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Evaluation of survival rate of fogera calves and their crossbred at Chagni Cattle breed improvement and andasa livestock research centres

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Abstract: The study was conducted in Chagni Cattle Bred Improvement and Andassa Livestock Research Center of Western, Amhara region to evaluate the survival rate of pure Fogera and their Holstein–Friesian crossbred calves. A retrospective type of study design was used for conducting the study. The data used in the study was taken from the records of Chagni ranch and Andassa Livestock Research Center between 2011 and 2017. The survival rates were estimated by using cox regression and Kaplan–Meier model of Stata software. The mortality rate was 3% which was nearly the optimum level that many scholars agreed for successful rearing practices. The result showed that breed, birth weight and season effects are significant risk factors of calves' survival. Our findings suggest that better management practices targeting at the first two months of age to and following weaning should be implemented to improve the survival rates of calves.

Key words: Fogera breed, calves, mortality rate, Chagni, Andassa

1. Introduction

Survival of neonatal calves is imperative for livestock replacement; however, a large number of calves die during the first year of their life causing heavy drain on the economics of livestock production. The survival rates of the calves are the most important factors determining the production efficiency of the cattle herds [1]. The successful rearing of the required numbers of heifer replacements annually is a key factor for a profitable dairy farm. However, a significant number of calves are either born dead or die during the calf-rearing period and thus; many potential replacement dairy heifers fail to reach their first lactation. The early death of calves not only affects the milk and meat production but also reduces genetic progress, and disrupts breeding programmes [2]. Early mortality reduces the availability of males for the selection and production of quality sire, and females for further replacement [3]. Generally, calf death represents a cost to the dairy farm due to the loss of the present value of the calf and the loss of genetic potential for herd improvement. High calf mortality rates may also delay progress in replacing culled cows or increasing the herd size. It might consequently result in a shortage of replacement heifers and a need to buy animals that further increases the replacement costs of the herd.

Calf survival is influenced by many factors, including genetic and environmental variables [4]. Calf mortality was associated with the environmental factors, including type of housing, feeding, managemental practices, weather conditions, external and internal parasites and bacterial infections [5]. Therefore, with improved management strategies leading to lower calving intervals, higher calving rates, reduced still birth and preweaned calf mortalities and higher conception rate in heifers can supply many more dairy herd replacements than today Such strategies can increase the number of replacement heifer calves in the herd from 15% to over 35%, thus allowing farmers to increase their herd sizes [6]. Calves are at highest risk for death in the first two weeks of life (especially in the first week) [7]. Calves older than three months of age were at lower risk of mortality than younger calves [8]. African countries report a wide range of calf mortality between 3% and 47% during the first year of life, the majority of deaths occurring in the first 3 month of life [9].

Breed effects on calf mortality were primarily the result of breed differences in calf birth weight [10]. As [11] found that among the major risk factors, exotic genetic influence affects calf mortality most. Implementation of improved calf management practices and optimization of more adaptable blood level of crossbred cattle would reduce

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calf mortality. Approximately, 15% of the imported exotic calves failed to reach first calving. It was reported that the sex of the calves has an effect on calf mortality [12]. Parity is known to be a principal factor influencing calf survival until weaning [7]. A range of 15 to 25% preweaning calf mortality is typical on many tropical dairy farms. In Ethiopia, peak mortality rate in calves is reported at age of 5 to 7 months (45%) during the dry season (April–June) [13].

Most researchers determined and estimated the pre-weaning growth and survival rates of the Ethiopian Fogera cattle [14–17]. However, there is limited information on studies regarding the postweaning growth and survival rates of Fogera and their crosses at Andassa Livestock Research Center (ALRC) and Chagni Cattle Breeding and Improvement Center (CCBI). Crossbred have higher mortality than local since crossbred calves are not well adapted to the tropical environment and are often subjected to environmental stress like high temperature and disease incidence, erratic rainfall, humidity and drought which leads them to high risks of health problems [12]. For the purpose of genetic improvement, Fogera cattle have been crossed with Holstein Friesian at ALRC and CCBI stations. Therefore, this study aims to determined survival rate of Fogera calves and thier crosses with Holstein Friesian under station managed conditions.

