breeds, longevity is considered one of the most important traits that significantly impact the profitability of herds (Groen, 1999; Aliloo et al., 2025). Functional features are described as characteristics that improve efficiency by lowering input costs (Kühn et al., 2003). Fertility, calving ease, temperament, and longevity are examples of what are known as functional traits. The extension of a female's career has two positive effects: it reduces the costs of the breeding phase and improves profits from the production phase, enhancing average herd productivity and animal health (Vukasinovic et al., 2001; Bang et al., 2025). Additionally, the expense of raising or purchasing replacement heifers is reduced as longevity increases. When replacement heifers aren't needed as frequently, the operation can be more selective about which heifers to keep, allowing breeders to make more informed decisions (Vukasinovic, 1999). However, the longevity of a cow is conditioned by its production characteristics, morphology, fertility, and health, meaning the reduction in the causes of culling. As a result, both the reasons for culling and the reasons for cows leaving the herd are two elements that need careful consideration to control renewal costs. Incorporating longevity into beef cattle breeding programs would assist farmers in selecting heifers with a higher likelihood of staying productive on the farm for an extended period, enabling them to set the age of culling based on their breeding goals (Caetano et al., 2013). Longevity is often assessed toward the end of an animal's productive life, resulting in a scarcity of direct data on younger animals. As the heritability of longevity is low, typically ranging between 0.2 and 0.3 (Horn 1995), estimating lifetime early on may be simplified by using related attributes evaluated during the early stages. These characteristics can serve as early predictors for beef cattle populations. Larroque and Ducrocq (2001) discovered that certain traits in dairy herds, such as the conformation of the udder, may act as early signs of longevity. In beef cows, relatively few traits have been identified as related to longevity, including dystocia and muscularity traits (Rogers et al., 2004; Forabosco, 2005; Williams et al., 2024). However, several studies found other factors that may affect longevity, such as age at first calving, herd size, the season of first calving, and sex of the first calf (Jovanovac et al., 2013; Morales et al., 2017; Morek-Kopeć and Zarnecki, 2017; Szabó et al., 2021). In order to study the effect of factors on longevity, different methods were used. Imbayarwo-Chikosi et al. (2016) found that survival analysis could handle censored data, take into account time-dependent environmental effects, and manage the skewed distribution of longevity features. According to Ducrocq (1994), deciding whether to include data from cows still alive during examination might introduce bias into estimates of parameters influencing longevity. Various techniques may be used to predict productive life. Linear models are unsuitable

for statistically analyzing longevity data because they do not meet the requirements of normality (Lagakos, 1979). Survival analysis takes into account both censored (still in production) and uncensored (culled) data, allowing for the inclusion of environmental time-independent factors like age at first calving, year and season of calving, herd size, and herd size variation (Strapáková et al., 2013). Furthermore, heritability estimates for longevity derived from the Weibull proportional hazards model typically range from 0.05 to 0.20, compared to 0.05 to 0.10 from standard linear models (Mészáros et al., 2010). As the ability to live a long life is a valuable economic asset and for a more comprehensive understanding of the factors influencing the longevity of beef cattle and to enhance practical implications for farmers and breeding programs, the main aim of the current research was to analyse the effect of various factors on the longevity of Hungarian Simmental beef purpose-bred cattle using survival analysis.

MATERIAL AND METHODS

The data used were obtained from the Association of Hungarian Simmental Breeders, with first calving recorded between 1986 and 2021. The database contains calving information of 14165 cows originating from 598 sires and 9077 dams.

The database was trimmed by removing the missing, inaccurate, and duplicate data. Animals that were not between 24 and 60 months old at the time of their first calving were eliminated. Cows having a first calving age of fewer than 24 months were removed from the dataset due to biological impossibility and the breeding system's normal ages. Furthermore, cows with a first calving age of more than 60 months were also removed from the database as they were supposed to have missing calving information in the database.

Cows were classified into seven classes based on their age at first calving, each class has almost the same number of animals:

- I: ≤ 27 months,
- II: 27 < and ≤ 30 months,
- III: 30 < and ≤ 33 months,
- IV: 33 < and ≤ 36 months,
- V: 36 < and ≤ 39 months,
- VI: 39 < and ≤ 46 months,
- VII: 46 < months).

The 41 herds in the data were divided into 3 groups depending on the size of the herd:

- Small ≤ 50 cows,
- Medium 50< and ≤ 250 cows,
- Large 250< cows.

The birth season was divided into 4 groups:

- Winter (December, January, February),
- Spring (March, April, May),
- Summer (June, July, August),
- Autumn (September, October, November).

