

Analysis of lactation specific demographic parameters in a crossbred cattle herd

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Abstract

Data for the present investigation were collected from history sheet of crossbred cattle at Instructional Dairy Farm of G. B. Pant University of Agriculture and Technology, Pantnagar. The data pertained to 1000 crossbred cattle with a total of 3583 calving records from 87 sires were distributed over a period of 32 years from 1988 to 2019. The calculated survival rate and loss rate in the first lactation were 82.24% and 17.61%, respectively. The probability of survival was highest during the first lactation and gradually decreased with in subsequent lactations. Furthermore, the loss rate in the first lactation, at 17.61%, was one-sixth of the total cows present in the first lactation. The overall values for survivorship were observed as 0.8239, 0.5090, 0.2732, 0.1198, and 0.0244 in the first, third, fifth, seventh, and ninth lactation, respectively. A total number of 24.65 percent cows were present in first lactation, while 20.31, 09.52, 02.95 and 00.60 percent in second, fifth, eighth and tenth lactations, respectively. The proportion of female cows being lost from the herd due to death and culling was estimated as 0.1761, 0.1659, 0.1488, 0.0733 and 0.0204 at first, second, third, seventh and tenth lactations. The expected herd life declined over different lactations. The expected herd life in crossbred herd was obtained as 3.043, 2.695, 2.374, 1.760, and 0.163 years in first, second, third, fifth and tenth lactations, respectively. This decline in expected herd life is a common pattern observed in dairy herds.

Key Word: Crossbred cows; Demographics; Herd-life; Lactation; Survivorship; Stayability; Loss rate

Introduction

The Indian dairy industry is characterized by large-scale production rather than mass production, with an impressive annual growth rate of 5.29%. In the year 2021-2022, the total milk production reached 221.06 million tonnes, a significant increase from 210.0 million tonnes in 2020-2021, which is more than twice the global milk production growth rate. The per capita milk availability in 2021-2022 stood at 444 grams, showing a rise of 17 grams compared to the previous year. Even though India holds the title of the world's largest milk producer, the average milk output per cow remains lower in comparison to the global average.

The major hindrance to expanding the dairy herd is involuntary culling, primarily caused by a lack of adequate replacements within the herd. Modern animal breeders now aim to select dairy cattle not only based on their production capacity but also their overall functional performance. This strategic selection process is aimed at decreasing the likelihood of involuntarily culling highly productive cows (Kumar et al., 2013).

The size of the milking animal group and how it's managed during subsequent lactations constitute a crucial aspect, which is directly influenced by the survival trends among lactating animals and the composition of the cow herd across different lactation periods. The specific survival and disposal trends during lactation, the makeup of the herd, the anticipated lifespan of the herd, and the overall statistical data over the lifetime of a cattle herd hold significance. These factors are necessary for creating, implementing, and assessing a breeding program aimed at genetic enhancement. They're also important for constructing models to optimize culling and replacement rates, as well as for supervising management practices to enhance animal production and reproduction. Consequently, a study was conducted to examine these attributes within the crossbred cattle at University farm.

Materials and methods

Data for the present investigation were collected from history sheet of crossbred cattle maintained at instructional dairy farm of G. B. Pant University of Agriculture and Technology, Pantnagar. The data pertained to 1000 crossbred cattle with a total of 3583 calving records from 87 sires were distributed over a period of 32 years from 1988 to 2019 were used to estimate the lactation specific demographic parameters i.e. Survival rate (P_x), Loss rate (Q_x), Survivorship or Stayability (L_x), Expected herd life (E_x), Lactation-specific losses (q_x) and Lactation-specific cow present in herd (P_x):

The following lactation specific demographic parameters were statistically analyzed as follows

Survival rate (P_x): It is the probability of a cow, assuming survival to lactation x , of surviving to lactation $x+1$ (Schons et al., 1985).

$$P_x = L_{(x+1)} / L_x = 1 - Q_x$$

Loss rate (Q_x): It is the probability of a cow, assuming survival to lactation x , of dying or culling before lactation $x+1$ (Schons *et al.*, 1985).

$$Q_x = d_x / n_x = 1 - P_x$$

Where,

d_x = Number of animals died or culled during lactation x ; n_x , number of animals present in the herd at the beginning of lactation x .