2. Materials and methods

2.1. Study area description

The study was conducted at Chagni Cattle Breeding and Improvement (CCBI), and Andasa Livestock Research Centers (ALRC). Chagni Cattle Breeding and Improvement Centre is founded in Guangua district of Awi Zone in Amhara National Regional State, and is situated about 505 km northwest from Addis Ababa (Figure 1). The center lies at 10°56'59.99"N and 36°29'59.99"E and at an altitude of 1829.5 meter above sea level. The annual mean relative humidity is 61.7% and it reaches to high from June to October (76.7%–83.8%). The ranch receives an average annual rain fall of 1730 mm; average temperature ranges from 13.7 °C to 29.50 °C. The rain fall distribution is bimodal [14]. Andassa Livestock Research Centre (ALRC) is also founded at 587 km northwest of Addis Ababa, and 22 km south of Bahir Dar city, on the way to Blue Nile fall. The center is situated at 11°29'N and 37°29'E with an elevation of 1730 meter above sea level. It receives an average annual rainfall of 1150 mm with temperature ranging from 6.5 °C to 30 °C [18].

2.2. Study design and sampling procedure

The study area was selected on purpose, according to the existence of on station Fogera cattle breed and crossbreeding practices with Holstien Friesian. The subject animal in the current study was calves of Fogera

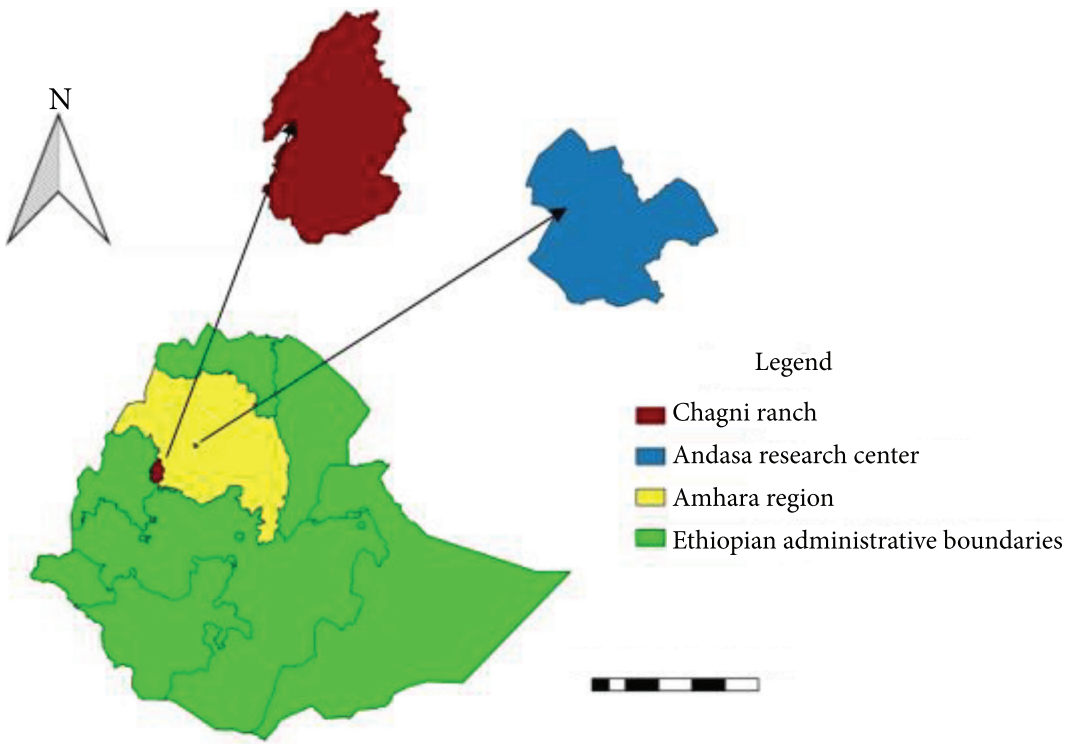

Figure 1. Map of the study area.