The number of calvings was defined as the longevity of cows. The records of cows calved after 1/1/2019 were considered as censored (5350), which present 37.7% of the data, and the rest as uncensored data.

The model used in the research contains the fixed effect of the herd, the year of birth, the age at first calving, the season (Winter, Spring, Summer, Autumn) and sex of first calf.

The structure of the model was:

$$\lambda(t) = \lambda 0(t) exp \{\sum i\ fi(t)\}$$

where:

$\lambda 0(t)$ is the baseline hazard function;

$\sum i\ fi(t)$ is the sum of fixed environmental effects (herd, birth year, age at first calving, season of first calving and sex of first calf);

The Weibull model in the Survival Kit program (Mészáros et al., 2013) was used to evaluate relationships between multiple parameters (herd, birth year, age at first calving, season of first calving and sex of first calf) and longevity. When compared to the reference class (where the risk ratio = 1), the risk ratios demonstrated the relative risk of culling. Culling was defined as the killing or slaughter of cows in our study. The reference class was chosen for each factor by the software as the class having the most uncensored records in the database.

The heritability of longevity based on the animal model was calculated by using the following formula:

$$h^2 = \frac{\sigma^2{}_a}{\frac{1}{p} + \sigma^2{}_a}$$

where:

h^2 = heritability.

σ^2_a = genetic variance estimated using the Survival Kit.

p = proportion of uncensored records (Mészáros et al., 2013).

RESULTS AND DISCUSSION

Distribution of the number of calving

In this study, we aimed to analyse the longevity of the Hungarian Simmental dual-purpose breed in order to understand the effect of non-genetic factors on the longevity of beef cattle and to enhance practical implications for farmers and breeding programs. The results obtained can be utilized to enhance both the longevity and productivity of beef cows. Among the studied population, 24% had only one calving, while 61% left the herd between the 2nd and 6th calving (Figure 1).

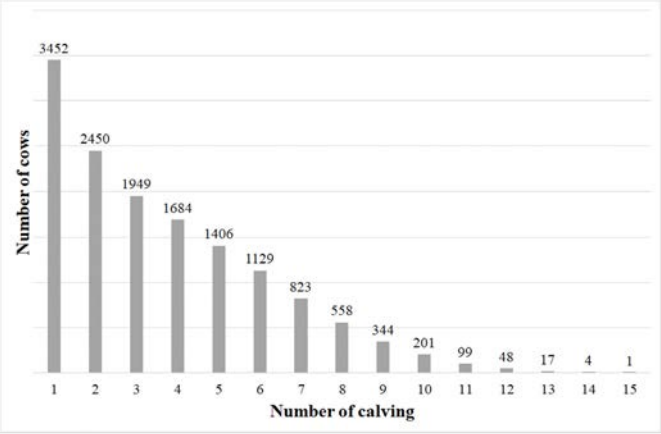

Figure 1. Distribution of the number of calving

Additionally, only 14% of the cows had more than 7 calving events. These findings suggest that a significant proportion of the studied population experienced a relatively low number of calving events. Furthermore, the majority of cows left the herd after a few numbers of calvings, indicating a potential trend towards reduced longevity within the population. This might be explained by the fact that some cows may have experienced reproductive challenges or were not bred during certain breeding seasons. Additionally, factors such as genetics, nutrition, and management practices could also contribute to the variation in calving numbers within the population (Murray et al., 2016; Brzáková et al., 2020; Klein et al., 2021; Larracharte et al., 2021)

Age at first calving

The risk ratio increases with the age at first calving (Figure 2), reaching the lowest risk in the first group where the age at first calving is between 24 – 27 months. This group shows a 20% lower risk of culling compared to the reference class (group 4, age at first calving between 34 and 36 months, risk ratio = 1.00).

