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Longevity and Culling Dynamics of Holstein–Friesian Cows in Hungary

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Abstract

Dairy cow longevity is a key driver of farm profitability, animal welfare, and environmental sustainability. Despite genetic progress in milk production, the average herd life has declined in many high-yielding dairy systems, raising concerns about early culling. This study analyzed data from 2057 Holstein–Friesian cows in Hungary to characterize the distribution and timing of culling events and to identify major risk factors affecting productive lifespan. We studied age, parity, milk yield, and culling reason using descriptive statistics, Kruskal–Wallis tests, multinomial logistic regression, and Kaplan–Meier survival analysis. Udder health problems were found to be the most frequent cause of culling (22.8%), followed by metabolic disorders (18.2%), locomotive problems (17.3%), and reproductive disorders (17.1%). Economic reasons such as low milk production contributed to a smaller proportion of culling. Most cows were culled after the second or third lactation, with survival probability dropping sharply within the first 1500–2000 days of life. Cows reaching four or more lactations represented a small but economically and genetically valuable subset of the herd. Our results indicated that in Hungary culling decisions are largely determined by health problems, which represent a greater limitation to the productive potential of dairy cows than economic factors. This research recommends that breeding programs prioritize genetic selection for robustness and that herd management adopts preventive health and reproductive strategies to prolong cow longevity, ultimately enhancing the efficiency and sustainability of dairy production systems. Additionally, prevention of animal wastage to foster animal welfare could be suggested as an additional advantage.

Keywords: animal welfare; culling; Holstein–Friesian; Hungary; longevity; profitability

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1. Introduction

Dairy cow longevity is a key factor in the sustainability of modern dairy farming, which is linked to farm profitability, environmental efficiency, and animal welfare. Extending the productive lifespan enables the high rearing and development costs of heifers to be distributed over more lactations, thereby increasing lifetime returns per cow [1,2]. Conversely, high replacement rates increase financial burdens and environmental impacts associated with raising calves [3,4]. From a welfare perspective, shortened lifespans

often reflect underlying health disorders, and improving longevity therefore contributes directly to better welfare outcomes [5,6]. Economically, it is well established that cows generally become profitable only after their second or third lactation, so premature culling prevents farms from recouping their initial investments [1,2,7]. Similar observations were reported by ref. [8] in Romanian Black and White cows, where herds with a longer productive lifespan, averaging nearly nine years, achieved significantly higher milk yield efficiency per day of life. Their findings emphasized that extended longevity substantially improves the economic return of dairy operations under Central and Eastern European production conditions. The aforementioned facts reveal that functional longevity has become a central target of both genetic selection and management strategies designed to enhance resilience and lifetime productivity [2,3,9].

Nevertheless, despite these benefits, productive lifetime in high-yielding dairy systems remains relatively short and shows a declining trend in several regions worldwide. In many high-yielding dairy systems, herd life is limited to three lactations, with annual culling rates of 25–40% [1,6,10]. Involuntary culling is mainly driven by health and fertility problems, which far outweigh voluntary removals based on production, with mastitis, reproductive failure, lameness, and metabolic disorders identified as the main factors [2,11,12]. These risks are not uniformly distributed across age groups: younger cows are more likely to be culled early due to reproductive inefficiency and locomotor disorders, while metabolic and chronic health problems tend to accumulate with age, ultimately reducing the productive lifespan of older animals [2,10].

In Hungary, similar culling patterns were detected. On average, Holstein–Friesian cows are culled after only 2.2 completed lactations and nearly one-third are removed from the herd during their first lactation [13,14]. Early culling prevents many cows from reaching their peak productive stage in the third lactation, thereby reducing overall farm efficiency and profitability. Health-related problems are the predominant reasons for culling, with low milk yield, reproductive disorders, and udder health problems together accounting for over two-thirds of all cases [13,14]. Chronic mastitis alone has been responsible for about 30% of all cullings in some herds, highlighting the importance of udder health problems [13]. A high proportion of first-lactation cows experience health problems within the first months after calving, and nearly half of the animals culled during their first parity are removed as a consequence of fertility-related problems [14]. These findings emphasize the critical need to improve reproductive efficiency and udder health management if longevity is to be extended.

