

# Occurrence and Determinants of Calf Mortality in Commercial Dairy Farms in Southern Highland Regions of Tanzania

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## SUMMARY

Calf mortality is among the major problems hindering the success of the dairy industry throughout the world. It has a negative impact on milk production by reducing future milking herds and eroding genetic improvement. A retrospective study was conducted in Iringa and Njombe regions to estimate the magnitude and determinants of mortalities in calves up to 12 months of age. Five years data from 1<sup>st</sup> July 2017 to 30<sup>th</sup> June 2022 about calf mortality and related information were analyzed by Kaplan-Meier and Cox Proportional Hazard analysis. It was found that a total of 4,466 calves were born, out of which, 343 died at different times. The crude mortality was 7.68% while the mortality risk was 11.2% and the mortality rate was 11.9 per 100 calf-year at risk. The first month of life registered 36.15% of mortalities and at 90 days of age 63.3% of mortalities occurred. Diarrhea (27.11%), pneumonia (19.53%), and accidents (17.2%) were the most common syndrome/ factors associated with calf mortality. Calf mortality was higher in Jersey calves (HR 1.7, 95% CI 1.37-2.31) compared to other breeds. Calves born during dry season had a lower likelihood of dying (HR=0.647, 95% CI; 0.47 – 0.90) than calves born during rainy season. The major causes of early calf mortalities are managerial related and risk factors are age, breed and season. Improvement in calf management practices during the first month of life, breed selection and breeding program which allow calving in dry season may help to reduce dairy calf mortalities in Iringa and Njombe regions.

**Keywords** Calf management; calving season; Diarrhea; risk rate; survival probability

## INTRODUCTION

The livestock sector has a significant importance in human life, economically, socially, and culturally both in developing and developed countries. In sub-Saharan Africa, livestock production plays a crucial role at the family, community and national levels in terms of nutrition and food security, income generation, working force, indicator of wealth status, insurance against future shocks and stresses (Randolph *et al.*, 2007). Globally the sector employs approximately 1.3 billion people and supports more than 600 million

smallholder farmers in developing countries (Thornton, 2010).

After Ethiopia, Tanzania ranks second in livestock population on the African continent. Tanzania stocks 36.6 million cattle, 26.6 million goats, 9.1 million sheep, 3.7 million pigs, and 97.9 million chickens (URT, 2023). Generally, the livestock sector in Tanzania contributes 7% to the country's GDP and grows at the rate of 5% per annum. This growth for a

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large part reflects an increase in livestock numbers rather than productivity gains (URT, 2023).

According to the ministry of Livestock Development and Fisheries, the annual milk production is 3.6 billion litres, out of which 67% come from traditional herd and 33% is produced by improved dairy cattle. Out of the 36.6 million cattle population in Tanzania, the dairy cattle population stands at 1.3 million (URT, 2023). Currently, commercial specialized dairy farms in Tanzania have more than 660,000 crossbreed cattle which produce an average of 10-12 liters of milk per day, with an average lactation length of 310 days (URT, 2017). Despite the huge number of cattle in the country, the industry is drastically constrained by low reproductive rates, high mortality and high disease prevalence, shortage of feeds especially during the dry season, and poor performance of indigenous breeds (URT, 2017). This set of challenges results in poor reproductive performance and lower economic benefit of dairy cattle sector.

Calf rearing is an essential part of dairy herd management and is a prerequisite for a productive lifetime of dairy animals (Hultgren and Svensson, 2009). One of the remarkable challenges in calf rearing in dairy farms worldwide is calf mortality. Usually, calf mortality above 5% call for managerial attention because it has significant effects on both farm economics and animal welfare issues (Heinrichs and Radostits, 2001, Mee, 2008).

Calf mortalities are attributed by infectious and non-infectious causes. Non-infectious causes of calf mortalities include improper feeding of colostrum, starvation, plant poisoning, dystocia, low birth weight, trauma, tympany, milk indigestion and poor management practices (Kochewad *et al.*, 2013, Thumbi *et al.*, 2013, Arnold, 2014). A number of infectious causes such as viruses, bacteria, protozoa, helminths and fungi have been associated with calf mortality (Thumbi *et al.*, 2013).

The major syndromes associated with calf mortalities are diarrhea, and pneumonia (Gitau *et al.*, 2010). Approximately 75% of dairy calf death are caused by diarrhea. These mortalities are prevalent in calves below three weeks of age and tends to decline with an advance in age (Wudu *et al.*, 2008). The common infectious causes of calf diarrhea include bovine rotavirus group A, bovine viral diarrhea virus, bovine coronavirus, *Salmonella* spp. *Escherichia coli*,

*Cryptosporidium parvum*, and *C. perfringens* (Cho *et al.*, 2013). Pneumonia, on the other hand, accounts for about 15% of calf mortality from birth to 6 months of age. The major bacterial causes of calf pneumonia are *Pasteurella multocida*, *Manhaemia haemolytica*, *Hemophilus somnus* *Actinomyces pyogenes* and *Mycoplasma* spp.), while the viral causes include *Respiratory syncytial virus*, Para influenza virus type 3, infectious bovine rhinotracheitis virus and bovine coronavirus (Campbell, 2012). Other causes of calf mortality are navel infection, Septicemia and vector-borne diseases including trypanosomiasis, anaplasmosis and babesiosis.

Calf mortality is one of the major problems hindering the success of the dairy industry throughout the world (Achá *et al.*, 2004). It has a negative impact on milk production by reducing sources of replacement stock and eroding genetic improvement. Moreover, calf mortalities increase farm expenditure through cost of drugs and veterinary services, and increases farm loss. It has been observed that 20% calf mortality will reduce the 38% of profit in the dairy industry. (Shiferaw *et al.*, 2003).

Mortality rates in calves and associated risk factors have been documented in different parts of the world. In developed countries such as Sweden, Britain and Norway, the mortality rate ranges between 3 to 5% (Svensson *et al.*, 2006, Ortiz-Pelaez *et al.*, 2008, Gulliksen *et al.*, 2009). Reports from developing countries such as Mali, Bangladesh, Sudan and Ethiopia, show that calf mortality can go as high as 50 % (Wymann *et al.*, 2006, Hossain *et al.*, 2013, Mansour *et al.*, 2014, Fentie *et al.*, 2020). In Tanzania, studies conducted in Morogoro, Iringa and Tanga regions show that calf mortality rate ranges from 9 to 45% (Shoo *et al.*, 1992, Masanja and Matovelo, 1993, Chang'a *et al.*, 2010, Swai *et al.*, 2010).

