



Survival rate of dairy heifer calves from birth to one year of age

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Abstract

The study examined the survival rate of dairy heifer calves from birth to one year of age over ten years (2009–2018). The frequency of heifer calves' death in different age periods has been identified, and the frequency of calf death depends on the dam age and their milk yield, as well as the season of birth of the heifer calves. In total, 2,825 heifer calves of Ukrainian Black-and-White dairy breeds with a high Holstein share heredity (93 % and higher) were included in the study. The farm where the study was conducted is located in the southern part of the Kyiv region. The average 305-d lactation milk yield was 8463 kg, and the average caw age in the herd – was 1.94 lactations. The calf's housing system was unchanged during the experimental period: colostrum was fed to newborn calves for at least three days, whole milk – until the age of 9–11 weeks; combined fodder intake – as much as calves want during the first month of life and 1.5 kg per day before weaning, getting used to hay from the age of 4 weeks. Calves were housed in individual hutches. It was established that for the investigated period, the herd's survival rate of dairy heifer calves was 85.4 % (81.5...90.1 %); 14.6 % of calves died before the age of one year for different reasons. By age, most heifer calves died within the first month after birth, which amounted to 53.3 % at the age of 1.1–3.0 months – 12.1 %, 3.1–6.0 months – 18.6 %, and 6.1–12.0 months – 16.0 %. Dams of died heifer calves were characterized by a slightly older age compared to the average age of cows in the herd (+ 0.21 lactations, $P < 0.01$) and lower 305-d milk yield in lactation that preceded heifer calf death (-230 kg, $P < 0.001$). It was found that, depending on the season of birth, the lowest proportion of heifer calves' deaths was observed in the group born in autumn – 19.6 %; in winter, spring, and summer, the part of heifer calves deaths varied from 26.2 to 27.6 %. Therefore, the survival rate of heifer calves depends to a certain extent on the age of calves, the age and milk productivity of dams, and the season of birth of calves.

Keywords: heifer calves; survival rate; dam age; milk yield; season of birth.

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1. Introduction

The goal of each cow's reproductive cycle, in addition to the beginning of the next lactation, is to obtain healthy replacement calves. Despite the fact that genetics, technology, and veterinary care are constantly improving, there was some increase in the risk of calf death in dairy cattle herds (Compton et al., 2017; Santman-Berends et al., 2019). Globally, between 1990 and 2000, the risk of calf death in the first two days after birth increased by 2 % (Compton et al., 2017). So, the issue of the calf survival rate in dairy herds is urgent and needs a comprehensive study.

In foreign literary sources, calf survival is traditionally characterized by two indicators: calf survival rate (Van Doormaal, 2007; Weller, 2021) and calf mortality rate (*mortality rate, calf mortality, juvenile death rate*) (Losinger & Heinrichs, 1997; Nix et al., 1998; Gulliksen et al., 2009;

Gundelach et al., 2009; Pedersen et al., 2014; Jorgensen et al., 2017; Santman-Berends et al., 2019; Mandal et al., 2019; NAHMS, 2021; Umaña Sedó et al., 2023).

Various terms and age periods are offered to assess the survival rate or mortality rate of calves. In 2001, O. M. Radostitis (2001), USA, studied the health and productivity management of dairy calves and replacement heifers. He divided calf mortality into *perinatal mortality* – stillborn calves after 270 days of gestation and up to 24 hours after birth and *neonatal mortality* – calves that died between 1 and 28 days of age.

In 2023, S. Umaña Sedó et al. (2023), Canada, used three terms to describe the mortality of calves: 1) *perinatal mortality* – the proportion of calves that died during birth or within 48 hours after birth; 2) *mortality before weaning* – from the third day after the birth to weaning, this period is divided into two sub-periods: 3–36 days after birth and 37

days – until the weaning; 3) *calf mortality* – the proportion of calves that died from birth to weaning, this period combines the first and the second periods.