Technological and management factors also shape longevity outcomes. Stress caused by human handling or unfamiliar milking procedures has been shown to negatively affect milk let-down and yield, indirectly contributing to vulnerability and culling risk [15]. In contrast, modernization of milking technologies may provide solutions. Recent Hungarian studies proved that robotic milking systems not only increase milk yield but also significantly reduce somatic cell counts compared to conventional parlors, thus improving both productivity and udder health [16]. Such evidence suggests that investments in technology, alongside targeted herd health programs, could help mitigate the leading causes of early culling.

Overall, the Hungarian dairy sector faces persistent challenges in achieving optimal cow longevity, with health- and fertility-related disorders still remaining the predominant causes of premature cullings. Given the strong influence of age, parity, and yield on the distribution of culling reasons, there is a clear need for detailed herd-level analyses. The present study therefore investigates the relationships between cow age, lactation number, milk yield, and culling causes in Holstein–Friesian herds in Hungary. By identifying which animals are most at risk of premature culling under specific conditions, this study

aims to support improved breeding and management decisions that enhance longevity, profitability, and welfare in Hungarian dairy production.

2. Materials and Methods

2.1. Animals

This study was conducted on a large-scale Holstein–Friesian dairy farm owned by MILKMEN Ltd., which is a part of CERES HOLDING Plc., located in Tolna County near Paks in the South Transdanubian region of Hungary. The area is characterized by a continental climate with warm, dry summers and cold winters. The farm maintains a herd of 480 lactating Holstein–Friesian cows of a similar age and operates an intensive commercial production system. The farm is equipped with advanced production technology, including eight Lely milking robots functioning in a free-flow traffic system, which allows voluntary milking attendance and provides improved herd management efficiency. This retrospective cohort study utilized routinely collected herd record data from this single dairy farm.

2.2. Dataset

Data were exported in 2022 from the RISKA farm's herd management software, which integrates animal identification, health events, reproductive records, and disposal (culling) information. The observational unit was the individual cow.

The analytical dataset comprised 2057 cows, of which 590 were in first parity, 614 in second, 436 in third, 263 in fourth, and 154 in fifth or higher lactations at the time of culling or censoring. Only animals that had calved at least once (parity ≥ 1) and were part of the lactating herd were included; nulliparous heifers and calves were not considered. Within the observation window, 1480 animals experienced a definitive culling event and 577 were administratively right-censored. Birth dates ranged from 24 August 2003 to 13 August 2019; culling events occurred between 6 January 2015 and 13 May 2021. Cows present in the herd on 14 May 2021 were censored on that date. Age at culling (or censoring) was calculated as the number of days from birth to the date of definitive removal from the herd (or to the censoring date), and all time variables were expressed in days. All Holstein–Friesian cows with complete identification and date fields required to define entry and culling and with a clearly specified reason for removal from the herd were included; no records were excluded during data preparation.

The primary outcome was definitive culling from the herd. For cows with multiple interim events, only the final removal was considered; thus, each recorded culling reason represents the ultimate cause of disposal. Cows still in production at the administrative end of follow-up were treated as right-censored. All time variables were expressed in days.

Two main explanatory variables were considered in the analyses. Parity at event was defined as the number of completed lactations at the time of culling or censoring. The culling reason, representing the mutually exclusive and final cause of removal, was categorized into six groups: udder problems, metabolic problems, locomotive problems, reproductive problems, low milk production, and other. The "other" category included infrequent causes such as accidents, pneumonia, or undiagnosed diseases. Each cow was assigned to one category only, corresponding to the ultimate reason for definitive removal from the herd.