Survivorship or Stayability (L_x): It is the probability of a cow at first lactation present in the herd to lactation x and estimated as number present at lactation x divided by the number alive at first lactation. The survivorship at first lactation was taken as unity ($L_0=1.0$) and hence (Schons et al., 1985).

$$L_x = n_x / n_0.$$

This can also be estimated as $L_x = P_x L_{(x-1)}$

Where,

n = Number surviving at lactation x ; n_0 , number of cows at first lactation.

Expected herd life (E_x): This is the number of additional years that an animal of lactation x is expected to remain in the herd E_x more years and it was estimated as the sum of probability of an animal of a given lactation remaining in the herd (P_x) through each succeeding lactation up to the last lactation. (Ahmed et al., 1992).

$$E_x = P_x + P_x P_{x+1} + P_x P_{x+1} P_{x+2} + \dots + P_x P_{x+1} P_{x+n}$$

Lactation-specific losses (q_x): Probability of cows being lost that is of each age group or lactation X (Schons et al., 1985).

$$q_x = Q_x \cdot L_{x-1} \text{ such that submission } q_x = 1.0 \text{ from } x-1 \text{ to } n$$

Lactation-specific cow present in herd (P_x): Probability of cows remaining in the herd that are of each age group or lactation X (Schons et al., 1985).

$$P_x = L_x / \sum_{i=1}^n L_x$$

such that $\sum_{i=1}^n p_x = 1.0$

Results and Discussion

Demographic parameters are the probability of certain lactation-specific traits in a crossbred cattle herd. These traits include the loss rate (Q_x), survival rate (P_x), survivorship (L_x), proportion of cows present in the herd (p_x), proportion of cows lost from the herd (q_x), and expected herd life (E_x).

Survival rate (P_x)

The first lactation's survival rate was calculated to be 82.24 percent, indicating that the likelihood of survival was highest during this initial lactation period. However, as subsequent lactations were considered, the survival rate showed a decreasing trend. Specifically, it was observed that only 70 percent of animals that survived the first lactation managed to survive until the fifth lactation. Comparing these results with the reports of Kumar's (1999) in his study on Haryana cattle, found that the lactation-specific survival rate was approximately 0.80 up to the seventh lactation, after which there was a decreasing trend as the lactation number increased. Similarly, Singh (2001) conducted research on Karan Fries cattle and reported that the probability of survival rate was highest (0.72) in the first lactation. Shahi and Kumar (2013) stated that the survival rate was around 0.74 up to the fourth lactation, after which it showed a declining trend with increasing lactation number. Additionally, Goshu and Singh (2013) reported that the survival rate of exotic cows was lowest (0.74) in the third lactation and continued to decline. Kumar et al., (2013) in Frieswal cattle, Upadhyay et al., (2014) in Sahiwal cattle, Maher et al., (2015) in Tharparkar cattle, and Vinothraj et al., (2017) in Jersey and Red Sindhi crossbred cattle showed similar trends. They reported that the survival rate was approximately 0.71 in the third lactation, and then decreased with subsequent lactations. Vinothraj et al., (2017) specifically highlighted the lowest survival rate of 0.65 in the first lactation for Jersey and Red Sindhi crossbred cattle.

Loss rate (Q_x)

The study found that the probability of a cow being lost from the herd during its first lactation was 17.61%. This indicated that approximately one-sixth of the cows in the herd would leave due to death or culling during their initial lactation period. Interestingly, the loss rate was observed to be at its minimum during the first lactation. However, as the lactation number increased, the loss rate also increased. These findings align with the similar study by Upadhyay et al., (2014) in Sahiwal cattle and Das et al., (2016), which also reported an increasing loss rate with successive lactations. On the other hand, other studies such as by Kumar (1999) for Haryana cattle and Kumar et al., (2013) for Frieswal cattle reported higher loss rates during the first lactation. Conversely, Shahi and Kumar (2013) for Sahiwal cattle and Maher et al., (2015) for Tharparkar cattle reported lower loss rates as compare to present finding during the first lactation. Furthermore, it was noted that approximately 71% of the total cows in their first lactation departed from the herd by the completion of the fifth lactation, leaving only about 29% of the most superior cows to continue producing offspring within the herd. Lalmuansangi et al., (2022) reported that probability of cow being lost from the herd after first lactation was 21%. In conclusion, the present results indicated that the probability of cows being lost from the herd was highest during their first lactation. As lactation number increased, the loss rate also tended to increase. These variations in loss rates across different studies and cattle breeds suggested that various factors, including breed-specific characteristics, management practices, and environmental conditions, influenced the likelihood of cows leaving the herd.

