



Factors influencing calf mortality in zebu and crossbred cattle reared under subtropical agroclimatic conditions

A SAKTHIVEL SELVAN¹, M S TANTIA², D RAVI KUMAR³, T KARUTHADURAI⁴, ARPAN UPADHYAY⁵,
S S LATHWAL⁶ and A KUMARESAN⁷

ICAR-National Dairy Research Institute, Karnal, Haryana 132 001 India

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ABSTRACT

Data on birth weight and mortality pattern of Zebu (Sahiwal and Tharparkar) and Crossbred (Holstein Friesian × Tharparkar) cattle spread over 16 years were utilized to analyze the causes of calf mortality and to study the effect of non-genetic factors on calf mortality. Calf mortality was higher in crossbred (27.7%) compared to either Sahiwal (20.7%) or Tharparkar cattle (11.9%). Age group wise analysis revealed maximum mortality within one month age in Zebu cattle, and during 1–3 months age in crossbred cattle. Mortality was higher in calves born during winter, summer and rainy seasons in Sahiwal, crossbred and Tharparkar, respectively. Mortality was higher among male calves compared to female calves. Significantly higher proportion of Sahiwal calves died due to respiratory problems, while general debility was the major reason for calf mortality in crossbred and Tharparkar cattle. Season of birth had highly significant influence within one month age in Sahiwal and crossbred cattle. Influence of all the non genetic factors on calf mortality at various age groups was found to be non significant in Tharparkar cattle. It is inferred that calf mortality was higher in crossbred compared to Zebu cattle and the effect of season of birth and birth weight had a significant effect on calf mortality during first three months age. Among the several causes, respiratory problem was a significant reason for the calf mortality.

Key words: Birth weight, Calf mortality, Crossbred, Non-genetic factors, Season, Zebu cattle

Newborn diseases and their mortality interferes with livestock propagation, as large number of calves die during their first year of life leads to heavy drain on the economics of livestock production (Piccione *et al.* 2008, Grondhal *et al.* 2007). Calf mortality is one of the vital indicators of health status in dairy farms (Ortiz-Pelaez *et al.* 2008). In bovines, the perinatal period and early postnatal periods are characterised by high mortality rates. Perinatal mortality may be defined as death of the perinate prior to, during or within two days of calving, which means calf had followed a gestation period of at least 260 days, irrespective of the cause of death or the conditions related to calving (Gulliksen

et al. 2009, Lombard *et al.* 2007 and Mee *et al.* 2008), whereas postnatal mortality is defined as death of calves from two days to approximately six months of age (Mee *et al.* 2014).

Perinatal mortality in bovine ranged from 2–45.6% (Mee *et al.* 2008, Pandey *et al.* 2012), out of which 75% mortality occurs within an hour of calving. Curtis *et al.* (1988) and Wells *et al.* (1996) reported the highest mortality rates in pre weaning dairy replacement calves raised under typical dry-lot management conditions. Generally, on an average, cost of calf mortality in terms of replacement stock may be higher than the cost of mortality due to calf's stillbirth, since it reduces the genetic gain as well as the economic return (NAHMS 2007). Department for Environment Food and Rural Affairs (2003) estimated a loss of about £60 million per annum, as 6% of the calves die before they reach 6 months of age born in the United Kingdom, whereas Razzaque *et al.* (2010) found high economic loss of KD 70 per calf died in Kuwait.

Numerous risk factors like dystocia, gestation length, birth type, diseases, diarrhoea, colostrum intake, season of birth, sex of calf and dam's parity have been found associated with decreasing calf survivability in organised farms. Although information on calf mortality under commercial large scale dairying in developed countries

Present address: ¹Assistant Professor (drasakthivel1987@gmail.com), Department of Animal Genetics and Breeding, Madras Veterinary College, TANUVAS, Chennai, Tamil Nadu; ²Principal Scientist (tantiams@gmail.com), ICAR-National Bureau of Animal Genetic Resources, Karnal, Haryana; ⁵Subject Matter Specialist (Animal Science) (upadhyay.arpan@gmail.com), Krishi Vigyan Kendra, Jhansi, Uttar Pradesh; ⁷Principal Scientist (ogkumaresan@gmail.com), Southern Regional Station, ICAR-National Dairy Research Institute, Adugodi, Bengaluru; ^{3,4}PhD Scholar (ravikumardhanapal@gmail.com, karuthu1992@gmail.com), Dairy Cattle Breeding Division; ⁶Principal Scientist (lathwal@gmail.com), Livestock Research Centre.