2.3. Statistical Analyses

All statistical analyses were performed in R 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria).

Descriptive and comparative analyses were first conducted to summarize the main characteristics of the dataset. Distributions of age at culling (or age at censoring) and parity were described using medians, interquartile ranges, minima, and maxima, while culling reasons were expressed as counts and percentages. Differences in parity among culling reason categories were assessed with the Kruskal–Wallis test, and when significant, pairwise comparisons were performed using Dunn's post hoc test with Bonferroni adjustment. Group proportions were compared using the Chi-square test.

To further investigate longevity patterns, survival analysis was performed using the Kaplan–Meier method, with time from birth to culling or censoring as the outcome variable. Survival functions were estimated for the entire herd and then stratified by parity and by culling reason. Differences between survival distributions were tested using the log-rank test, with a two-sided significance level of $\alpha = 0.05$. Survival curves were plotted with 95% confidence intervals and included risk tables at regular time intervals.

3. Results

3.1. Distribution of Culling Reasons

The descriptive analysis of culling reasons revealed that health-related disorders were the predominant drivers of cow removals from the herd. Udder problems, which include clinical and subclinical mastitis as well as chronic teat and gland issues, accounted for the largest share of cullings (22.8%). This was followed by metabolic disorders (18.2%), locomotive or lameness problems (17.3%), and reproductive failures (17.1%). By comparison, low milk yield was responsible for only 11.0% of culling cases, while "other" reasons such as accidents, injuries, or unspecified factors contributed 13.5%. The distribution of culling reasons differed significantly among categories (Chi-square = 380.2, $p < 0.001$). The predominance of udder, metabolic, and reproductive disorders underscores that involuntary culling associated with impaired health far outweighs planned removals based solely on production levels.

3.2. Age at Culling

The distribution of age at culling showed a marked peak between 1200 and 1400 days, which is equal to approximately 3.5–4 years regarding the age of cows (Figure 1). This age range represented the most prevalent stage for removal from the herd. The distribution was clearly right-skewed: while the majority of cows left the herd relatively young, a small subset achieved substantially longer lifespans, with some individuals remaining in production until 4000–5000 days (10–13 years). Although biologically possible, such extended longevity was rare in the studied herd, highlighting that under prevailing management and health conditions, only a minority of cows survive long enough to reach their maximum productive potential. The high concentration of removals before 1500–2000 days also aligns with the average timing of second and third lactations, suggesting that many cows fail to progress beyond these economically critical stages.

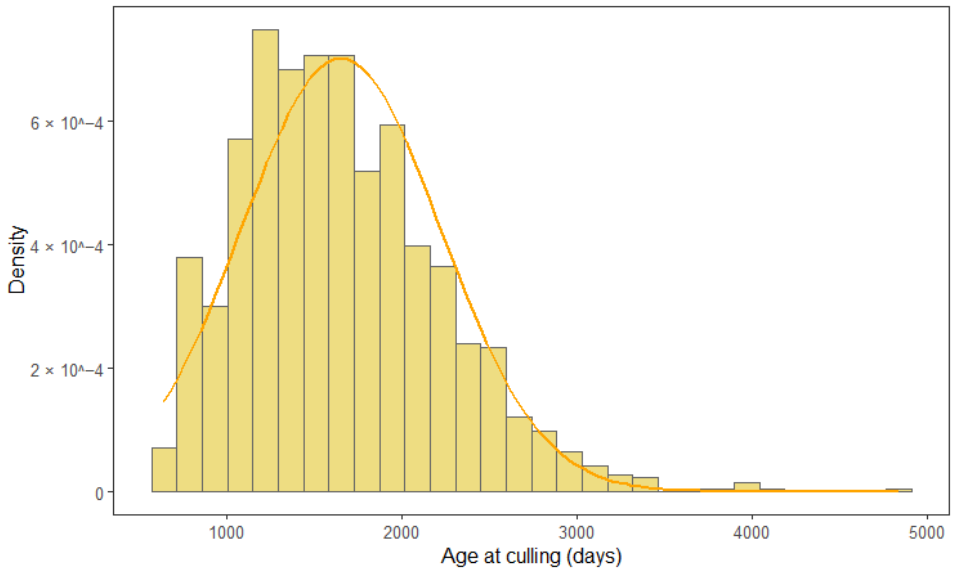

Figure 1. Histogram of cow age at culling.