Dutch researchers I. M. G. A. Santman-Berends et al. (2019) believed that it is more informative to study the mortality of calves in the following periods: 1) *perinatal mortality* – mortality during or after birth before identification of calves with ear tags; 2) *mortality after calving* (≤ 14 days); 3) *mortality before weaning* (15–55 days); 4) *mortality of weaned calves* (56 days – 1 year).

In Ukrainian literature, one term is usually used – *calf survival rate* – the proportion of live calves relative to newborns in a certain age period.

The calf mortality rate in different countries and herds ranged from 2.1 to 28.9 % (Agerholm et al., 1993; Svensson et al., 2006; Gulliksen et al., 2009; Jorgensen et al., 2017; Pathak et al., 2018; Weller et al., 2021). Ukrainian researchers I. V. Kovalchuk et al. (2022) noted that nowadays, all available heifers in the herd are used for herd replacement except for apparent defects. According to standard indicators, the loss of heifer calves is quite significant – up to 18 %, particularly before weaning – up to 11.5 %.

The period from birth to 1 month of age was considered the most critical period of calves survival: in this period, the highest risk of mortality was observed (Agerholm et al., 1993; Wells et al., 1996; Svensson et al., 2006; Kharkar et al., 2017); sometimes the highest risk of mortality up to 3 months of age was noted (Mandal et al., 2019).

The leading cause of perinatal calf mortality was dystocia at an older age – pneumonia, diarrhea, respiratory diseases, and gastroenteritis (Agerholm et al., 1993; Chassagne et al., 1999; Gundelach et al., 2009; Compton et al., 2017). In Swedish dairy herds, 27 % of calf mortality is caused by pneumonia. However, under the age of 31 days, enteritis was the most common cause of calf mortality, 211–450 days – trauma dominated; at the age of over 450 days, young stock died mainly due to trauma and calving-related diseases (Svensson et al., 2006). In the USA, the most common cause of calf mortality was neonatal diarrhea (56.5 %), followed by respiratory diseases (24.0 %), and third by umbilical infections (3.0 %) (Stanton et al., 2012; NAHMS, 2021). In addition to calf death, neonatal diarrhea, and respiratory diseases lead to reduced live weight, older age at first calving, lower 1-st lactation milk yield, and, as a result, economic losses for milk producers (Stanton et al., 2012; Aghakeshmiri et al., 2017). It should be noted that in most cases, the reason for calf mortality is multifactorial – it was the influence of dams, infections, poor feeding, housing, animal welfare, unsatisfactory management, and veterinary care.

Regarding the influence of the dam age (parity number) on the calf survival rate, there were different data in literary sources. Calves from primiparous (Nix et al., 1998; Van Doormaal, 2007; Van Pelt et al., 2012) and multiparous dams (Norberg et al., 2013) have been reported to have higher mortality rates. In particular, M. Van Pelt et al. (2012) found that the lowest calf mortality rate was observed in cows at nine parity and higher. However, the influence of dam age on the calf survival was usually insignificant. This was proved by S. M. Gulliksen et al. (2009) in herds of Norwegian Red cattle and K. Pathak et al. (2018) in crossbred Jersey herds.

It should be noted that selecting based on the trait “calf survival”, is quite challenging, as it features low heritability and high variability. According to various data, the heritability of calf survival from birth to the first calving ranges from 0 to 12 % depending on the animal's age (Hansen et al., 2003; Fuerst-Waltl & Sørensen, 2010; Norberg et al., 2013; Pathak et al., 2018; Weller et al., 2021). Despite the low heritability of the trait “calf survival”, it is increasingly used in selection. In Canada, since 2007, it has been included in selection indexes (Van Doormaal, 2007). In Israel, including the trait “calf survival” in a dairy breeding program was predicted to increase calf survival by 0.5 % over ten years but reduce the progress of other traits by 8 % (Weller et al., 2021).