Despite presence of several reports on calf mortality in Tanzania, most the studies were conducted in small holder farms (Chang'a *et al.*, 2010, Swai *et al.*, 2010), and those few conducted on dairy forms represented a quite distinct area with different topographic and climatic features (Shoo *et al.*, 1992, Masanja and Matovelo, 1993). As such, there is lack of up-to-date information in respect of causes of calf mortality in large-scale commercial dairy farms in Southern Highlands of Tanzania. This information is important in advising farmers on when, how and what to do to control calf mortalities. Therefore, the current study

aimed at determining the magnitude and time-related risk factors for the occurrence of calf mortalities in

large-scale commercial dairy farms in the southern part of Tanzania

## MATERIALS AND METHODS

### Study Area Description

This study was conducted in two Southern Highland regions of Tanzania, Iringa and Njombe as shown in Figure 1. A large number of commercial dairy farms are located in Iringa. Iringa has more than 23 large scale commercial dairy farms, while Njombe has four large scale commercial dairy farms. Iringa region lies at an elevation from 900 to 2,300 meters above sea level and its area stretches between latitude 07°39' and 08°06'S and longitude 35°30' and 36°04'E. The humidity in Iringa region ranges from 55.16% to

80.80%, and the region receives an annual rainfall up to 168mm. The average temperatures are from 11.6°C to 26°C, Njombe region is located at an elevation of 600 to 3,000 meter above sea level. It lies between latitude 9°19' 59.99" S and longitude 34° 46' 0.01" E. Njombe region has humidity ranging from 74% to 84%, and receives annual rainfall up to 234mm. The region has temperatures ranging from 8°C to 24.7°C. In general, Iringa and Njombe regions are cold highland regions, which provide optimal conditions for production of dairy cattle exotic and cross breeds

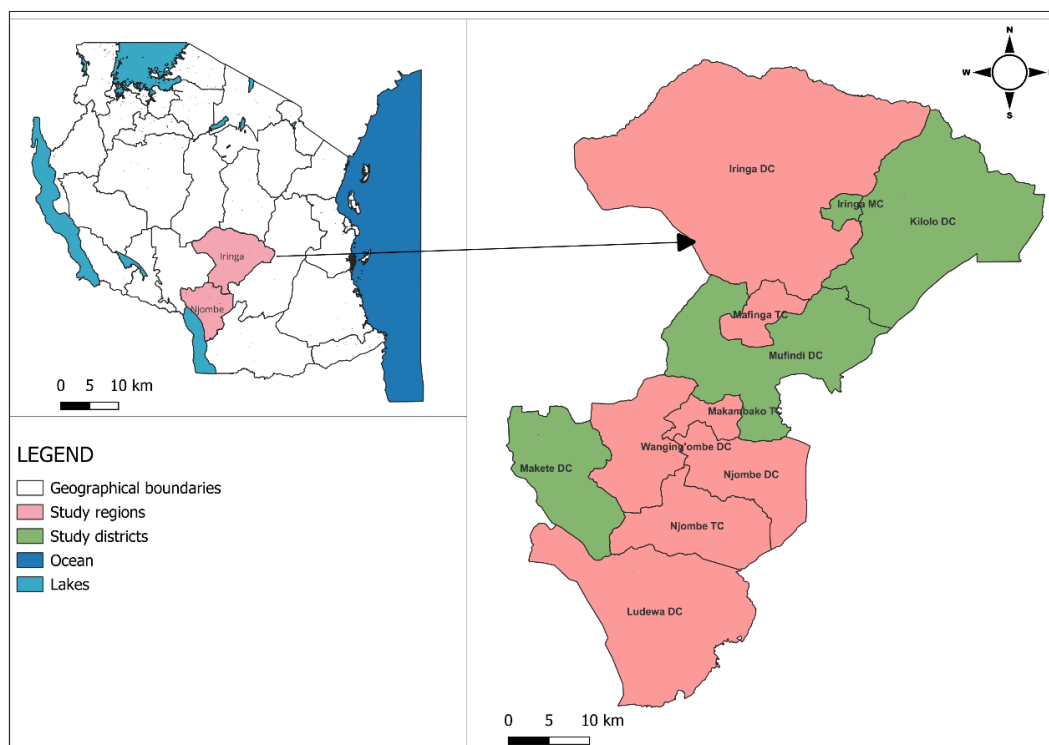


Figure 1 Map of Iringa and Njombe regions showing the study areas

### Study Farms

This study involved five large scale commercial dairy farms, four farms from Iringa and one from Njombe region. Two farms belong to the Ministry of Livestock Development and Fisheries and the other three (3) farms belong to private investors.

Kitulo Livestock Multiplication Unit (LMU) is located in Makete District in the Njombe region about 144.7

km from Njombe town. The climate at Kitulo LMU is largely temperate which is influenced by its altitude of around 3000 meters above sea level. The maximum daily temperature varies from 14.5 °C to 18°C and the minimum ambient temperature ranges from 7°C to 8°C between December and April and can go as low as 0.5°C during June-August period. The average annual rainfall is 1600mm ranging from 1500-1700mm.

Ndoto and Rutuba dairy farms are located in Kilolo District Iringa Region, 55 km and 70 Km from Iringa town respectively. Altitude ranges between 900 and 2,700 meters above sea level. The high-altitude areas encounter temperatures of 8°–10°C, and 1,000–1,600 mm of precipitation annually, while low-altitude areas have temperatures of 15°–27°C and receive 500–600 mm of rainfall annually.

Sao Hill LMU is located in Mufindi District, Iringa about 77 km from Iringa town. The climate at Sao Hill LMU is temperate, and the altitude is 1500- 2500 meters above sea level. The maximum daily temperature varies from 14.5 °C to 22°C and the minimum ambient temperature ranges from 9°C to 10°C between December and April. The average annual rainfall is 1600mm ranging from 1500-1700mm.

ASAS dairy farm is located in Iringa urban about 30 Km from Iringa town. The climate is cold, and the altitude is 1500- 2500 meters above sea level. The daily average temperature varies from 14.5 °C to 22°C. The average annual rainfall is ranging from 1000-1500mm.

### **Study Population and design**

Both crossbreed and pure exotic breeds dairy calves of both sexes reared under commercial dairy farms aged between births to 12 months were recruited in the study. A retrospective study was conducted in October to December 2022 extracting calf records from 1<sup>st</sup> July 2017 to 30<sup>th</sup> June 2022 in selected farms within two regions.

### **Farm selection criteria**

In this study, a commercial dairy farm was defined as that farm with more than 50 dairy cattle of all ages and sexes. Selection of study farms was purposive based on the following eligibility criteria; (1) willingness of farm owners to participate in the study, (2) the farm must have at least a herd size of 50 cattle of all age and sex, (3) Farm must have a complete record of an individual animals, and (4) farm must own pure or

cross breed dairy cattle. At the time of the study, Iringa region had 38 commercial farms and the Njombe region had 4 farms. Out of 42 commercial farms, 23 (53.5%) keep dairy cattle. We managed to visit 16/23 (69.6%) commercial dairy farms in Iringa and Njombe regions, while the remaining 7 farms (30.4%) did not agree to participate in the study. From the 16 commercial dairy farms, five farms (one farm from Njombe region and four farms from Iringa region) met the eligibility criteria and were included in the study. The other 11 farms were excluded due to the following reasons: - (1) 3 farms were established recently between 2020 to 2022; therefore, they were excluded from the study due to lack of three years data. (2) 6 farms had poor record keeping i.e., lack of animal identification, no records of the date of births, and no records of the date of terminal events, and (3) 2 farms agreed to participate but they failed to provide the record of individual animals in time.