under temperate agroclimatic conditions is available, the factors influencing calf mortality in Zebu and crossbred cows reared under subtropical agroclimatic conditions has not been studied in detail. Identifying the factors influencing calf mortality in different breeds would help to develop suitable management strategies to downsize its incidence. Therefore, the present study was undertaken to identify the most significant causes of calf mortality and to study the effect of non-genetic factors on calf mortality in Zebu (Sahiwal and Tharparkar) and crossbred (Holstein Friesian × Tharparkar crossbred) cattle.

MATERIALS AND METHODS

Data collection and management: The birth weight and mortality data of Zebu (Sahiwal and Tharparkar), Crossbred (Holstein Friesian × Tharparkar) calves (spread over 16 years; 1999–2014) maintained at Livestock Research Centre, National Dairy Research Institute, Karnal were utilized for the study. Data on Sahiwal (1697), Tharparkar (328) and Crossbred (2448) calves were obtained from history sheets, birth register and calf mortality register maintained at different sections of the farm from record unit, Dairy Cattle Breeding Division, Animal Health Complex and Livestock Research Centre. The data related to calf birth (date of birth, sex and birth weight of calf) and its mortality (reasons for mortality) were utilized for analysis. All the calves were weaned at the time of birth. They were fed with colostrum for the first 5 days and then with whole milk up to 30 days. Proper vaccination and deworming of calves was followed at the farm as per the standard schedule.

Classification of data: The data of calf mortality was classified according to season of birth, period of birth, age group of calf, sex of calf and birth weight of calf and assigned separate codes for statistical analysis. Different seasons were classified as winter (December to March), summer (April to June), rainy (July to September) and autumn (October and November). Periods were classified as P-1 (1999–2002), P-2 (2003–2006), P-3 (2007–2010) and P-4 (2011–2014). The age groups of calves were categorised as 0–1 month, 1–3 months and 3–6 months. Sex of calf was classified into either male or female. Birth weight of the calves were grouped into different categories based on the average birth weight of the farm (≤ 22 kg, 23–33 kg, ≥ 34 kg for crossbred calves; ≤ 17 kg, 18–22 kg, ≥ 23 kg for Sahiwal calves and ≤ 18 kg, 19–23 kg, ≥ 24 kg for Tharparkar calves). Grouping of birth weight was carried out using the formula: $\text{Mean} \pm 1 \text{ Standard deviation}$.

Dead calves were subjected to post-mortem to ascertain the cause of death. Causes of death were classified into 8 (Sahiwal, Crossbred calves) and 4 (Tharparkar) groups respectively, based on post-mortem findings of deceased calves; 1. Respiratory problems (Pneumonia, bronchitis, bronchopneumonia and asphyxia), 2. Digestive problems (Enteritis and gastroenteritis), 3. General debility 4. Toxaemia and septicaemia, 5. Anaemia, 6. Liver problems, 7. Cardiac and neurological problems (cardiac arrest,

cardiac failure) and 8. Miscellaneous causes (congenital anomalies, anorexia, cold sock, disposal of carcass, snake bite, peritonitis, hypothermic shock, joint-ill, parasitic diseases).

Statistical analysis: The percent of calves died due to different reasons was calculated as proportion using descriptive statistics. Influence of non-genetic factors like season of calving, period of calving and birth weight of calves on calf mortality up to six months were statistically analyzed using Logistic regression model of Statistics Analysis System (SAS version 9.3) Programme. The following dichotomous logistic regression model was used:

$$\ln \left[\frac{p}{1-p} \right] = \beta_0 + \sum_{j=1}^c \beta_j X_j$$

where, $\ln$ denotes the natural logarithm, p is the probability that the dependent variable equals a case, β_0 is the intercept from the linear regression equation (the value of the criterion when the predictor is equal to zero), $\beta_j X_j$ is the regression coefficient multiplied by some value of the predictor. The test of significance of linear regression coefficients β was based on sum of square type I tests (Wald Chi square values). Logistic regressions work with odds rather than proportions. The odds are simply the ratio of the proportions for the 2 possible mutually exclusive events. If p is the proportion for one event, then $(1-p)$ is the proportion for the alternate event; Odds = $p/(1-p)$.