3.3. Parity at Culling

Analysis of parity revealed that the majority of cows were removed after their second or third lactations. Overall, the numbers of cows in parities 1, 2, 3, 4, and ≥5 were 590, 614, 436, 263, and 154, respectively (Figure 2). Median values ranged between two and three lactations across all culling categories, reinforcing the observation that most cows fail to reach the stage where they are both biologically mature and maximally profitable. However, the distribution showed heterogeneity. Some cows were culled as early as their first lactation, while others remained productive for six to eight lactations and, in some cases, up to ten. Parity at culling differed significantly among culling reason categories (Kruskal–Wallis test, $\chi^2(5) = 28.81$, $p < 0.001$). Cows culled for udder problems (mean rank = 808.6), metabolic disorders (776.4), and other causes (764.8) tended to be of higher parity at removal than those culled for reproductive problems (640.5), locomotive disorders (719.8), or low milk production (697.8). This finding suggests distinct life-course trajectories of risk: fertility and locomotive problems jeopardize animals early, while metabolic wear-and-tear accumulates with advancing age.

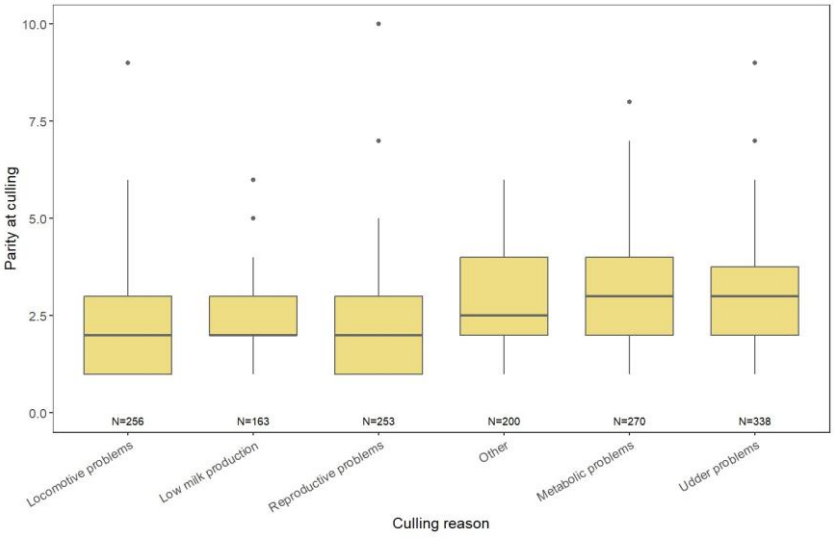

Figure 2. Parity distributions based on different culling reasons (N below each box indicates the number of culled cows in the corresponding culling reason category).

3.4. Survival Analysis

The Kaplan–Meier survival analysis for the entire herd provided further insights into the overall longevity profile (Figure 3). The survival curve declined steeply during the first 1000–1500 days of life after calving, reflecting a high proportion of early cullings. Thereafter, the curve flattened gradually, with survival probability decreasing more slowly until approximately 4000–5000 days. By 1500–2000 days, that is, equal approximately 4–5.5 years of age, around half of the population had been culled. These results confirm that the economically productive lifespan of most cows is relatively short, with many individuals leaving the herd before they can capitalize on their most profitable lactations. Only a minority of animals achieved extended longevity, demonstrating that while long-lived cows exist, they represent an exception rather than the norm under present herd conditions.