### **Data Collection**

Data covering a period of five 5 years from 1<sup>st</sup> July 2017 to 30<sup>th</sup> June 2022 were retrieved. Specific variable on dairy calf mortality, causes, and risk factors were extracted from farm records. A questionnaire survey using face-to-face interviews with owners or farm attendants was carried out. Monthly and annual data on total number of calves on farm, sex, breed, age, calf deaths, causes of death, farm characteristics, and calf management technique including feeding and housing were recorded. Data were entered into a Microsoft Excel 2013 spreadsheet.

### **Statistical data analysis**

Descriptive statistics such as crude mortality, mortality rate and mortality risk were computed in Microsoft Excel. Survival analysis procedures such as Kaplan-Meier and Cox's proportional Hazard analysis were run in Epi Info version 7.2.2.2.

### **Estimation of Calf Mortality Rate and Risk**

In this study calf Mortality was defined as any observed death of a calf irrespective of cause aged from calving to 12 months of age.

Crude mortality was calculated as follows;

$$\text{Crude mortality} = \frac{\text{number of dead calves due to any cause at a given period}}{\text{total number of calves born in that given time}}$$

The numerator was the number of occurrences of the outcome of interest, whereas the denominator was the number of calves at risk for the given period.

Calf mortality rate, which measures the speed death, was estimated by the equation;

$$\text{Mortality rate } (\lambda) = \frac{\text{number of dead calves during study time}}{\text{total number of calf - day at risk}}$$

Mortality risk, also known as Risk rate, which is the probability of a calf not surviving 1 year, was computed by the equation;

$$\text{Mortality risk } (\eta) = 1 - e^{-\lambda}$$

where  $e$  = natural base logarithm and  $-\lambda$  = exponentiated mortality rate

### Determination of risk factors for calf mortality

Survival analyses of calf mortality were conducted using Kaplan-Meier tests and Cox's regression models. The event of interest was death and survival time was the focal outcome parameter. Calf records from birth to the age of one year (365 days) were investigated. Survival time was defined as time in days from birth to death, whereas, calves which did not die within the age of 365 days were considered as censored.

The prognostic factors for calf mortality included (i) calf-level factors, namely; calf sex, age, and breed, (ii) farm-level factors such as animal housing, calving pen, bedding, colostrum feeding, methods of colostrum feeding, and method of breeding and (iii) other miscellaneous factors including geographical location of the farm, herd size, season of calving, farm

ownership, calf caretaker education, gender, and their experience.

Kaplan-Meier analysis was run to estimate survival time of calves. Differences in survival curves for different variables were determined by the log-rank test at 5% significance level. A Cox's regression model was fitted to estimate the hazard ratio for different factors on calf mortality. The hazard ratio is an estimate of the ratio of the hazard rate in categories of different variables, where it indicates the relative likelihood of occurrence of death of calves.

### Ethical approval

This research was approved by Sokoine University of Agriculture Ethical committee (SUA/DPRTC/R/186/VOLIV-68). Moreover, verbal consent was granted by dairy farmers in Iringa and Njombe regions.

## RESULT

### Calf population characteristics and mortalities

A total of 4,466 calves were born from 1<sup>st</sup> July 2017 to 30<sup>th</sup> June 2022, among them, 2337 (52.3%) were female and 2129 (47.7%) were male calves. Six breeds were identified in this study, namely; Ayrshire cross, Boran, Friesian cross, Jersey, Red Danish, and Simmental (Table 1).

A total of 343 calves died between 1<sup>st</sup> July 2017 and 30<sup>th</sup> June 2022 from five dairy commercial farms in Iringa and Njombe regions. Among the dead calves, 189 (55.1%) were females and 154 (44.9%) were males (Table 1). The crude mortality in five years of study was 7.68% (95% CI: 6.92 – 8.50). The lowest crude mortality of 4.51% was recorded in 2021/2022 while the highest crude calf mortality (12.82%) was reported in the year 2020/21 (Table 1).

**Table1.** Characteristics of calf mortality distribution in commercial dairy farms in Iringa and Njombe regions

| Variable          | Categories  | No. Calves<br>Born (%) | Dead Calves |       |        |         |          | Total number<br>dead (%) |
|-------------------|---|------------------------|-------------|-------|--------|---------|----------|--------------------------|
|                   |   |                        | 0-2d        | 3-30d | 31-90d | 91-180d | 181-365d |                          |
| Farm              | Kitulo LMU  | 1087 (24.3)            | 0           | 24    | 22     | 11      | 1        | 58 (5.34)                |
|                   | Ndoto DF  | 808 (18.1)             | 15          | 29    | 30     | 5       | 0        | 79 (9.78)                |
|                   | Rutuba DF   | 234 (5.2)              | 10          | 11    | 4      | 3       | 2        | 30 (12.82)               |
|                   | Sao Hill LMU  | 1637 (36.7)            | 1           | 8     | 37     | 31      | 73       | 150 (9.16)               |
|                   | ASAS DF   | 701 (15.7)             | 5           | 21    | 0      | 0       | 0        | 26 (3.71)                |
| Sex               | Female  | 2337 (52.3)            | 17          | 55    | 61     | 25      | 31       | 189 (8.09)               |
|                   | Male  | 2129 (47.7)            | 14          | 38    | 32     | 25      | 45       | 154 (7.23)               |
| Year              | Year 1 (1 <sup>st</sup> JUL 17-30 <sup>th</sup> Jun 18) | 783 (17.5)             | 3           | 14    | 4      | 9       | 16       | 46 (5.87)                |
|                   | Year 2 (1 <sup>st</sup> JUL 18-30 <sup>th</sup> Jun 19) | 921 (20.6)             | 7           | 22    | 20     | 7       | 24       | 80 (8.69)                |
|                   | Year 3 (1 <sup>st</sup> JUL 19-30 <sup>th</sup> Jun 20) | 980 (21.9)             | 6           | 14    | 21     | 8       | 17       | 66 (6.73)                |
|                   | Year 4 (1 <sup>st</sup> JUL 20-30 <sup>th</sup> Jun 21) | 850 (19)               | 8           | 30    | 38     | 17      | 16       | 109 (12.82)              |
|                   | Year 5 (1 <sup>st</sup> JUL 21-30 <sup>th</sup> Jun 22) | 932 (20.9)             | 7           | 13    | 10     | 9       | 3        | 42 (4.51)                |
| Breed             | Ayrshire  | 1431 (32)              | 5           | 16    | 25     | 20      | 52       | 118 (8.25)               |
|                   | Boran   | 536 (12)               | 0           | 1     | 12     | 11      | 21       | 45 (8.4)                 |
|                   | Friesian  | 1178 (26.4)            | 0           | 28    | 22     | 11      | 1        | 62 (5.26)                |
|                   | Jersey  | 1039 (23.3)            | 25          | 40    | 34     | 8       | 2        | 109 (10.49)              |
|                   | Red Danish  | 263 (5.9)              | 1           | 8     | 0      | 0       | 0        | 9 (3.42)                 |
|                   | Simmental   | 17 (0.4)               | 0           | 0     | 0      | 0       | 0        | 0 (0.00)                 |
| Season of Calving | Cold  | 1048 (23.5)            | 11          | 24    | 23     | 11      | 10       | 79 (7.54)                |
|                   | Dry   | 1218 (27.3)            | 8           | 19    | 16     | 10      | 11       | 64 (5.25)                |
|                   | Rainy   | 2000 (44.8)            | 12          | 50    | 54     | 29      | 55       | 200 (10.00)              |