Since calf survival in the herd is closely related to the formation of replacement young animal groups and adequate herd replacements, the improvement of productive and breeding qualities of dairy cattle, the level of milk productivity, and the profitability of the industry as a whole, the study of heifer calves survival rate over ten years was chosen for our research.

2. Materials and methods

The research was conducted in a retrospective statistical experiment in the Ukrainian Black-and-White Dairy breed herd. The materials from the electronic database Dairy Management System ORSEK for 2009–2018 were used. All heifer calves obtained during this period (in total, 2825 calves) aged from one day to one year were included in the study. Heifer calf's survival rate was evaluated in the following chronological periods (years): 2009–2010, 2011–2012, 2013–2014, 2015–2016, 2017–2018, and depending on dam age (lactations), their 305-d milk yield in lactation that preceded heifer calf death (kg), the season of birth (winter, spring, summer, autumn) and the age of heifer calves (months). Four groups were formed according to the age of heifer calves (months): 0–1.0; 1.1–3.0; 3.1–6.0; 6.1–12.0.

The farm where the study was conducted is located in the southern part of the Kyiv region, Ukraine. Dairy cows were housed in tie-stall barns during the winter season and outside untied on the feeding grounds in the warm season; cows were milked in the milking pipeline. Cows gave birth to calves in the maternity ward, and soon after birth, calves were transferred to individual hutches. Calves were fed with colostrum for at least three days (six feedings), then with whole milk for 9–11 weeks, depending on the live weight of newborns, average daily gains, season of the year, and animal health. Calves were accustomed to combined fodder from the fifth to the seventh day and fed hay from the age of 4 weeks. The norm of whole milk was 450–500 kg per calf; combined fodder was fed until the age of 4 weeks as much as the calf wanted, and 1.5 kg per day from the age of four weeks to the weaning.

The calculations were performed using parametric statistics with the software package Statistica 12.0 (Fetisov, 2018). The reliability of the results was compared with three standard levels of statistical significance with their designation ¹ – $P < 0.05$, ² – $P < 0.01$ ³ – $P < 0.001$.

3. Results and discussion

Calf survival in the herd is a critical element of milk productivity and the development of the dairy industry. In the investigated herd, on average, over ten years, heifer calves' survival rate was 85.4 %, ranging from 81.5 to 90.1 %; that is, by the age of 1 year, an average of 14.6 % of heifers died (Table 1).

Similar results were obtained in Israel, where the average Holstein calf survival rate born in the period 2001–2008 was 85 % (Weller et al., 2021), and in India, where the calf survival rate in crossbred Jersey was 89.77 % (Sheikh, 2010). According to other data, calf mortality in Indian herds was higher and amounted to 28.90% by one year of age (Pathak et al., 2018).

However, the indicator obtained in this study on calf mortality (survival) was significantly higher than the results received on the farms of Sweden, Denmark, Norway, and

Canada. In Sweden, the average calf mortality rate on 485 dairy farms was reported to be only 2.1 % (Svensson et al., 2006). In Denmark, the Holstein calf mortality rate in 2008–2012 was 7.5 % in heifer calves and 10 % in bull calves (Pedersen et al., 2014). In Norway, the mortality of calves registered in the Norwegian Dairy Herd Recording System (NDHRS) in 2005 in 14,474 dairy herds was 7.8 %, including abortions (0.7 %) and stillbirths (3.4 %) (Gulliksen et al., 2009). In Canada, the average calf survival rate in Holstein, Ayrshire, Jersey, Swiss, and Guernsey breeds ranged from 93.1 to 94.9 % (Van Doormaal, 2007), i.e., calf mortality rate there was at the level of 5.1–6.9 %.

One of the tasks of this research was to identify the rate of heifer calves' mortality depending on dam age and their 305-d milk yield in lactation that preceded heifer calf death. It was established that the dams whose heifers died were slightly older compared to the average cow's age in the herd (Table 2).