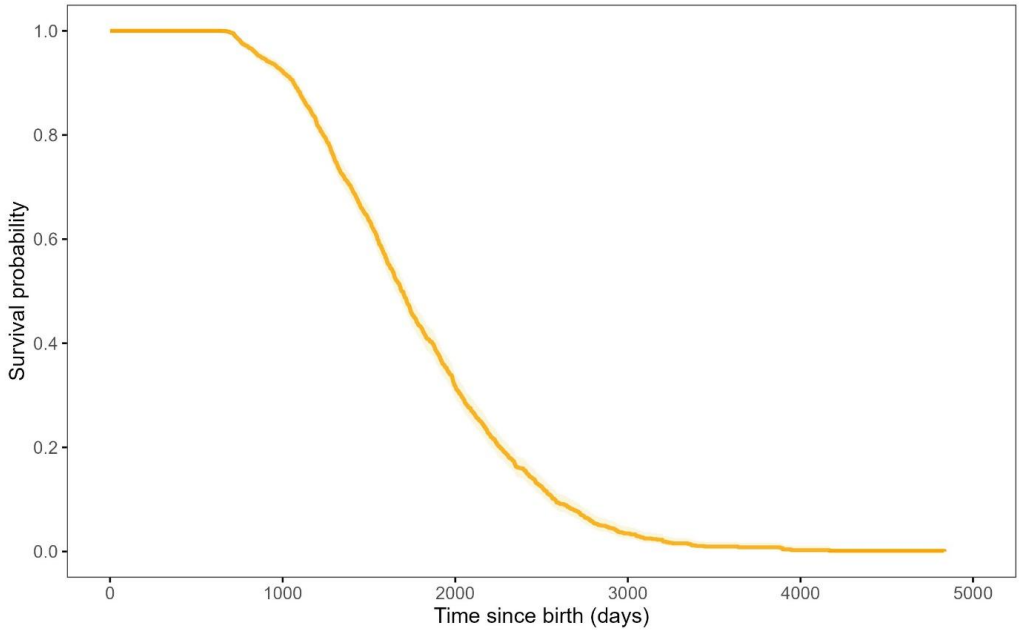

Figure 3. Kaplan–Meier survival curve for the whole studied population.

3.5. Survival by Parity

When survival curves were studied according to parity, a clear differentiation emerged between life-course groups (Figure 4). These differences were statistically significant (log-rank test: $\chi^2(4) = 2231.45$, $p < 0.001$). Cows culled during their first lactation showed a sharp decline in survival probability around 1000 days, underscoring the vulnerability of primiparous animals to early culling. In contrast, cows in their second and third lactations exhibited survival curves shifted toward later ages, with most cullings occurring between 1500 and 2500 days. Fourth-lactation cows demonstrated even longer survival, with curves extending to 3000 days or more, while animals that reached five or more lactations often remained productive for exceptionally long periods, exceeding 4000 days. Although these long-lived cows were few in number, their contribution to the herd was disproportionate, providing both significant lifetime milk yield and potential genetic value.