and their 50% crosses with Holstein Friesian. To obtain improved, precise and accurate data, seven years of data recording (2011–2017) was evaluated for this study and used to determine the mortality rate of both crossbreds and conserved Fogera cattle breed. Parity was classified as 1, 2, 3, 4 and ≥ 5. Because of small number of observations; parities above five were included and considered as ≥ 5. From birth to postweaning weight measurements were grouped as used and reported by [15]. A retrospective type of study was carried out based upon the secondary data obtained from the two study stations. Mortality recordings of seven years of Fogera and their crossbred calves at CCBI and ALRC were used. A total of 3239 calves for birth weight have been recorded from the two-location herd book retrospectively and considered in this study.

2.3. Survival analysis and modelling for calf mortality

Retrospective type of data recording design was used. The proportion of calves dying up to a given point in time was calculated using follow up life table/survivorship curve (Stata SE14 for Windows). The proportion of calves dying up to one year was compared in blood levels, sex, birth weight, year of birth, age, seasons and location. Additionally, the effect of age of the dam and parity classes on the mortality rate of calves was determined using Wilcoxon (Gehan) Kaplan–Meier curve, long rank statistical model was used for comparison of proportions for single factor and Cox proportional hazards model [19] for multiple factors or variables. In all the analyses for mortality, significance level was held at 95% confidence interval.

The Cox model is expressed by the hazard function denoted by h(t). Briefly, the hazard function can be interpreted as the risk of dying at time t. It can be estimated as follows:

$h(t) = h^0(t) \times \exp(b1\ x1 + b2x2 + ... + bpxp)$,

where

· t represents the survival time.

· h(t) is the hazard function determined by a set of p covariates (x1, x2..., xp) that is the risk factors such as breed type, sex, birth weight, season of birth, parity, year of birth and place of birth).

· The coefficients (b1, b2..., bp) measure the impact (i.e. the effect size or death with respective of factors) of covariates.

· The term h^0 is called the baseline hazard. It corresponds to the value of the hazard if all the xi is equal to zero [the quantity exp (0) equals 1]. The 't' in h(t) reminds us that the hazard may vary over time.

3. Results and discussion

3.1. Hazard analysis for calves mortality

Table 1 presents the results of the univariate analysis of cox-regression of the association between dichotomous outcome variable (calve is dead or alive) and the explanatory variables. For calf mortality, the results in Table 1 showed that calves survival rate is significantly ($p < 0.05$) associated with season, breed and birth weight. Season, breed and birth weight were significant with the hazard ratio of 1.60, 0.55, and 0.88, respectively (Table 1). The significant association between calf mortality rate and season of birth stated in our study was consistent with the report of [20,21]. On contrary, a nonsignificant effect of season of birth on calf survival rate was reported by [15,22]. Among the significant risk factors investigated, birth weight (HR = 0.88, p = 0.000) was found to be the most important determinant factor of calf mortality. This finding is compatible with previous studies [15,23–25] reported that low birth weight of calves is associated with high mortality rates. The higher risk of calf mortality in low birth weight than higher birth weight was also reported by other authors [26–28]. When the effect of breed on mortality rate was analysed, a significant value of p = 0.026 (Table 1) was obtained. The mortality rates in pure Fogera cattle were significantly higher than its Friesian crosses. However, mortality rates were not affected by year, sex, parity and location ($p > 0.05$), indicating that there was no significant difference in the mortality rates of calves born with different gender, from different location, parity and among different years.

Table 1. Explanatory variables significantly associated with the incidence mortality based on univariate analysis using Cox regression.

Variables	t| haz. ratio	SE.	p-value (CI = 95%)
Breed	0.55	0.15	0.026
Sex	0.94	0.19	0.761
Parity	0.96	0.09	0.667
Year	1.02	0.06	0.653
Season	1.60	0.35	0.033
Location	1.38	0.46	0.365
Bwt	0.88	0.03	0.000

Haz. ratio = hazard ratio; t = risk of dying at time (t); SE = standard error, Bwt = body weight.