**Table 2.** Major factors associated with calf mortality stratified by sex, age and breed

| Cause of death          | Mortality |                        | Sex        |            | Age        |            |            | Breed      |            |            |          |            |
|-------------------------|-----------|------------------------|------------|------------|------------|------------|------------|------------|------------|------------|----------|------------|
|                         | Dead calf | Proportional Mortality | Female (%) | Male (%)   | ≤3 (%)     | Mo >3 (%)  | Mo         | Ayrshire   | Boran      | Friesian   | Jersey   | Red Danish |
| Diarrhea                | 94        | 27.41                  | 56 (59.6)  | 38 (40.4)  | 75 (79.8)  | 19 (20.2)  | 24 (25.53) | 9 (9.57)   | 2 (2.13)   | 55 (58.51) | 4 (4.26) |            |
| Pneumonia               | 67        | 19.53                  | 39 (58.2)  | 28 (41.8)  | 50 (74.6)  | 17 (25.4)  | 16 (23.88) | 4 (5.97)   | 26 (38.81) | 19 (28.36) | 2 (2.99) |            |
| Accident                | 59        | 17.2                   | 25 (42.4)  | 34 (57.6)  | 18 (30.5)  | 41 (69.5)  | 34 (57.63) | 14 (23.73) | 5 (7.46)   | 9 (15.25)  |          |            |
| General body weakness   | 37        | 10.8                   | 16 (43.2)  | 21 (56.8)  | 21 (56.8)  | 16 (43.2)  | 10 (27.03) | 9 (24.32)  | 9 (24.32)  | 7 (18.92)  | 3 (8.11) |            |
| FMD                     | 13        | 3.8                    | 12 (92.3)  | 1 (7.7)    | 12 (92.3)  | 1 (7.7)    |            | 1 (7.69)   |            | 12 (92.31) |          |            |
| Coccidiosis             | 10        | 2.92                   | 7 (70)     | 3 (30)     | 6 (60)     | 4 (40)     | 3 (30)     | 2 (20)     |            | 5 (50)     |          |            |
| Hematopoietic diseases  | 25        | 7.23                   | 14 (56)    | 11 (44)    | 9 (36)     | 16 (64)    | 22 (88)    | 1 (4)      | 2 (8)      |            |          |            |
| Bloat                   | 4         | 1.2                    | 1 (25)     | 3 (75)     | 1 (25)     | 3 (75)     |            | 4 (100)    |            |            |          |            |
| Congenital malformation | 9         | 2.6                    | 5 (55.6)   | 4 (44.4)   | 7 (77.8)   | 2 (22.2)   |            |            | 9 (100)    |            |          |            |
| Other causes            | 25        | 7.29                   | 11 (44)    | 14 (56)    | 12 (48)    | 13 (52)    | 7 (36.84)  | 1 (5.26)   | 9 (47.37)  | 2 (10.53)  |          |            |
| Cold season             | 79        | 23.03                  | 39 (49.37) | 40 (50.63) | 58 (73.42) | 21 (26.58) | 20 (25.32) | 15 (18.99) | 13 (16.46) | 28 (35.44) | 3 (3.79) |            |
| Dry season              | 64        | 18.66                  | 39 (60.94) | 25 (39.06) | 43 (67.19) | 21 (32.81) | 19 (29.69) | 12 (18.75) | 10 (15.63) | 22 (34.37) | 1 (1.56) |            |
| Rainy season            | 200       | 58.31                  | 111 (55.5) | 89 (44.5)  | 116 (58)   | 84 (42)    | 79 (39.5)  | 18 (9)     | 39 (19.5)  | 59 (29.5)  | 5 (2.5)  |            |

It was revealed that the Jersey breed was the most affected breed with a crude mortality of 10.49% while the Simmental breed experienced no mortality. Moreover, there was variation in calf mortality in different calving seasons such that more calf deaths were observed during rainy season (10%), followed by cold and dry seasons with 7.54%, and 5.25% crude mortalities respectively. (Table 1)

The time at risk contribution of calves during the study time was 1,053,071 days (2,885.1 years). The mortality rate was 11.9 per 100 calf year at risk, while the mortality risk was 11.22%

### Factors associated with calf mortalities

The most common factors/ syndromes associated with calf mortality were diarrhea (27.11%), pneumonia (19.53%) and accidents (17.2%). Other factors related to calf mortality in this study were coccidiosis, bloat, congenital malformation, general body weakness, FMD and hemopoietic diseases such as ECF and Anaplasmosis (Table 2). A total of 94 mortalities (27.41%) were associated with diarrhea. Approximately, 80% of diarrhea related mortalities occurred in calves less than 90 days of age (Table 2). Most cases of diarrhea (59.6%) were recorded from the Jersey breed, and 61.7% of diarrhea calves mortality occurs during the rainy season (Table 2).

Pneumonia had a count of 67 cases, 74.6% of which, were reported from calves under three months of age, and the most affected breed were Friesian and jersey with 26 and 19 cases respectively (Table 2).

On the other hand, accidents contributed to 17.4% of all calf deaths. The types of accidents included; dog

bites, fighting, mud stalk, pit fall, snake bite and plant poisoning. Most of these accidents (70%) affected calves older than three months of age (Table 2).

### Survival probability and determinants of calf mortality

The mortality risk of calves from calving to 365 days was 11.2% while the probability of a calf remaining alive was 88.8%. The first month of life registered 36.15% of mortalities and at 90 days of age 63.3% of mortalities had occurred. The survival probability (Fig. 2) and the hazard rate for calf mortality (Table 3) decreased with an increase in age. The survival probability of calve was comparable for male and females (Log-Rank Test Statistic = 0.2980, df = 1, p-value = 0.5851), such that there was no statistically significant difference in mortality between male and female calves.