RESULTS AND DISCUSSION

Mortality rates in Sahiwal, Tharparkar and Crossbred calves of different age group under different periods of birth, seasons of birth and sex of calf are shown in the Tables 1–3. Age group wise analysis revealed maximum mortality within one month of age in indigenous cattle and during 1–3 months of age in crossbred cattle. Mortality was higher in male calves compared to female calves in Sahiwal and crossbred, whereas the reverse is true in Tharparkar cattle.

Effect of period on calf mortality: Maximum mortality in zebu and crossbred calves was noticed in P-4 and P-3 periods, respectively (Tables 1, 2). Results revealed a highly significant influence ($P < 0.01$) of period of birth on calf mortality in crossbred cattle of under 3 months of age. Estimated odds ratio revealed that the likelihood of maximum mortality was during the first period (1999–2002) in calves less than 3 months of age in crossbred calves (Table 4).

Effect of season on calf mortality: The calves born in winter, summer and rainy seasons showed higher cases of mortality in Sahiwal, crossbred and Tharparkar, respectively with the mean of 24.16, 35.34 and 18.18, respectively. The season of birth had significant influence on calf mortality in Sahiwal and crossbred cattle calves within one month age ($P < 0.01$) and 1–3 months age group ($P < 0.05$). The estimates of odds ratio for season of birth revealed that under 1 month of age, the likelihood of mortality was higher in Sahiwal calves born during winter and lower during the rainy season. In 1–3 months aged calves, higher odds value

Table 1. Mortality rate in Sahiwal calves of different age group under different periods of birth, seasons of birth and sex of calf

	No. of calves born	0–1 month	1–3 months	3–6 month	Total died
	1697	256 (15.08)	59 (4.09)	36 (2.60)	351 (20.68)
<i>Period</i>					
P-1 (1999–02)	284	47 (16.55)	14 (5.91)	0	61 (21.48)
P-2 (2003–06)	428	51 (11.92)	11 (2.92)	9 (2.46)	71 (16.59)
P-3 (2007–10)	447	54 (12.08)	14 (3.56)	8 (2.11)	76 (17.00)
P-4 (2011–14)	538	104 (19.33)	20 (4.61)	19 (4.59)	143 (26.58)
<i>Season</i>					
S-1 (Dec-Mar)	741	141 (19.03)	29 (4.83)	9 (1.58)	179 (24.16)
S-2 (Apr-June)	464	66 (14.22)	16 (4.02)	10 (2.62)	92 (19.83)
S-3 (July-Sept)	334	36 (10.78)	6 (2.01)	16 (5.48)	58 (17.37)
S-4 (Oct-Nov)	158	13 (8.23)	8 (5.52)	1 (0.73)	22 (13.92)
<i>Sex of calf</i>					
Male	886	136 (15.35)	33 (4.4)	24 (3.35)	193 (21.78)
Female	811	120 (14.80)	26 (3.76)	12 (1.80)	158 (19.48)

Figures in parentheses indicate percentage.

was observed in favour of mortality in calves born during autumn (1.000) in comparison to others (i.e. 0.432, 0.318, 0.092 in winter, summer and rainy season, respectively) indicating that the likelihood of calf mortality was lesser during winter (by 56.8%), summer (by 68.2%) and rainy (by 90.8%) season compared to autumn. In crossbred cattle under 0–1 month of age, odds values in favour of mortality were higher in calves born during rainy (2.454) and winter (2.431) seasons than rest of the seasons (1.240, 1.000 in summer and autumn, respectively) revealing higher likelihood of mortality in rainy and winter seasons (Table 4).

Effect of birth weight on calf mortality: The effect of birth weight on calf mortality was significant in crossbred cattle. Calves with birth weight less than 23 kgs had more likelihood of mortality in crossbred while the effect of birth weight was non-significant on calf mortality in Zebu cattle (Table 4).