Survivorship/Stability (L_x)

The survivorship refers to the likelihood of an animal's survival or its ability to remain within the herd until a specific lactation stage, representing the cow's stability in the herd. The overall survivorship values were observed to be 0.8239, 0.5090, 0.2732, 0.1198, and 0.0244 in the first, third, fifth, seventh, and ninth lactation, respectively. The trend indicated that as the lactation number advanced, a lesser number of females survived in the herd. Kumar (1999) reported a survivorship ranging from 1.0 to 0.37 from the first to the sixth parity in Haryana cattle, with a declining trend observed thereafter. Singh (2001) found a survivorship of 0.72 at the first lactation in Karan Fries cattle, which decreased with each subsequent parity.

Shahi and Kumar (2013), Kumar et al., (2013), and Goshu and Singh (2013) observed that survivorship was initially unity in the first lactation but declined with each subsequent parity, with values dropping below 0.10 after the eighth parity in Sahiwal, Frieswal, and Holstein Friesian cattle, respectively. Similarly, studies by Upadhyay et al., (2014), Maher et al., (2015), and Dash et al., (2016) in Sahiwal, Tharparkar, and Karan Fries cattle, respectively, also revealed a decreasing trend in survivorship with increasing age or parity of lactation. Vinothraj et al., (2017) reported a survivorship of 0.12 at the fifth parity in Jersey and Red Sindhi crossbred

cattle. Lalmuansangi et al., (2022) reported the stayability for first lactation was one; decreased in subsequent lactations. The results indicated a decline in survivorship as lactation number increased, suggesting that fewer cows survived in the herd with each subsequent lactation.

The proportion of cows present in the herd (p_x)

In present study, it was observed that 24.65 percent of cows were present during their first lactation, and this proportion gradually decreased in subsequent lactations, with 20.31 percent in the second, 09.52 percent in the fifth, 02.95 percent in the eighth, and 00.60 percent in the tenth lactations. Kumar (1999) in his study on Haryana cattle; found that approximately one-fifth of the herd consisted of first calvers. Singh (2001) observed in Karan Fries cattle that one-third of the total herd consisted of first calvers, while the majority (70.3%) belonged to the 10th lactation. A small percentage (about 1.94%) of females in the herd were in their 10th or more lactations. Shahi (2004) studied Sahiwal cattle and reported that around one-fourth of the total cows in the herd were in their first parity, and two-thirds of the total cows belonged to the first through third parity. In Frieswal cattle, Kumar et al., (2013) found that approximately 88% of the herd consisted of cows in their first to fourth lactation. Similarly, Maher et al., (2015), Dash et al., (2016), and Vinothraj et al., (2017) reported that around 30% of the total cows in the herd were in their first parity in Tharparkar, Karan fries, and Jersey and Red Sindhi crossbred cattle, respectively.

The proportion of cows left the herd (q_x)

The study estimated the proportion of female cows being lost from the herd due to death and culling during various lactations. The estimated proportions were 0.1761, 0.1659, 0.1488, 0.0733, and 0.0204 for the first, second, third, seventh, and tenth lactations, respectively. These findings were in close agreement with similar studies conducted by Kumar (1999) on Haryana cattle, it was observed that approximately one-fourth of the total cows left the herd after completing their first lactation. Similar findings were reported by Singh (2001), Shahi and Kumar (2013), Kumar et al., (2013), and Upadhyay et al., (2014) for Karan Fries, Sahiwal, Frieswal, and Sahiwal cattle, respectively. They found that more than half of the females that completed their first lactation left the herd before reaching their third lactation. Additionally, Maher et al., (2015), Dash et al., (2016), and Vinothraj et al., (2017) reported that more than half of the females that completed their first lactation left the herd before reaching their second lactation in Tharparkar, Karan Fries, and Jersey and Red Sindhi crossbred cattle, respectively.