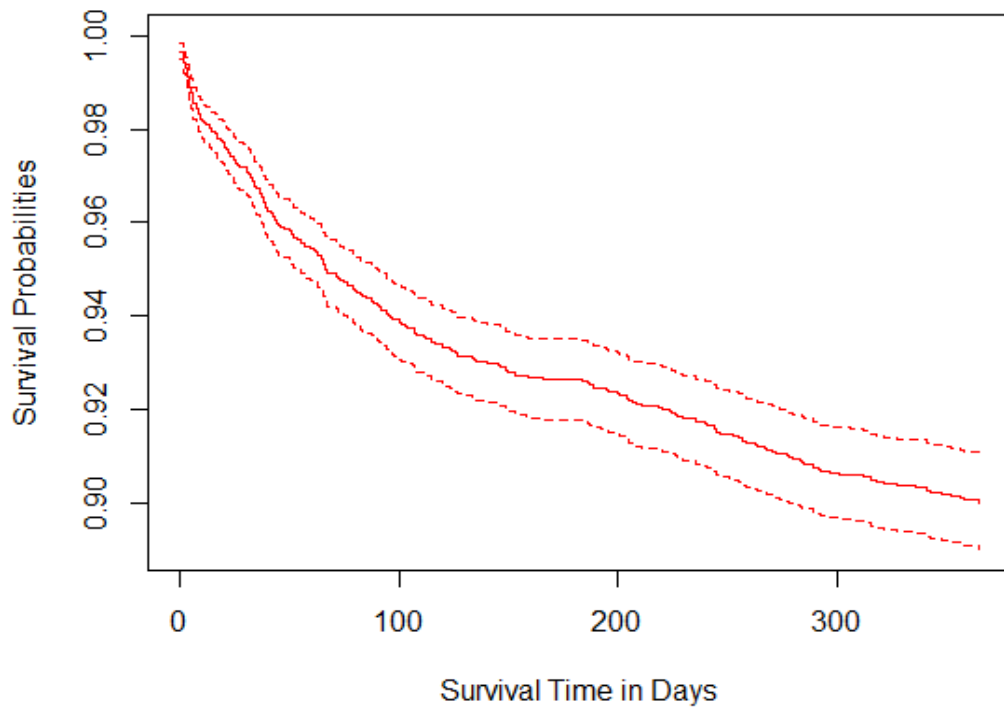
The survival probability of calves varied across breeds (Log-Rank test: Statistic = 54.8497, df = 5, p-value = 0.0000), with Jersey breed showing the lowest survival probability followed by Friesian. Boran breed had the highest survival probability followed by Ayrshire (figure 3).

The survival probability of calves had statistically significant difference for farm ownership (Log-Rank Test Statistic = 46.6388, df = 1, p-value = 0.0000). Calves in government owned farms had a higher survival probability than those in private farms (figure 4).

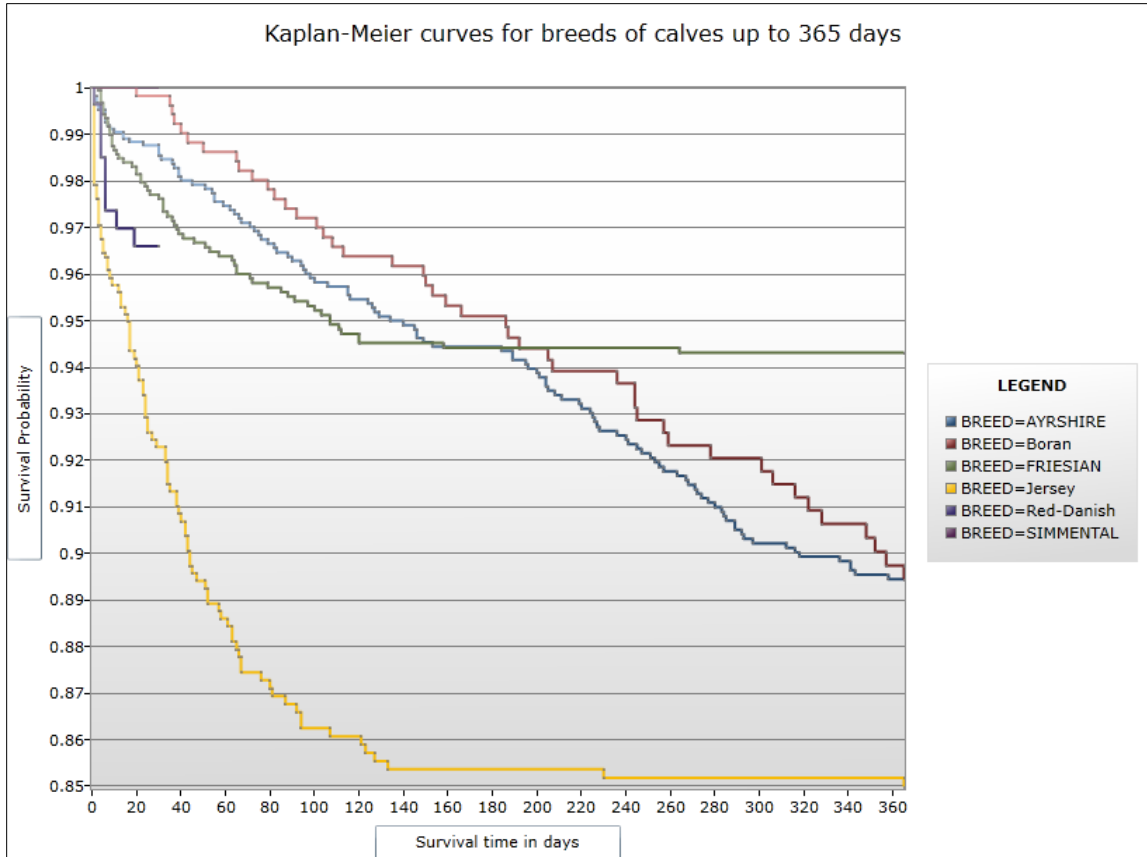
**Table 3.** Life table of calves in commercial dairy farms in Iringa and Njombe regions.

| Time in days | Number of calves at risk | Number of calves (%) | Number of dead calves (%) | Survival probability | 95% CI of survival probability | Proportion Failure | Hazard Rate |
|--------------|--------------------------|----------------------|---------------------------|----------------------|--------------------------------|--------------------|-------------|
| 0-2          | 4466                     | 31 (9.04)            |                           | 0.993                | 0.991-0.995                    | 0.007              | 0.0035      |
| 2-30         | 3864                     | 93 (27.11)           |                           | 0.971                | 0.966-0.976                    | 0.029              | 0.000967    |
| 30-90        | 3001                     | 93 (27.11)           |                           | 0.942                | 0.935-0.950                    | 0.058              | 0.000644    |
| 90-180       | 2824                     | 50 (14.58)           |                           | 0.926                | 0.918-0.935                    | 0.074              | 0.000411    |
| 180-365      | 2460                     | 76 (22.16)           |                           | 0.9                  | 0.890-0.910                    | 0.1                | 0.000274    |