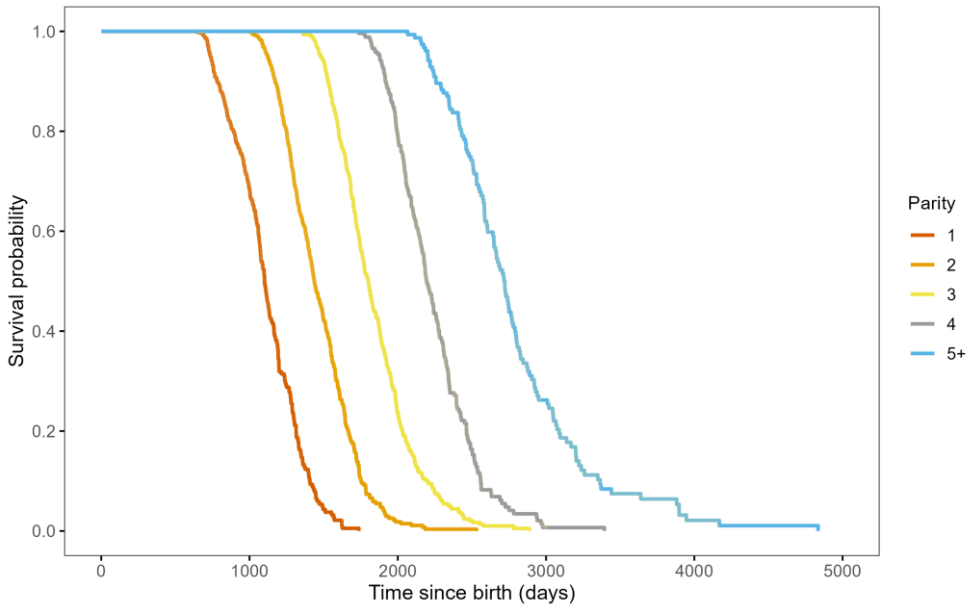

Figure 4. Kaplan–Meier survival curves studied according to parity.

3.6. Survival by Culling Reason

Survival analysis grouped by culling reason revealed distinct temporal patterns (log-rank test: $\chi^2(5) = 1.80$, $p = 0.876$; Figure 5). Cows culled for reproductive problems and low milk yield showed reduced survival probabilities earlier in life, indicating a tendency for earlier removal. In contrast, cows removed due to metabolic and locomotive disorders, as well as those grouped under "other reasons", tended to remain in production longer before culling. These patterns suggest that different causes of removal follow unique risk patterns: reproductive failures and production insufficiencies tend to truncate the productive lifespan prematurely, while chronic metabolic or locomotive conditions accumulate gradually and manifest in later lactations. Although the overall survival distributions did not differ significantly between culling reasons, this apparent heterogeneity of risk supports the need to tailor herd health and management strategies to specific vulnerabilities at different stages of life of the animals.

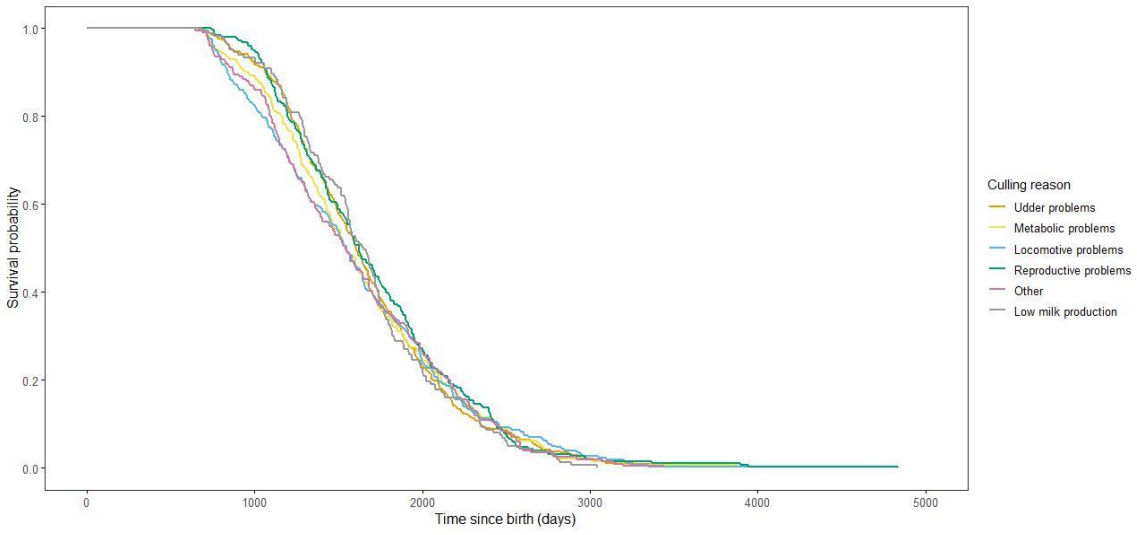

Figure 5. Kaplan–Meier survival curves classified by culling reason.