Based on multivariate cox-regression analysis, only breed was significantly ($p < 0.05$) associated with mortality rates. According to the model, holding the effect of other variables constant, the relative hazard of mortality in those Fogera calves were 2.38 times higher than that of crossbred calves (Table 2). These might be due to the better management and nutrition provided for crossbred calves until they distributed to dairy producers. As noted

Table 2. Risk factors associated with the incidence of mortality rates based on multivariate analysis using Cox regression.

Variables t | haz. ratio	SE	p-value (CI = 95%)
Season		
Dry| 0.76	0.17	0.219
Wet| 1.49	0.34	0.08
Breed		
Fogera| 2.38	0.61	0.00
Cross| 0.57	0.16	0.042
Sex		
Male| 0.97	0.189	0.87
Female| 0.86	0.17	0.45
Parity		
1| 1.05	0.44	0.90
2|1.37	0.34	0.20
3|1.09	0.35	0.78
4|0.88	0.36	0.75
5|0.96	0.41	0.914
Year		
2011|1.39	0.63	0.46
2012|1.13	0.51	0.75
2013|1.31	0.56	0.52
2014|1.24	0.57	0.65
2015|1.32	0.57	0.53
2016|2.46	1.02	0.03
2017|0.90	0.420	0.83
Location		
Chagni|1.10	0.39	0.79
Andassa|1.39	0.52	0.38

Haz. ratio = hazard ratio; t = risk of dying at time (t); SE = standard error.

in the current study, the mortality rate of Fogera–Friesian crossbred calves was compatible with previous report for the same breed by [15]. Mortality rates obtained for Fogera–Friesian crossbred calves in the present study were also compatible with Boran–Friesian crossbred calves [29]. On the contrary, [12,23,30–33] indicated that crossbred calves had higher risk of mortality comparable to purebred calves. This might be due to the influence of exotic blood level on high calf mortality rates under the tropical environment. The multivariate cox regression also demonstrated that there was a significant difference between the mortality rates registered in 2016 than the rest of the study period. According to the model, when the effects of other variables fixed, the hazard of mortality was 2.46 times higher for calves, those recorded in 2016 than others.

This study also indicated that other potential risk factors as calf sex, dam parity, year of birth and location did not show significant effect on calf mortality rates at an early age of the calves. Sex differences were not found to be significant in the present study, were consistent with results from previous studies [22,34]. On the contrary, [11] indicated that sex was important source of variation and risk of mortality in male calves are higher than female calves.

3.2. Survival probability analysis of calves

The Kaplan–Meier curves indicate a slightly difference in the survival probability of calves born during the different seasons (Figure 2). Kaplan–Meier curves suggest that calves born in dry season, the cumulative survival probability is higher up to the 12 months of age than the calves born in wet season. However, mortality rates for calves under two months of age are comparable to the season they were born in.

Observed and predicted survival curves (Figure 2) in wet season appear to be overlapping up to two months, indicating that survival probability of calves during the first two months at preweaning period was almost the same for the observed and predicted events during wet season. There was deviation after two months up to five months of age; which may be due to small number of events in the validation data set. On the other hand, the observed and predicted survival curves (Figure 2) for dry season appear to be overlapping up to 12 months of age. However, the observed survivor probability of calves in the dry season was slightly lower than predicted events. The differences between observations and predictions were slightly higher for wet season than the dry season. The differences between observations and predictions indicate that calves were unable to survive as predicted.

The Kaplan–Meier curves indicated a difference in the survival probability of Fogera and its Friesian crossbred calves (Figure 3). The survival probability of Fogera breed calves was lower than Friesian crossbred calves. The Kaplan–Meier curves indicated that from birth onward, the observed and predicted survival curves of Fogera breed calves appear to be overlapping. The observed survivor probability of Friesian crossbred calves was slightly lower than predicted events up to eight months of age. Improvements for the observed survival probability of Friesian crossbred calves were observed after eight months of age than predicted events.