Table 1

Heifer calves survival rate up to one year of age

| Year | Heifer calves number | Calf mortality: | | Heifer calves survival rate, % |
|---------------|----------------------|-----------------|------|--------------------------------|
| | | n | % | |
| 2009-2010 | 562 | 56 | 9.9 | 90.1 |
| 2011-2012 | 510 | 74 | 14.5 | 85.5 |
| 2013-2014 | 573 | 106 | 8.5 | 81.5 |
| 2015-2016 | 549 | 97 | 17.5 | 82.4 |
| 2017-2018 | 631 | 80 | 12.7 | 85.8 |
| Total/average | 2825 | 413 | 14.6 | 85.4 |

Table 2

Dam age and 305-d lactation milk yield, *Mean ± SE*

| Year | Dam age, lactation: | | Milk yield, kg: | |
|-----------|---------------------|---------------------------|---------------------------|---------------|
| | herd average | dam | herd average | dam |
| 2009–2010 | 2.04 ± 0.037 | 2.48 ± 0.184 ¹ | 8,078 ± 82.9 | 8,190 ± 310.2 |
| 2011–2012 | 1.99 ± 0.071 | 2.36 ± 0.054 ³ | 8,063 ± 75.3 | 7,949 ± 153.2 |
| 2013–2014 | 1.90 ± 0.050 | 1.94 ± 0.120 | 8,419 ± 68.8 | 8,769 ± 166.5 |
| 2015–2016 | 1.80 ± 0.061 | 2.21 ± 0.129 ² | 9,012 ± 90.6 ¹ | 8,595 ± 180.5 |
| 2017–2018 | 1.95 ± 0.047 | 2.00 ± 0.111 | 8,670 ± 91.4 ³ | 7,523 ± 173.4 |
| Average | 1.94 ± 0.033 | 2.15 ± 0.061 ² | 8,463 ± 41.6 ³ | 8,233 ± 92.2 |

Note: dam age was shown in the lactation when the calf died; milk yield was shown for previous lactation.

Dams whose calves died were significantly older in 2009–2010 – by 0.44 lactations ($P < 0.05$), 2011–2019 – 0.37 lactations ($P < 0.001$), and 2015–2016 – 0.41 lactations ($P < 0.01$). On average, during the studied period, the dam age whose calves died was higher by 0.21 lactations or 11 % ($P < 0.05$). The results of our research coincide with the data of E. Norberg et al. (2013), who found that the mortality risk of Jersey calves increased with the dam age. However, most researchers reported a higher mortality rate in calves from primiparous cows compared to multiparous cows (Nix et al., 1998; Van Doormaal, 2007; Van Pelt et al., 2012). According to B. Van Doormaal (2007), the calf survival rate of primiparous cows averaged 92.2 %, and the calf survival rate of multiparous cows – 95.1 %. J. M. Nix et al. (1998) attributed this to the lower colostrum quality of primiparous cows.

During the studied period, dams whose calves died were characterized by an average of 230 kg lower lactation milk yield than the herd ($P < 0.001$). Dams whose calves died were significantly inferior to the herd average milk yield in

2015–2016 by 417 kg ($P < 0.05$) and in 2017–2018 by 1147 kg ($P < 0.001$). However, this advantage cannot be called a permanent trend since dams whose calves died in 2009-2010 and 2013–2014 had a higher milk yield than the herd average.

It was established that the vast majority of heifer calves in the studied period died before one month (53.3 %), the least – at the age of 1.1–3.0 months (12.1 %), except for 2009–2010. Heifer calves mortality rate in the herd was 18.6 % up to 6 months of age and 16.0 % between the ages of 6 months and one year (Table 3).