Disease conditions: Mortality pattern among various age groups of Zebu and crossbred calves are depicted in Table 5. Overall, the results indicated that the major reason for calf mortality was respiratory problems (33.34%), followed by general debility (29.36%) and digestive problems (21.36%) in Sahiwal cattle. General debility was major reason of calf mortality in crossbred and Tharparkar with the percentage of 30.09 and 46.16, respectively. Among

Table 2. Mortality rate in Crossbred calves of different age group under different periods of birth, seasons of birth and sex of calf

	No. of calves born	0–1 month	1–3 months	3–6 months	Total died
	2448	278 (11.36)	280 (12.90)	120 (6.35)	678 (27.70)
<i>Period</i>					
P-1 (1999–02)	559	81 (14.50)	75 (15.70)	14 (3.47)	170 (30.41)
P-2 (2003–06)	647	55 (8.50)	46 (7.77)	21 (3.85)	122 (18.86)
P-3 (2007–10)	707	65 (9.19)	96 (14.95)	43 (7.88)	204 (28.85)
P-4 (2011–14)	535	77 (14.40)	63 (13.76)	42 (10.63)	182 (34.02)
<i>Season</i>					
S-1 (Dec-Mar)	928	129 (13.90)	97 (12.14)	46 (6.11)	272 (29.31)
S-2 (Apr-June)	549	64 (11.66)	84 (17.32)	46 (11.47)	194 (35.34)
S-3 (July-Sept)	595	60 (10.08)	49 (9.16)	16 (3.29)	125 (21.00)
S-4 (Oct-Nov)	376	25 (6.65)	50 (14.35)	12 (3.54)	87 (23.14)
<i>Sex of calf</i>					
Male	1223	162 (13.25)	134 (12.63)	59 (6.36)	355 (29.03)
Female	1225	116 (9.47)	146 (13.17)	61 (6.33)	323 (26.37)

Figures in parentheses indicate percentage.

Table 3. Mortality rate in Tharparkar calves of different age group under different periods of birth, seasons of birth and sex of calf

	No. of calves born	0–1 month	1–3 months	3–6 months	Total died
	328	23 (7.01)	12 (3.93)	4 (1.37)	39 (11.89)
<i>Period</i>					
P-1 (1999–02)	33	4 (12.12)	2 (6.90)	0	6 (18.18)
P-2 (2003–06)	48	0	0	1 (2.08)	1 (2.08)
P-3 (2007–10)	120	10 (8.33)	5 (4.55)	0	15 (12.5)
P-4 (2011–14)	127	9 (7.09)	5 (4.24)	3 (2.65)	17 (13.39)
<i>Season</i>					
S-1 (Dec-Mar)	120	9 (7.5)	6 (5.41)	0	15 (12.5)
S-2 (Apr-June)	96	5 (5.21)	3 (3.30)	1 (1.13)	9 (9.38)
S-3 (July-Sept)	66	7 (10.61)	3 (5.08)	2 (3.57)	12 (18.18)
S-4 (Oct-Nov)	46	2 (4.35)	0	1 (2.27)	3 (6.52)
<i>Sex of calf</i>					
Male	159	9 (5.66)	5 (3.33)	1 (0.69)	15 (9.43)
Female	169	14 (8.28)	7 (4.52)	3 (2.03)	24 (14.2)

Figures in parentheses indicate percentage.

Table 4. Influence of various non-genetic factors on mortality of Sahiwal, Crossbred and Tharparkar calves (expressed in terms of odds ratio)