3.3. Hazard function analysis on calves survival

Calves were reported to have the highest probability of death up to the first one month of age, after which

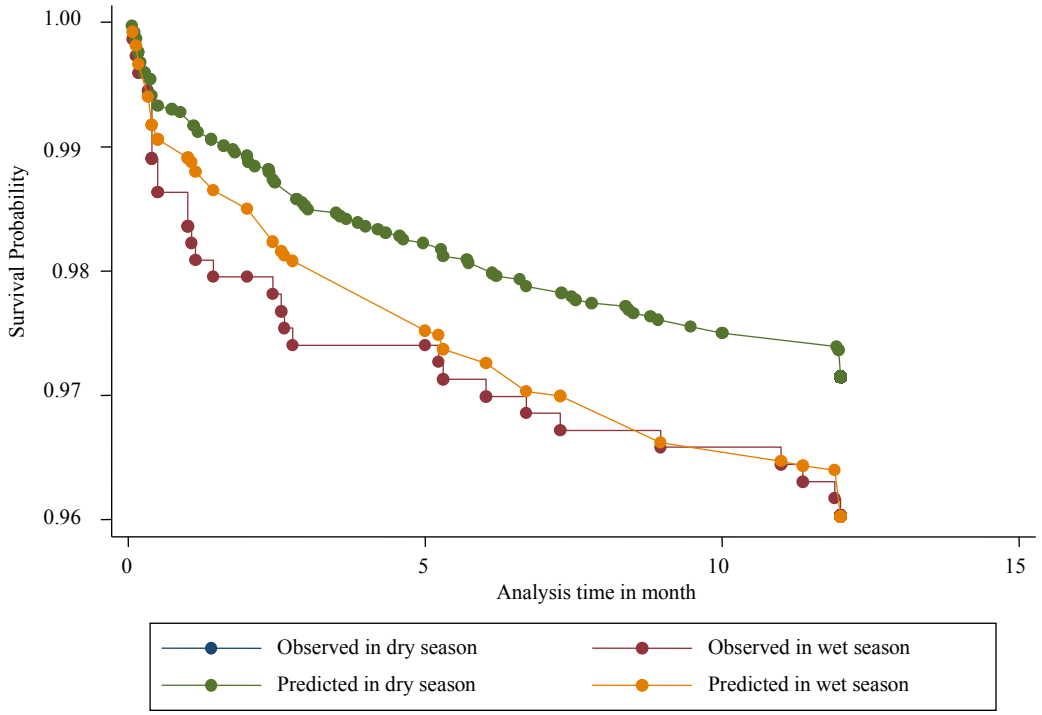

Figure 2. Kaplan–Meier curves showing the cumulative survival probability of calves from day of birth to 12 months of age stratified by season.