During the studied years, approximately the same tendency of heifer calf mortality rate was observed in all age periods. At the age of 0–1.0 months, the heifer calves mortality rate ranged from 43.4 to 66.2 %; 1.1–3.0 months – 8.1–14.4 %; 3.1–6.0 months – 11.2–24.7 %; 6.1–12.0 months – 10.8–21.7 %. Literary sources reported that the herd's most significant proportion of dairy heifers died within the first month after birth. W. Knauer (2019) reported that on US dairy farms, an average of 5 to 7 % of calves were

either stillborn or died within the first 48 hours of life. The calf mortality rate decreases significantly from the second month of life (Svensson et al., 2006; Sheikh, 2010; Abuelo et al., 2019; Knauer, 2019).

In the studied herd, 7.8 % of heifer calves died within the first month after birth. After one month, the calf mortality rate decreased and varied from 0.2 to 1.2 % per month until one year of age (Fig. 1).

Our results were close to the data on dairy farms in the United States and Jersey herds in India. Specifically, in the US, the average calf mortality rate that is either stillborn or

dies within the first 48 hours after birth ranges from 5 to 7 % (Knauer, 2019). In India (Sheikh, 2010), calf mortality rate up to 2 months of age was 10.22 % (up to 30 days of age – 9.08 %, 30–60 days – 1.14 %). However, the results obtained in our study exceed the results of calf mortality rate noted A. Abuelo et al. (2019) in Australian dairy herds – 7 % before weaning at the age of two months and Sweden dairy herds, where up to the age of 90 days, 3.1 % of calves died, 91–210 days – 0.9 %, in the period from 211 days to the first calving – 2.2 % (Svensson et al., 2006).

Table 3
Heifer calves mortality depending on age, number of heifer calves

| Year | Age group, months: | | | |
|-----------|--------------------|-------------|-------------|-------------|
| | 0–1.0 | 1.1–3.0 | 3.1–6.0 | 6.1–12.0 |
| 2009–2010 | 31 | 8 | 10 | 7 |
| 2011–2012 | 49 | 6 | 11 | 8 |
| 2013–2014 | 46 | 14 | 23 | 23 |
| 2015–2016 | 44 | 14 | 24 | 15 |
| 2017–2018 | 50 | 8 | 9 | 13 |
| Total | 220 (53.3 %) | 50 (12.1 %) | 77 (18.6 %) | 66 (16.0 %) |