Explanatory variable	Sahiwal			Crossbred			Tharparkar		
	Age group of calves (months)			Age group of calves (months)			Age group of calves (months)		
	0 to 1	1 to 3	3 to 5	0 to 1	1 to 3	3 to 5	0 to 1	1 to 3	3 to 5
<i>Season</i>	S (p<0.01)	S (p<0.05)	NS	S (p<0.01)	NS	NS	NS	NS	NS
Winter	2.465	0.432	<0.001	2.431	0.697	0.231	0.821	>999.999	0
Summer	1.597	0.318	<0.001	1.240	0.547	0.216	0.607	>999.999	1.000
Rainy	0.875	0.092	<0.001	2.454	0.880	0.358	0.485	>999.999	<0.001
Autumn	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
<i>Period</i>	NS	NS	NS	S (p<0.01)	S (p<0.01)	NS	NS	NS	NS
1999–2002 (P-1)	1.343	>999.999	-	1.381	3.746	1.001	1.987	<0.001	>999.999
2003–2006 (P-2)	1.215	0.932	2.531	1.162	1.446	0.428	1.829	>999.999	-
2007–2010 (P-3)	1.025	1.204	0.750	0.652	1.554	0.802	1.000	1.000	1.000
2011–2014 (P-4)	1.000	1.000	1.000	1.000	1.000	1.000	-	-	-
<i>Birth weight (kg)</i>	NS	NS	NS						
Less than 18	2.572	1.547	<0.001						
18 to 22	1.176	0.404	1.429						
More than 22	1.000	1.000	1.000						
<i>Birth weight (kg)</i>				NS	S (p<0.05)	NS			
Less than 23				1.173	2.528	0.249			
23 to 33				1.090	1.787	0.267			
More than 33				1.000	1.000	1.000			
<i>Birth weight (kg)</i>							NS	NS	NS
Less than 19							2.511	<0.001	-
19 to 23							1.364	<0.001	-
More than 23							1.000	1.000	-

NS, non significant; -, no observations found.

Table 5. Mortality pattern of different age group of Sahiwal, Crossbred and Tharparkar calves

Age group	Total died	Respiratory problems	Digestive problems	General debility	Toxaemia, septicemia	Anaemia	Liver problems	Cardiac and neurological problems	Misc.
<i>Sahiwal</i>									
0–1 month	256 (72.93)	92 (26.21)	56 (15.95)	69 (19.66)	14 (3.99)	3 (0.85)	3 (0.85)	14 (3.99)	5 (1.43)
1–3 months	59 (16.81)	17 (4.85)	15 (4.27)	18 (5.13)	3 (0.85)	2 (0.57)	0	4 (1.14)	0
3–6 months	36 (10.26)	8 (2.28)	4 (1.14)	16 (4.57)	1 (0.28)	1 (0.28)	0	4 (1.14)	2 (0.57)
Overall died	351 (100)	117 (33.34)	75 (21.36)	103 (29.36)	18 (5.12)	6 (1.70)	3 (0.85)	22 (6.27)	7 (2.00)
<i>Crossbred</i>									
0–1 month	278 (41.00)	83 (12.24)	60 (8.85)	68 (10.03)	32 (4.72)	3 (0.44)	9 (1.33)	16 (2.36)	7 (1.03)
1–3 months	280 (41.30)	41 (6.04)	77 (11.36)	91 (13.42)	33 (4.87)	11 (1.62)	4 (0.59)	23 (3.40)	0
3–6 months	120 (17.70)	13 (1.93)	16 (2.36)	45 (6.64)	12 (1.77)	14 (2.06)	3 (0.44)	14 (2.06)	3 (0.44)
Overall died	678 (100)	137 (20.21)	153 (22.57)	204 (30.09)	77 (11.36)	28 (4.12)	16 (2.36)	53 (7.82)	10 (1.47)
<i>Tharparkar</i>									
0–1 month	23 (58.97)	7 (17.95)	4 (10.26)	8 (20.51)	3 (7.69)	0	1 (2.56)	0	0
1–3 months	12 (30.77)	1 (2.56)	2 (5.14)	8 (20.51)	1 (2.56)	0	0	0	0
3–6 months	4 (10.26)	1 (2.56)	1 (2.56)	2 (5.14)	0	0	0	0	0
Overall died	39 (100)	9 (23.07)	7 (17.96)	18 (46.16)	4 (10.25)	0	1 (2.56)	0	0

Figures in parentheses indicate percentage.

the infectious causes, digestive and respiratory problems accounted for 22.57% and 20.21% of calf mortality in crossbred cattle; 17.96% and 23.07% of calf mortality in Tharparkar cattle. Influence of all non genetic factors on calf mortality in various age groups was found to be non significant in Tharparkar cattle ($P>0.05$) (Table 4).

In the present scenario of dairy development, healthy and disease free calves are considered as the worth possession of a dairy enterprise as they are the future herd stock (Kumaresan *et al.* 2009). The calf morbidity and mortality is a perennial problem throughout the world and the most susceptible period is the first few weeks after its

birth (Kumaresan *et al.* 2012). Since the factors influencing calf mortality varies with climate, production system and management practices followed in a particular region, identification of potential factors associated with calf mortality in different breeds in the region would help in formulating strategies to reduce the incidence. In study, we have reported the factors influencing calf mortality in zebu and crossbred cattle reared under subtropical agroclimatic conditions.