## Survival Time of Dairy Calves



**Figure 2.** Kaplan-Meier curve showing survival probability for dairy calves up to 365 days of age

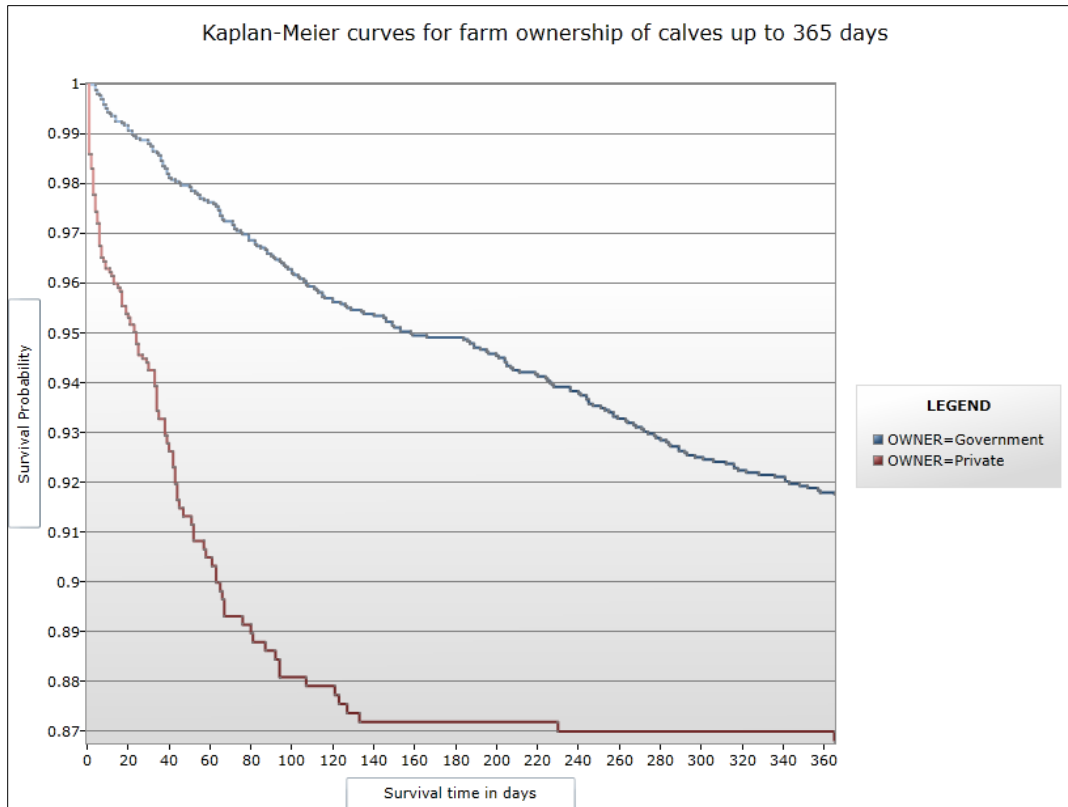


**Figure 3.** Kaplan-Meier curve comparing survival time between breeds dairy calf up to 365 days

The final multivariable Cox proportional hazards regression model identified six. These include age, breed, calving season, attendants' experience, and infrastructures such as bedding and calving pen.

Calves above the age 90 days had a lower likelihood of dying compared to calves aged below 90 days (HR=0.25, 95% CI: 0.20-0.32). The Jersey breed had a higher likelihood succumbing death (HR=1.7, 95% CI: 1.37-2.31), while Friesian breed had a relatively lower death likelihood (HR=0.59 (95% CI: 0.43-0.80) compared to other breeds. On the other hand, no death was recorded for Simmental calves during the 365 days follow up period. Farm ownership was associated with calf mortality, whereby, calves in government

farms had a lower mortality likelihood than those in private owned farms (HR=0.4669, 95% CI: 0.37-0.58). Calf caretaker's experience was found significantly associated with calf mortality, experience below five years increased risk of calf dying at an HR = 1.6 (95% CI: 1.26-2.02) compare to individuals with experience above five years. The absence of calving pen and bedding were protective factors for calf mortality with HR of 0.58 (95% CI: 0.46-0.73) and HR of 0.69 (95% CI: 0.55-0.86). Calving season was associated with calf mortality, whereby, calves born in dry season had a lower likelihood of dying (HR= 0.647, 95% CI: 0.47-0.90) compared to calves born in rain and cold seasons (Table 4).



**Figure 4.** Kaplan-Meier curve comparing survival time of calves up to 365 days under different farm ownership

**Table 4.** Risk and protective factors for calf mortality in Iringa and Njombe regions by Cox regression

| Variable          | Categories                | Log-rank test | Hazard Ratio | 95% CI      | P-value |
|-------------------|---------------------------|---------------|--------------|-------------|---------|
| Sex               | Female vs male            | 0.6           | 1.061        | 0.86 – 1.31 | 0.6     |
| Breed             | Ayrshire vs Boran         | P<0.00        | 0.93         | 0.66-1.31   | 0.66    |
|                   | Ayrshire vs Friesian      |               | 0.59         | 0.43-0.8    | 0.0007  |
|                   | Ayrshire vs Jersey        |               | 1.7          | 1.37-2.31   | 0.00002 |
|                   | Ayrshire vs Red Danish    |               | 1.3          | 0.61-2.45   | 0.6     |
|                   | Ayrshire vs Simmental     |               | 0.00         | 0.00-inf    | 0.99    |
| Age               | >3 mo vs < 3 mo           | P<0.00        | 0.2526       | 0.20-0.32   | 0       |
| Ownership         | Government vs private     | P<0.00        | 0.4669       | 0.37-0.58   | 0       |
| Season of Calving | Cold vs Dry               | P<0.00        | 0.647        | 0.47- 0.90  | 0.00    |
|                   | Cold vs Rainy             |               | 1.163        | 0.90-1.51   | 0.26    |
| Calving pen       | No v/s yes                | P<0.001       | 0.69         | 0.55-0.86   | 0.001   |
| Attendant         | Female V/s Male           | P<0.000       | 1.022        | 0.83-1.26   | 0,000   |
| Experience        | Below 5yrs v/s above 5yrs | P<0.000       | 2.12         | 1.69-2.66   | 0.000   |
| Bedding           | No v/s yes                | P<0.001       | 0.69         | 0.55-0.86   | 0.001   |

## DISCUSSION

The current study reports the crude mortality of 7.68%, mortality rate of 11.9 per 100 calf-year and mortality risk of 11.22% in calves from calving up to 12 months of age in commercial dairy farms in Iringa and Njombe regions. The crude mortality of the present study is comparable to that of 7.7% reported a decade ago (Chang'a *et al.*, 2011), but it is lower than 10.6% reported in Ethiopia (Abebe *et al.*, 2023). On the other hand, the reported mortality rate is lower than the 14.2 per 100 animal year reported in the study area (Swai *et al.*, 2010). The difference could be due to differences in study design, whereby the current study investigated mortalities in calves up to one year of age in large farms for five years while Swai and friends investigated all herd members in smallholder farms for one year. Moreover, the current calf mortality rate is higher than the 3.8 per 100 calf-months reported in Ethiopia (Abebe *et al.*, 2023), where the shorter follow up period of six month could be responsible for the dissimilarities. All in all, the mortality levels in the current study is above the economically tolerable level of 3-5% (Heinrichs and Radostits, 2001) and therefore, call for interventions to reduce the calf mortality.