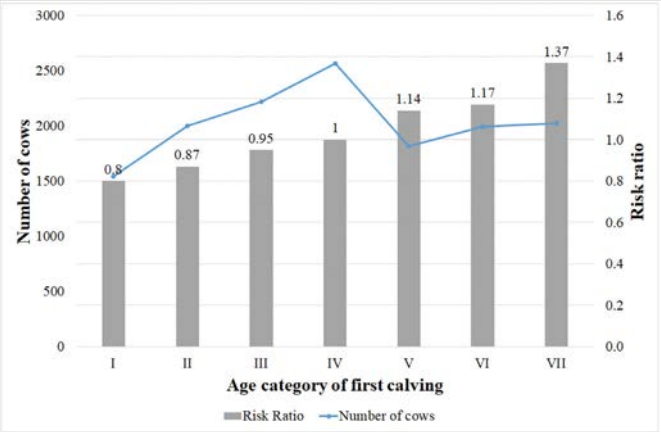

Figure 2. Effect of age at first calving on the relative culling risk

Furthermore, the 7th group, with the age of first calving between 46 and 60 months, presents the highest risk ratio, 37% higher than the reference class. These results align with findings from various researchers in different breeds, such as Morek-Kopeć and Zarnecki (2017) in Polish Simmental cows, Forabosco et al. (2004) in Chianina beef cattle, Morales et al. (2017) in the Retinta beef breed, Phocas and Ducrocq (2006) in Charolais cows, Bot Steffl et al. (2024) in South African Afrikaner cows and Chirinos et al. (2007) and Török et al. (2021) in Holstein Friesian cows. This alignment underscores a consistent pattern across various breeds, highlighting the impact of age at first calving on the risk of culling. This pattern may be explained by the fact that decisions on cow culling

primarily depend on economic factors later in the cows' lives. According to Nunez-Dominguez et al. (1991), the economic efficiency, measured as the difference between output and input, was found to be 6 to 8% higher in cows that gave birth at a younger age compared to heifers that were bred to give birth for the first time at three years of age. Zavadilová and Štípková's (2013) joint study reveals that cows calving for the first time at a later age (between 33 and 46 months) exhibit worse fertility during their first lactation and have a shorter lifespan in terms of productivity compared to those that calved earlier. Furthermore, Twomey and Cromie (2023) observed that cows calving for the first time at a later age exhibited a longer calving interval. This underlines the long-term implications of age at first calving on both reproductive and productive outcomes.

Herd size

The majority of herds of this population are large in size, with a number of animals, which is more than 250 cows. Cows in the herd with medium size 50< and ≤ 250 had the highest risk of being culled (Figure 3). When compared to the reference class (herd size >250, risk ratio = 1.0), it has a 23% higher risk of culling. The herd with a small size ≤50 presents a 13% higher chance of culling compared to the reference class. The findings are consistent with Török and Posta (2019), where a higher risk ratio was detected in medium-sized herds. Additionally, Miller et al. (2008) observed a slight, yet constant, decline in the number of cows leaving the herd as its size increased. In contrast, several studies have reported the lowest risk ratio in small-sized herds (Jovanovac et al., 2013; Raguž et al., 2014), though their classes have differed from ours. For instance, Raguž et al. (2014), divided the groups as follows: small herd size < 6 cows, medium herd size ≥ 6 and ≤ 15 cows, and larger herd size > 15 cows, which differs from our grouping in the present research of small herds ≤ 50 cows, medium herds 50 < and ≤ 250 cows, large herds 250 < cows. Furthermore, our results can be explained by the likelihood of changing herd size being higher in medium and small-sized herds compared to larger herds. This is due to the presence of less advanced equipment and fewer workers in smaller herds, making it more challenging to detect problems in cows. Consistent with this, Chirinos et al. (2007) mentioned in their research that animals in herds that reduced by more than 20% of the total size had a higher relative chance of being culled compared to animals in herds with a small increase or reduction in size.

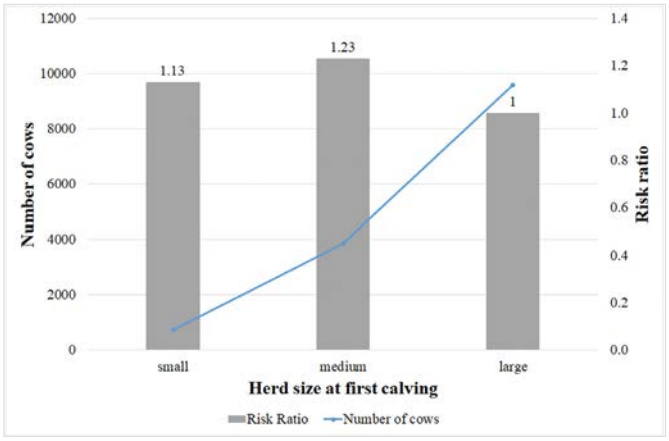

Figure 3. Effect of herd size on the relative culling risk

First calving season

Figure 4 illustrates the impact of the season of first calving on the longevity of cows. The highest risk ratio was observed for cows with their initial calving in spring, serving as the reference class (risk ratio = 1). The second-highest risk ratio was identified in the summer, with an estimated culling risk only 1% lower than the reference class. Conversely, the lowest risk ratio was found in autumn, indicating a 7% lower chance of culling than cows that calved in spring. Cows calving in winter exhibited the smallest culling risk, with a 14% lower probability than the reference class. Notably, a majority of cows in this population had their first calving in winter. Our findings align with Török and Posta (2019), indicating that cows calving in winter face a lower risk of culling compared to those calving in other seasons. In contrast, these results differ from Szabo et al. (2021) findings, which suggested that cows calving in spring or summer have a longer productive life and a reduced risk of early culling compared to those calving later in autumn or winter. On one hand, this difference can be attributed to the fact that Szabo et al. (2021) study involved different beef breeds, whereas