4. Discussion

The present work aimed to study the main reasons for culling in a dairy herd in Hungary and evaluated how age, parity, and yield affected culling patterns, using descriptive statistics and survival analyses. The results clearly indicated that most cows were culled prematurely after the second or third lactation and that the overwhelming majority of culls were involuntary, caused by health-related disorders rather than economic reasons. Udder problems, reproductive failures, metabolic disorders, and locomotive problems accounted for more than two-thirds of all cullings, whereas low milk yield alone explained only a small portion. These findings are not only consistent with previous research [2,11,17–19] but also confirm the large body of evidence showing that cow longevity is driven less by productivity itself and more by health and fertility limitations. Although this analysis was conducted using data from a single large-scale Holstein–Friesian herd, the farm's high-yielding cows, uniform genetic background, typical Hungarian forage-based total mixed ration, and modern milking technology are representative of intensive dairy production systems in Hungary. Therefore, the results are considered to have relevance beyond the studied herd.

4.1. Health-Related Drivers of Culling

The most prominent cause of culling was udder health problems (22.8%). Mastitis has been repeatedly identified as one of the leading causes of premature culling worldwide, in all kind of systems [12,18,20]. Clinical mastitis reduces both the quality and the quantity of milk, incurs veterinary and treatment costs, and imposes milk withdrawal periods, all of which make cows unprofitable and often lead to their culling [21,22]. However, udder problems are not merely an economic issue but also a major welfare concern, as mastitis causes pain, inflammation, and systemic illness [5,23]. Thus, the high proportion of mastitis-related culls in this study underscores the dual challenge of safeguarding profitability and welfare. Similar patterns were reported by ref. [13] in a Hungarian dairy herd, where udder health problems accounted for about 30% of all culling cases, confirming that mastitis remains one of the leading causes of early removal under domestic production conditions. Reproductive problems (17.1%) also contributed substantially to early removals. Fertility decline has long been recognized as a global issue in high-yielding dairy systems [24–26]. Infertility or repeat breeding not only delays calving intervals but also increases replacement pressure when conception fails despite multiple inseminations [27,28]. The multifactorial origin of fertility-related culling includes postpartum uterine diseases, metabolic stress, and genetic predisposition, representing the complexity of managing reproductive efficiency [25,27,29].

Lameness and locomotive disorders (17.3%) represented another major cause of involuntary culling. Numerous studies report that 10–20% of dairy cows are removed due to lameness, particularly in high-producing Holstein herds [23,30,31]. Lame cows exhibit reduced mobility, impaired grazing and feeding, decreased reproductive performance, and higher susceptibility to secondary diseases, which together increase the likelihood of culling [32,33]. It is important to note that lameness is also one of the most visible welfare issues in dairy farming, drawing significant public and ethical attention [23,34].

Metabolic problems (18.2%) were common in older and higher-parity cows, in accordance with the literature showing that energy balance challenges, such as ketosis or displaced abomasum, accumulate as animals age and as milk yields increase [17,27,35]. These disorders often arise around the transition period and compromise both productivity and survival [29,36]. The finding that metabolic disorders were strongly linked to higher-parity removals suggests that preventive health programs focusing on transition cow management may significantly improve longevity outcomes.

4.2. Age and Parity Patterns

Our results showed that most cows were culled at 1200–1400 days (3.5–4 years), consistent with the time of the second and third lactations. This pattern aligns with studies from North America and Europe, where the average productive lifespan is 3–4 lactations [1,3,6,37]. Although a small subset of cows in this study reached 4000–5000 days (10–12 years), these cases were rare, supporting evidence that while extended longevity is biologically feasible, it is seldom achieved in commercial herds [9].