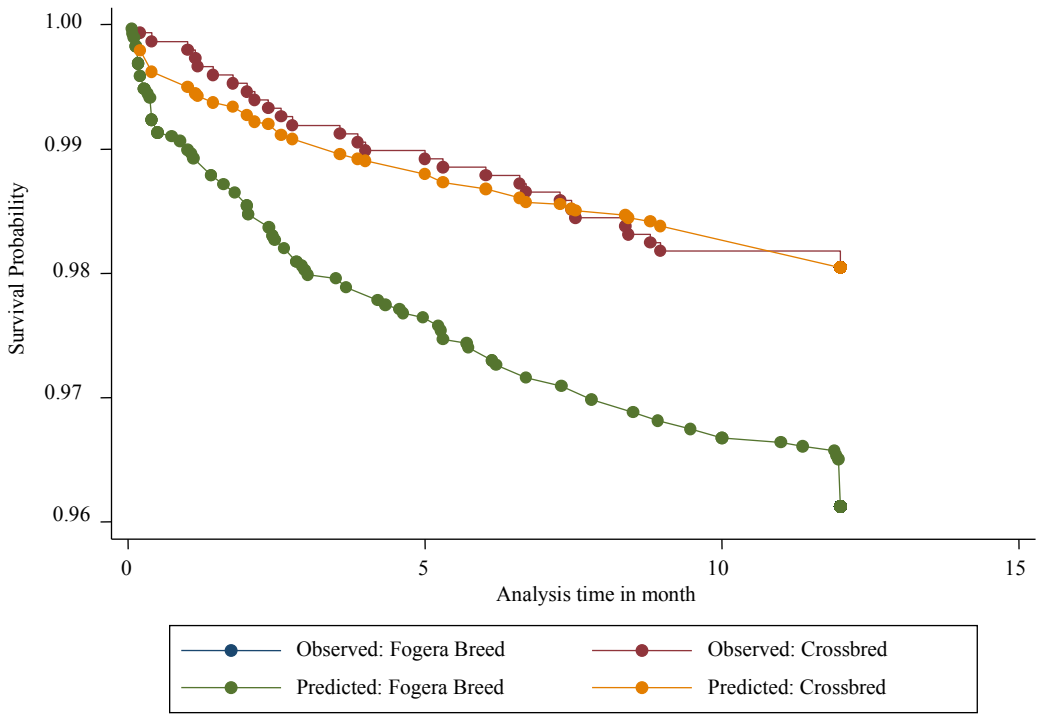

Figure 3. Kaplan–Meier curves showing the cumulative survival probability of calves from day of birth to 12 months of age stratified by breed.

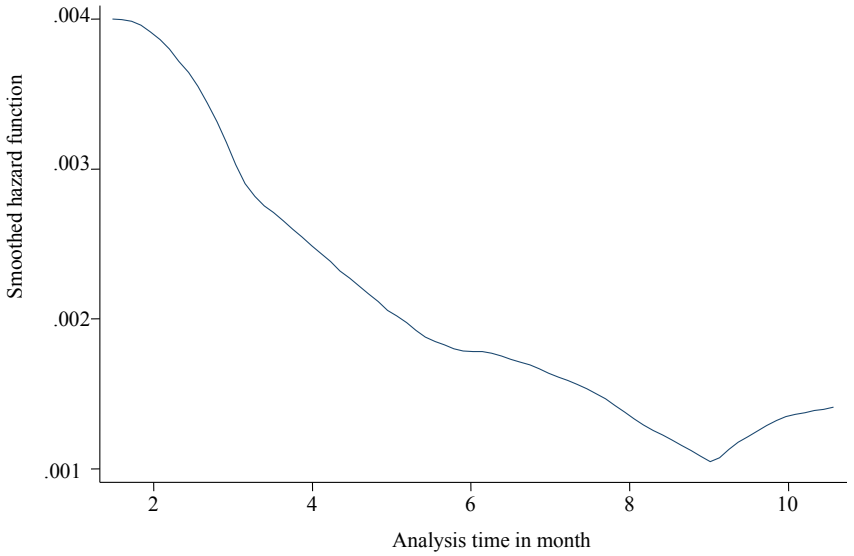

Figure 4. Cox proportional hazards regression smoothed hazard function.

it decreased markedly. The relatively high first month mortality rate in this study has also been supported by previous studies [8,27,35]. Struggle to adapt new environment and difficulty in sucking milk from their dam might be leading to a higher mortality rate being reported at early age of calves. This indicated that calves need great care for the early ages of their life. Many authors [25,36,37] also reported that the great cares during the first weeks of calves' life are critical to the growth and long-term performance in dairy cattle. The high mortality rates decrease progressively with age, reaching low percentages after gradually developing their immunity system through consuming colostrum, supplemental feed and adapting environmental stress. On contrary, [38] reported that older calves had a higher risk of death than younger calves. After weaning, the environmental stress together with diseases, may have led to the gradual increase in calf mortality rates immediately. Due to the above facts, the hazard functions rise starting from the nine months of age as depicted in Figure 4.

4. Conclusion

Among the potential risk factors investigated, breed, season and birth weight were found significantly associated with mortality. Crossbred calves are superior in most of the survival traits than Fogera calves. At the same time there were significantly high hazards for calf's mortality in 2016 than the rest of the years considered in this study. Therefore, understanding and manipulating of risk factors associated with high mortality is very crucial for the purpose of exerting subsequent application of improved calf management practices. Generally, management practices should be improved to avoid variability in survival rates of calves since management associated factors significantly affected both survival traits in both cattle improvement centers. Furthermore, detailed study in investigating the impacts of each factor and their interaction effect on productivity and survival traits is recommended.

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Conflict of interest

The authors declare that there is no conflict of interest on the publication of the manuscript.

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