Table 1: Lactation specific demographic parameters of crossbred cattle

Lactation No.	Total cows	Survival Rate (P_x)	Loss Rate (Q_x)	Survivorship/ Stayability (L_x)	Herd structure of cow at each lactation		Expected herd life (E_x)
					Died and Culled (q_x)	Present in the herd (p_x)	
1	1760	0.824	0.1761 (310)	0.8239	0.1761	0.2465	3.043
2	1450	0.799	0.2014(292)	0.6582	0.1659	0.2031	2.695
3	1158	0.774	0.2263(262)	0.5090	0.1488	0.1622	2.374
4	896	0.759	0.2411(216)	0.3863	0.1227	0.1255	2.095
5	680	0.707	0.2927(199)	0.2732	0.1131	0.0952	1.760
6	481	0.707	0.2931(141)	0.1931	0.0801	0.0674	1.489
7	340	0.621	0.3794(129)	0.1198	0.0733	0.0476	1.106
8	211	0.545	0.4550(96)	0.0653	0.0545	0.0295	0.781
9	115	0.374	0.6261(72)	0.0244	0.0409	0.0161	0.435
10	43	0.163	0.8372(36)	0.0040	0.0204	0.0060	0.163
11	7	0.00	0.00(7)	0.00	0.0040	0.0009	00.00

Expected herd life (E_x)

The expected herd life in Crossbred cattle decreases with each successive lactation. The calculated expected herd life for the Crossbred cattle was found to be 3.043 years in the first lactation, 2.695 years in the second lactation, 2.374 years in the third lactation, 1.760 years in the fifth lactation, and only 0.163 years in the tenth lactation. These findings were consistent with previous research conducted by Kumar (1999) and Shahi and Kumar (2013) on Haryana and Sahiwal cows, respectively, the expected herd life during the first parity was observed to be 3.52 and 3.14 lactations, with a decreasing trend as the lactation number increased. Singh (2001) reported an expected herd life of 2.14 lactations at first parity, which remained relatively consistent up to the sixth lactation and then declined with subsequent lactations of cattle. Kumar et al., (2013) in Frieswal cattle, Goshu and Singh (2013) in Holstein Friesian cattle, and Upadhyay et al., (2014) in Sahiwal cattle reported

expected herd life at first parity to be 2.05, 2.45, and 2.59 lactations, respectively, with a declining trend observed in subsequent lactations. Dash et al., (2016) found the lowest expected herd life at first parity in Karan Fries cattle to be 1.80 lactations, while Vinothraj et al., (2017) reported an expected herd life of 1.47 lactations in Jersey and Red Sindhi crossbred cattle.

Conclusion

The probability of survival was highest during the first lactation and gradually decreased with an increase in subsequent lactation numbers. As lactation number increased beyond the first lactation, the loss rate increased. The overall values for survivorship were indicated that the proportion of females that survived in the herd decreased as the lactation number advanced. A total number of 24.65 percent cows were present in first lactation. This is a common pattern in dairy herds, where the number of cows typically decreases in higher lactation numbers due to factors such as culling, replacement, and management decisions. As the lactation number increases, the proportion of cows lost from the herd decreases. The expected herd life declined over different lactations. This decline in expected herd life is a common pattern observed in dairy herds and is influenced by factors such as reproductive performance, milk production, and overall health and management practices. On an average, the cows present in the herd had undergone 3.73 lactations. The cows that were lost from the herd on an average had completed approximately 4.58 lactations during their time in the herd. This suggests that most of the cows were replaced at a higher age, typically after completing four lactations. The fact that cows were replaced after completing multiple lactations indicating that the herd management strategy involved keeping cows for an extended period before culling or replacing them.

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