Majority of mortalities (63.3%) occurred within the first 90 days of life, and more importantly, about 36% of calves die in the first month of life. This finding is similar to previous reports (Abebe *et al.*, 2023, Ahmedin and Assen, 2023) and the main causes are diarrhoea, pneumonia and accidents, which have also been reported earlier (Hordofa *et al.*, 2017, Ahmedin and Assen, 2023, Yohannes and Geinoro, 2024). These are management related causes which can be avoided by improving calf management husbandry. It has been postulated that good practices can alleviate disease burden and mortalities despite the levels of stress and exposure (Shija *et al.*, 2022). Therefore, improved calf management during the first three months of life is recommended to reduce calf mortalities. Some statistically quantified managerial factors to consider in order to reduce calf morbidity and mortality include condition and site of birth, floor, first time of colostrum ingestion, breed, breeding technique and parity of dam (Yohannes and Geinoro, 2024).

This study is reporting that breed of calves was associated with mortalities, with high incidences in Jersey breed, less in Friesian and no mortality in Simmental breed. Other studies have also reported the influence of breed on calf mortality and shown that Friesian breed survive better and are suitable in tropical environment (Swai *et al.*, 2010, Yohannes and Geinoro, 2024). Therefore, it is important to consider the breed of cattle, if calf survivability and performance are concerned.

Farm ownership has shown to be associated with calf mortality in dairy farms in Iringa and Njombe regions. The likelihood of calves dying in government farms was lower than that in private owned farms. The reason for lower mortality in government farms could be attributed to presence of skilled labour. According to the scheme of service of the government, one to be employed, including farm attendants, should have formal qualification. This is not the case with private farms, where a person can be hired for criteria other than professional qualification.

The present study reports that calving season is related to calf mortality in Njombe and Iringa regions. Calves born in dry season had a lower likelihood of dying compared to calves born in rainy and dry seasons. Similar findings have been reported in Tanzania (Chang'a *et al.*, 2011) and Ethiopia (Hordofa *et al.*, 2017). This could be attributed to the fact that rain season provide conducive environment for microorganism to multiply and infect calves. This scenario may be supported by variation in quality of colostrum produced by cows in different seasons. It has been reported that the IgG content in dairy cow colostrum is highest during hot and dry season and lower quality during the winter months (Gulliksen *et al.*, 2008). This means that calves born in dry season are well immunologically protected than those born in rainy. Consequently, mortalities are high in rainy season, especially, due to infectious syndromes such as diarrhoea and pneumonia. Therefore, it is advised to breed cows such that they will give birth during dry season.

Sex of calves has not been found to be associated with mortality, that is, in the present study, mortalities occur

in male and female calves equally. This finding is in agreement with previous report by Hordofa and friends (Hordofa *et al.*, 2017). On the other hand, the finding of the current study contradicts with other reports which have found a statistically significant difference whereby male calves were at more risk of dying compared to female calves (Mellado *et al.*, 2014, Ahmedin and Assen, 2023). The explanation given for more mortalities in males is that male calves are less valuable in dairy herd compared to females. The later are considered as a replacement stock and future

lactation herd. Thus, the male calves are not given due attention. This difference in findings could be due to differences in farm management and expected farm products and economics. Presence of veal calf facilities may not only generate income to dairy farms and reduce calf mortality, but may also facilitate improvement in health and welfare of both male and female dairy calves (Renaud *et al.*, 2017, 2018, Renaud and Pardon, 2022). In this scenario, both male and female become valuable.

## CONCLUSION AND RECOMMENDATIONS

The mortalities of calves in commercial dairy farms in Iringa and Njombe regions are higher than economically tolerable levels. Significant number of deaths occur in the first 30 days of life especially when calves are born in rainy season. Jersey calves have a higher likelihood of dying than other breeds. Therefore,

improvement in calf management practices is recommended especially during the first 30 days of life. Selection of cattle breed which has high survivability is important and the breeding programme should be designed to allow caving during dry season.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest in this study.

## REFERENCE

- Abebe, R., Dema, T., Libiyos, Y., Teherku, W., Regassa, A., Fekadu, A., and Sheferaw, D. Longitudinal study of calf morbidity and mortality and the associated risk factors on urban and peri-urban dairy farms in southern Ethiopia. *BMC Vet. Res.*, 19 (1), 1–10, 2023.
- Achá, S.J., Kühn, I., Jonsson, P., Mbazima, G., Katouli, M., and Möllby, R. Studies on calf diarrhoea in mozambique: Prevalence of bacterial pathogens. *Acta Vet. Scand.*, 45 (1–2), 27–36, 2004.
- Ahmedin, U.M. and Assen, A.A. Calf morbidity, mortality, and management practices in dairy farms in Jimma City, Southwestern Ethiopia. *BMC Vet. Res.*, 19 (1), 1–12, 2023.
- Arnold, M. Colostrum Management for Dairy Calves, 2014.
- Campbell, J. Enzootic Pneumonia of Calves and Shipping... - Google Scholar, 2012.
- Chang'a, J., Mdegela, R., Ryoba, R., and Løken, T. Calf health and management in smallholder dairy farms in Tanzania. *Trop. Anim. Heal. Prod.*, 42 (8), 1669–1676, 2010.
- Chang'a, J.S., Reksen, O., Løken, T., and Mdegela, R. Calf health and growth in small-holder dairy farms in Tanzania. *Livest. Res. Rural Dev.*, 23 (7), 2011.
- Cho, Y., Han, J., Wang, C., Cooper, V., Schwartz, K., Engelken, T., and Yoon, K.J. Case-control study of microbiological etiology associated