our research focused only on the Hungarian Simmental. According to Arthur et al. (1993), the breed significantly influences the longevity and lifetime production of cows. On the other hand, our results may be explained by the fact that cows calving in spring or summer are subsequently inseminated during the summer or autumn, coinciding with a high risk of heat stress. As mentioned by Sönmez et al. (2005) and Gupta et al. (2025), heat stress during the summer can impact dairy and beef cows, resulting in reduced estrus behaviour and lower conception rates.

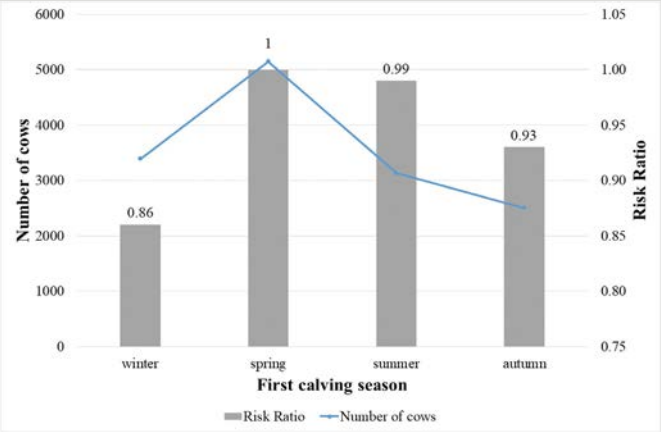

Figure 4. Effect of the first calving season on the relative culling risk

Sex of the first calf

A marginal difference in the risk ratio was observed for the first calf's sex. It is slightly higher for males compared to females, which presents the reference class (risk ratio = 1), with an estimated 0.4% higher chance of culling. Most studies on beef cattle suggest that the sex of the first calf has no significant effect on longevity (Szabó and Dákay, 2009; Morales et al., 2017). This difference in results could be explained, in part, by the larger database used in our study. For instance, Szabó and Dákay (2009) utilized data from 1800 cows only, while our analysis incorporated data from 14165 cows. Furthermore, our results may be attributed to the better calving ease observed in female calves compared to male calves, as mentioned by Morek-Kopeć et al. (2021). Additionally, they noted that the need for birth assistance is lower for female calves compared to males, and the culling risk is twice as high in cases requiring birth assistance. However, cows that give birth unassisted or with minimal help tend to have a longer productive lifespan compared to those requiring veterinarian intervention or experiencing stillbirth, as dystocia significantly contributes to the premature culling of beef females (Rogers et al., 2004).

Heritability

The animal variance was determined to be 0.394, resulting in a heritability of 0.20 for longevity (measured by the number of calvings), using a censoring rate of 37.7% (where P = 0.623 represented the proportion of uncensored data). Our findings closely align with the study of Morales et al. (2017), which reported a heritability of longevity at 0.30, where the number of calvings was used as the measure. Furthermore, productive life is defined as the period between the first calving and culling and can be used to evaluate longevity along with the number of calvings. Forabosco (2005) found that Chianina beef cattle had a low heritability of longevity, measuring 0.087. Caetano et al. (2017) conducted a study on Nellore beef cattle using age at last calving as a longevity variable and found a heritability of 0.25. The latest research indicates that the heritability of beef cattle longevity features varies from 0.01 to 0.30 (Phocas and Ducrocq, 2006; Meszaros et al., 2008; Bonetti et al., 2009; Strapáková et al., 2013; Bot Steffl et al., 2024; Passafaro et al., 2024).

CONCLUSION

In the present study, we showed that the age at first calving, herd size, season of the first calving and the sex of first calf were all critical factors that have a significant effect on the longevity of the Hungarian Simmental purebred beef cattle. The risk of culling is increasing with the increase in the age at first calving. In the medium herd sizes between (50-250 cows), the cows are estimated to have a higher culling risk (23%) than the reference class. Cows calving for the first time in winter have a lower risk ratio (14%) than cows calving in spring. For the sex of the first calf, there was a slightly higher risk ratio (0.4%) in males than in females. In conclusion, all the factors studied have an impact on longevity, even with a low-risk

ratio. Therefore, it is crucial for farmers to consider these factors in order to enhance the longevity of their herds. Additionally, the heritability for the number of calvings was h^2 = 0.20 in the present research. Since it has low heritability, it can be used as an important selection trait for longevity, as it is easier and more precise to collect.

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