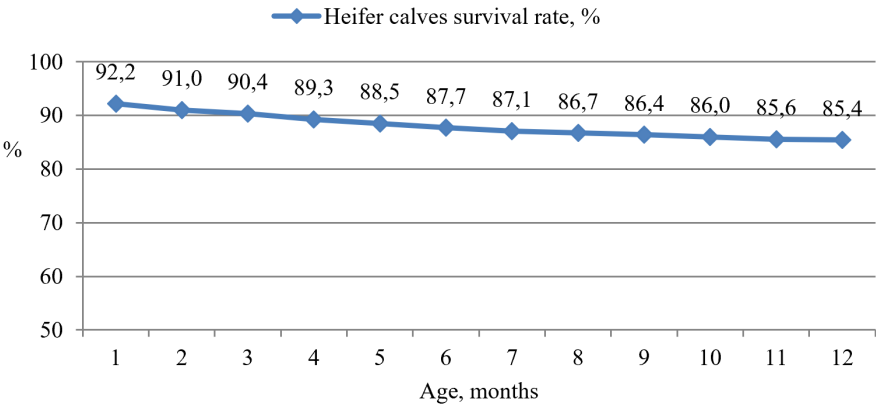


Fig. 1. Dynamics of heifer calves survival rate from birth to 1 year of age, %

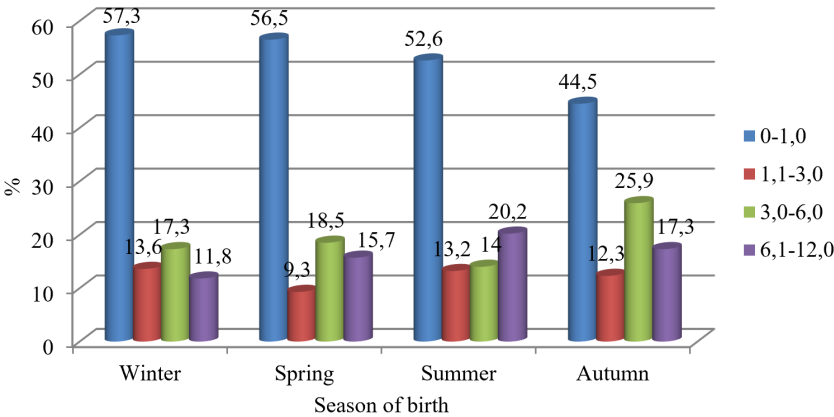


Fig. 2. Heifer calves survival rate depends on the season of birth and the age of death, %

Specialists of the Dairy Calf and Heifer Association (USA), based on long-term research, concluded that an acceptable and reasonable calf mortality rate should not exceed 5 % at the age 24 hours after birth to 60 days, at the age of 61–120 days – < 2 %, 121–180 days – < 1 %, 6–12 months – < 1%. In the studied herd, the heifer calf mortality rate in the indicated age periods was somewhat higher, except for 61–120 days. In particular, from 24 hours after birth

to 60 days heifer calves mortality rate was 9.0 %, 61–120 days – < 1.2 %, 121–180 days – < 2.1 %, 6–12 months – < 2.3 %.

The literature reports that the rate of calf morbidity, treatment, and mortality from birth to weaning depends on the season of birth. In the studied herd, the rate of mortality of heifer calves born in winter, spring, and summer was almost the same and ranged from 26.2 to 27.6 % of the total

number of heifer calves. The mortality rate of heifers calves born in autumn was the lowest – 19.6 %.

The highest mortality rate before the age of 1 month was observed in the groups of heifer calves born in the winter-spring season – 56.5–57.3 %, slightly lower – in the summer-born (52.6 %) and the lowest – in the autumn-born (44.5%) (Fig. 2). It should be noted that in the autumn-born heifer calves at the age of 3–6 months the highest mortality rate was observed (25.9 %), that is, these heifers died during the winter.

The results of our study partially correspond to the statement that better calf survival rates were observed in the warm season compared to the cold season (Svensson et al., 2006; McCorquodale et al., 2013; Jorgensen et al., 2017; Kharkar et al., 2017; Weller et al., 2021). These results were obtained in different breeds of dairy cattle.

In the literature, it has been reported that critical temperature (Silva et al., 2019) and heat stress (Dado-Senn et al., 2020) should be avoided for high calf survival. The lower limit of the critical temperature for dairy calves decreases with age from 13 °C at one day to 6.4 °C at 30 days; the upper limit is 26 °C (Silva & Bittar, 2019). It is obvious that autumn-born calves avoid critical high and low temperatures and heat stress; it could be why they were characterized by a slightly higher survival rate in the herd. However, this issue requires further study.

4. Conclusions

It was established that the herd's average heifer calves survival rate for 2009–2018 was 85.4 %. Most heifers died during the first month after birth (53.3 %), the lowest part – in 1.1–3.0 months (12.1 %). Dams whose calves died were slightly older compared to the average cow age in the herd, and they had lower milk yield in lactation, which preceded the death of heifer calves. The mortality rate of heifer calves born in winter, spring, and summer was slightly higher (26.2–27.6%) than that of heifers born in autumn (19.6 %).

Therefore, controlling heifer calves' mortality rate, determining the mortality reasons, establishing the factors that affect higher heifer calves' survival rate, and taking them into account will contribute to optimizing the heifer's calves' survival rate, their effective selection, and as a result, high-quality herd replacement.

The perspective of the following study is to investigate the survival of dairy heifer calves from birth to one year of age, as well as the influence of genetic factors.

Conflict of interest

The authors declare that there is no conflict of interest.

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