- with calf diarrhea. *Vet. Microbiol.*, 166 (4), 375–385, 2013.
- Fentie, T., Guta, S., Mekonen, G., Temesgen, W., Melaku, A., Asefa, G., Tesfaye, S., Niguse, A., *et al.* Assessment of Major Causes of Calf Mortality in Urban and Periurban Dairy Production System of Ethiopia. *Vet. Med. Int.*, 2020 (1), 2020.
- Gitau, G.K., Aleri, J.W., Mbuthia, P.G., and Mulei, C.M. Causes of calf mortality in peri-urban area of Nairobi, Kenya. *Trop. Anim. Heal. Prod.*, 42 (8), 1643–1647, 2010.
- Gulliksen, S.M., Lie, K.I., Løken, T., and Østerås, O. Calf mortality in Norwegian dairy herds. *J. Dairy Sci.*, 92 (6), 2782–2795, 2009.
- Gulliksen, S.M., Lie, K.I., Sølverød, L., and Østerås, O. Risk Factors Associated with Colostrum Quality in Norwegian Dairy Cows. *J. Dairy Sci.*, 91 (2), 704–712, 2008.
- Heinrichs, A.J. and Radostits, O.M. Health and production management of dairy calves... - Google Scholar. *In: O.M. Radostits, ed. Herd Health, Food Animal Production Medicine.* Philadelphia: W.B. Saunders, 333–395., 2001.
- Hordofa, D., Abunna, F., Megersa, B., and Abebe, R. Incidence of morbidity and mortality in calves from birth to six months of age and associated risk factors on dairy farms in Hawassa city, southern Ethiopia. *Heliyon*, 7 (12), e08546, 2017.
- Hossain, M.M., Kamal, A.H., and Rahman, A.A. Retrospective study of calf mortality on Central Cattle Breeding and Dairy Farm (CCBDF) in Bangladesh. *Eurasian J. Vet. Sci.*, 29 (3), 121–125, 2013.
- Hultgren, J. and Svensson, C. Heifer rearing conditions affect length of productive life in Swedish dairy cows. *Prev. Vet. Med.*, 89 (3–4), 255–264, 2009.
- Kochewad, S., Singh, J., Patil, V., ... V.K.-I., and 2013, U. Calf mortality: causes and control measures. *Indian Farming*, 60 (10), 23–26, 2013.
- Mansour, A., Abdelgadir, A., and Zubeir, I. El Major causes and risk factors associated with calf mortality in dairy farms in Khartoum State, Sudan. *J. Vet. Med. Anim. Heal.*, 6 (5), 145–153, 2014.
- Masanja, S.L. and Matovelo, J.A. Pathological and Aetiological Observations Associated With Calf Mortality in Herds at the Sokoine University of Agriculture in Morogoro, Tanzania. *Tanz. Vet. J.*, 13 (2), 27–35, 1993.
- Mee, J.F. Newborn Dairy Calf Management. *Vet. Clin. North Am. Food Anim. Pract.*, 24 (1), 1–17, 2008.
- Mellado, M., Lopez, E., Veliz, F.G., De Santiago, M.A., Macias-Cruz, U., Avendaño-Reyes, L., and Garcia, J.E. Factors associated with neonatal dairy calf mortality in a hot-arid environment. *Livest. Sci.*, 159 (1), 149–155, 2014.
- Ortiz-Pelaez, A., Pritchard, D.G., Pfeiffer, D.U., Jones, E., Honeyman, P., and Mawdsley, J.J. Calf mortality as a welfare indicator on British cattle farms. *Vet. J.*, 176 (2), 177–181, 2008.
- Randolph, T.F., Schelling, E., Grace, † D, Nicholson, ‡ C F, Leroy, J.L., Cole, D.C., Demment, M.W., Omore, A., *et al.* Invited Review: Role of livestock in human nutrition and health for poverty reduction in developing countries. *J. Anim. Sci.*, 85 (11), 2788–2800, 2007.
- Renaud, D. and Pardon, B. Preparing Male Dairy Calves for the Veal and Dairy Beef Industry. *Vet. Clin. North Am. - Food Anim. Pract.*, 38 (1), 77–92, 2022.
- Renaud, D.L., Duffield, T.F., LeBlanc, S.J., Haley, D.B., and Kelton, D.F. Management practices for male calves on Canadian dairy farms. *J. Dairy Sci.*, 100 (8), 6862–6871, 2017.
- Renaud, D.L., Kelton, D.F., LeBlanc, S.J., Haley, D.B., and Duffield, T.F. Calf management risk factors on dairy farms associated with male calf mortality on veal farms. *J. Dairy Sci.*, 101 (2), 1785–1794, 2018.
- Shiferaw, Y., Tenhagen, B.A., Bekana, M., and Kassa, T. Reproductive Performance of Crossbred Dairy Cows in Different Production Systems in the Central Highlands of Ethiopia. *Trop. Anim. Heal. Prod.*, 35 (6), 551–561, 2003.
- Shija, D.S., Okeyo, M.A., Migwi, P.K., Kelya, N.J., Bebe, B.O., Shija, D.S., Okeyo, M.A., Migwi, P.K., *et al.* Assessing Animal Disease Prevalence and Mortality in Smallholder Dairy Farms under Contrasting Management Practices and Stressful Environments in Tanzania. *Open J. Vet. Med.*, 12 (11), 117–134, 2022.

- Shoo, M., Semvua, R., Kazwala, R., and MsoLla, P. A study on the cause-specific mortality rates of dairy calves on farms in the eastern zone of Tanzania. *Prev. Vet. Med.*, 13 (1), 59–62, 1992.
- Svensson, C., Linder, A., and Olsson, S.. Mortality in Swedish dairy calves and replacement heifers. *J. Dairy Sci.*, 89 (12), 4769–4777, 2006.
- Swai, E.S., Karimuribo, E.D., and Kamarage, D.M. Risk factors for smallholder dairy cattle mortality in Tanzania. *J. S. Afr. Vet. Assoc.*, 81 (4), 241–246, 2010.
- Thornton, P.K. Livestock production: recent trends, future prospects. *Philos. Trans. R. Soc. B Biol. Sci.*, 365 (1554), 2853–2867, 2010.
- Thumbi, S.M., Bronsvoort, M.B., Kiara, H., Toye, P.G., Poole, J., Ndila, M., Conradie, I., Jennings, A., *et al.* Mortality in East African shorthorn zebu cattle under one year: Predictors of infectious-disease mortality. *BMC Vet. Res.*, 9 (1), 1–14, 2013.
- URT (United Republic of Tanzania) *Tanzania Livestock Master Plan (2017/2018 – 2021/2022)*, 2017.
- URT (United Republic of Tanzania) *Budget speech, 2023-2024. Ministry of Livestock and Fisheries.* Dodoma, 2023.
- Wudu, T., Kelay, B., Mekonnen, H.M., and Tesfu, K. Calf morbidity and mortality in smallholder dairy farms in Ada'a Liben district of Oromia, Ethiopia. *Trop. Anim. Heal. Prod.*, 40 (5), 369–376, 2008.
- Wymann, M., Bonfoh, B., Schelling, E., Bengaly, S., Tembely, S., Tanner, M., and Zinsstag, J. Calf mortality rate and causes of death under different herd management systems in peri-urban Bamako, Mali. *Livest. Sci.*, 100 (2–3), 169–178, 2006.
- Yohannes, T. and Geinoro, T. Calf morbidity and mortality rates Associated risk factors in smallholder dairy farms in Kembata Tembaro zone, Southern Ethiopia. *J. Anim. Reprod.*, 13, 67–81, 2024.