Parity-specific results further demonstrated that reproductive and locomotive problems were more common in younger cows, often leading to cullings after the first or second lactation, whereas metabolic problems accumulated with age, causing cullings later in cows' life. These life-course trajectories align with findings from refs. [10,11,17], showing that disease risks shift with parity. Early culling of primiparous cows has serious economic implications, as these animals rarely recover their rearing costs before their third lactation [1,7]. Preventing early removals is therefore one of the most effective strategies to improve herd profitability and sustainability [2,37].

4.3. Survival Analysis and Longevity

The Kaplan–Meier survival curve indicated that 50% of the herd was culled by 1500–2000 days (4–5.5 years), consistent with survival profiles reported by refs. [3,19,37]. Grouping by parity revealed that cows surviving to their fourth or fifth lactation achieved markedly longer lifespans, often exceeding 3000 days. These long-lived cows, though relatively few, have been shown to deliver disproportionate economic returns by reducing replacement costs and maximizing milk yield over their lifetime [7,9].

Grouping by culling reason further clarified that reproductive failures and low yield truncated lifespan earlier, while locomotive and metabolic disorders were associated with later cullings. Similar patterns have been reported by several authors [10,12,38].

4.4. Implications for Farm Management, Welfare and Sustainability

From an economic point of view, premature culling before the third lactation prevents farms from recovering rearing costs [1,7]. Extending average longevity reduces the annual replacement rate, saving on heifer-rearing costs, which can represent up to 20–25% of dairy farm expenses [2,35]. Long-lived cows dilute these costs over more productive years, thereby improving profitability [39,40].

From a welfare perspective, the predominance of health-related cullings indicates that cow well-being is often compromised before culling. Lameness and mastitis, for example, are painful conditions that not only precipitate culling but also raise serious ethical concerns [23,34,41]. Therefore, reducing involuntary culling is aligned with both ethical imperatives and consumer expectations regarding animal welfare [5].

From an environmental perspective, extended cow longevity has a direct sustainability benefit. Raising replacements requires large amounts of feed, water, and land, while emitting greenhouse gases. By reducing replacement rates and increasing the proportion of lifetime spent in production, farms can substantially lower their per-unit milk carbon footprint [4,40]. This makes longevity a key lever for achieving climate goals in the dairy sector.

5. Conclusions

Within the studied high-yield Holstein–Friesian herd in Hungary, most cows were culled prematurely, with the majority of culling events occurring between the second and third lactations and around 1500–2000 days of life. Health-related problems, rather than economic considerations, drive most cullings. Udder disorders, metabolic problems,

locomotive problems, and reproductive disorders together accounted for more than two-thirds of all cullings, while low milk yield alone explained only a minor part. Distinct patterns were observed across life stages. Younger cows, particularly in their first and second lactations, were most vulnerable to early culling due to fertility problems and locomotive disorders, reflecting the fragility of primiparous animals. In contrast, older cows were more frequently culled due to metabolic problems and chronic health conditions that accumulate with age and repeated calvings. Although a small subset of cows survived well beyond the herd's average lifespan and contributed disproportionately to milk output and genetic value, such cases remained rare under current management conditions. These findings underline the urgent need for targeted strategies to address stage-specific risks: reproductive and locomotor health programs for young cows and preventive metabolic management for higher-parity animals. Although the findings were derived from a single herd, its characteristics closely reflect large Hungarian dairy systems, supporting the wider applicability of these findings. By focusing on the health and reproductive problems identified in this study, Hungarian dairy farms can extend productive lifespan, reduce involuntary culling, and enhance the overall efficiency, profitability, and welfare of their herds.

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Conflicts of Interest: Author Gergő Sudár was employed by the company CERES Holding Ltd. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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