The Calf mortality rate was highest in crossbred compared to Zebu cattle. Higher calf mortality in crossbred cattle may indicate lower adaptability and survivability of this breed under subtropical climatic conditions compared to Zebu cattle. Analysis of the influence of age on calf mortality indicated that mortality was highest up to three months of age, especially during their first month indicating the importance of protecting the calves during this period. Present findings are in agreement with those reported by Hossain *et al.* (2014) observed that age of the calves was significantly and negatively associated with mortality. Similar reports indicating high mortality rate in first month of age in indigenous cattle were also reported by Prasad *et al.* (2004), Upadhyay *et al.* (2014) and Mishra *et al.* (2015). In case of crossbred cattle, higher mortality was observed between one and three months of age (Prasad *et al.* 2004, Panmei *et al.* 2014).

In 1–3 months age group, period of birth had highly significant influence ($P < 0.01$) on calf mortality in crossbred cattle. Similar findings were reported by Shahi and Kumar (2014) who found that the period of birth had significant effect on mortality rate from birth to one month and 1–3 month age groups, whereas Kumar *et al.* (2002) reported non-significant effect of period on mortality from birth to 12 month of age in Jersey crossbred cattle. The variation in mortality rate over the periods may be attributed to change in managerial practices and variation in environmental factors over the period. This is also envisaged by Hansen *et al.* (2003) suggesting that mortality of calves and heifers is different at different periods of life.

The season of birth had significant influence on mortality of calves under one ($P < 0.01$) and 1–3 month of age ($P < 0.05$) in Sahiwal and under one month of age ($P < 0.01$) in crossbred cattle. Similar results were observed by Upadhyay *et al.* (2015) in Sahiwal calves. Higher likelihood of calf mortality during rainy, summer and winter seasons in Zebu and crossbred cattle under one month of age may be attributed to higher incidence of gastroenteritis and pneumonia due to exposure to inclement hot and cold weather conditions. This is in agreement with Panmei *et al.* (2014) who reported that calf mortality was highest in summer (33.57%) and autumn (33.06%) seasons in crossbred male calves than those born in winter (31.03%) and rainy (4.66%) seasons.

In present study, mortality was more in male calves compared to female in Sahiwal and crossbred cattle which may be due to better care and attention given to female calves because of their economic importance. Further,

longer gestation lengths associated with male calves and more body weight at birth compared to female calves may cause dystocia (French *et al.* 2001, Johanson and Berger 2003), thereby increasing the risk of mortality.

Newborn calves that already experiences stress during and after calving, extreme hot or cold environment are more susceptible to infectious diseases, when they are exposed to pathogens commonly found in many herds like coliforms, rotavirus, coronavirus. Present findings revealed that infectious causes like respiratory, digestive problems and non infectious causes like general debility accounts for maximum mortality in calves up to six months of age. These disorders are usually multi factorial that involves an interaction between microorganisms with the calf's immunity, nutrition and environment, thereby lowering the defence mechanisms thus giving a way to disorders. General debility in calves may be due to unhealthy condition, lack of exercise and sufficient food, etc. Several studies indicated that digestive problems (Alam *et al.* 2012, Hur *et al.* 2013 and Mishra *et al.* 2015) respiratory problems (Islam *et al.* 2005, Panmei *et al.* 2014), both digestive and respiratory problems (Prasad *et al.* 2004, Svensson *et al.* 2006, Gulliksen *et al.* 2009), poor management problems (Chaudhary *et al.* 2013) were the major reason for calf death. Birth weight group had significant influence ($P < 0.05$) on calf mortality in crossbred cattle under one month of age.

Collectively, present findings indicate that crossbred calves were more prone for mortality compared to Zebu cattle and the effect of season of birth, period of birth and birth weight had a significant effect on calf mortality during first three months age. Among the several causes for calf mortality, respiratory problems were the major reason followed by general debility and digestive disorders. All these indicate that intensive health care and management is the prerequisite for calves of age up to three months age especially during adverse weather conditions to minimize the calf mortality.

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