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# Growth Performance and Survival Rate of Fogera and Their Crossbred Calves at Government Ranches in Ethiopia

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The economic benefit of dairy products can be enhanced by increasing the efficiency of growth and survival rate of calves. The objective of the study was to evaluate the effects of non-genetic factors on pre- and post-weaning growth traits and mortality rate of pure Fogera and their F1 cross Fogera × Holstein Friesian calves at the Andassa and Chagni Cattle Breeding and Improvement Ranch. Retrospective types of study design and direct measurement were used to collect the data. A total of 3,626 for pre-weaning weight records and 107 for post-weaning measurements were used for analysis. Genotype, sex, dam parity, year of birth, the season of birth, and location were the considered production factors. The overall least square means (LSM ± SE) of birth weights were 22.33 ± 0.12 and 24.56 ± 0.11 kg for Fogera and their crosses, respectively. The overall LSM ± SE of weaning weights were 93.25 ± 0.85 and 111.63 ± 0.84 kg for Fogera and their cross calves, respectively. The overall post-weaning weight for Fogera and their cross calves were 101.02 ± 1.62 and 111.08 ± 2.65, respectively. All variables considered in the model, except dam parity, significantly ($P < 0.05$) affected post-weaning weight. The overall recorded mortality rate was 3% which was nearly the optimum that many scholars agreed to successful rearing practices.

**Keywords: crossbreed, Fogera, growth, mortality rate, production traits**

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## INTRODUCTION

Ethiopia is endowed with huge livestock resources of varied and diversified genetic pools with specific adaptations to a wide range of agro-ecologies (Roessler et al., 2008; Duguma et al., 2010). A recent report indicates that there are about 32 breeds of cattle in Ethiopia (Kebede et al., 2017). The Fogera cattle are among these and distributed around Lake Tana in south Gondar and west Gojjam zone of Amhara Region, Ethiopia. Among indigenous livestock species, cattle provide draught power, income to farming communities, means of investment, and an important source of foreign exchange to the nation. Moreover, they provide milk, meat, manure, and serve as a hedge against risk. Cattle together with sheep and goats are the most important sources of live animals, and skins for export markets (Belete et al., 2010).

The productivity of cattle depends largely on their reproductive performance and the survival of calves. Calf morbidity and mortality are the major problems in all countries where cattle are raised, and the problem is more acute in developing countries (Amuamuta et al., 2006). According to reports, calf mortality rates in the first year can be as high as 50% in the tropics due to bad management, poor adaptation of exotic breeds to the prevailing tropical environment, and endemic diseases (Kim et al., 2013). A high mortality rate causes great economic losses to the dairy industry around the world, and the survival of dairy calves and replacement heifers is paramount in modern dairy breeding (Hailiang et al., 2019). The economic benefit of dairy products can be enhanced by increasing the efficiency of calf growth and the survival rate of calves. 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 (Nigussie, 2019).

In Ethiopia, calf morbidity and mortality are the second biggest problems next to mastitis for dairy production. A pre-weaning calf mortality rate of 30% was reported in mixed crop-livestock production systems in Amhara Region and an 18% mortality rate was found in market-oriented dairy farms in Central Ethiopia (Nigussie, 2019). High calf mortality rates may also delay progress in replacing cull 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 (Maddalena et al., 2013).

Currently, conservation and genetic improvement through the selection of Fogera breed are done at Andassa Livestock Research Center and Chagni Cattle Breeding and Improvement Ranch. The two sites were initially established to conserve and improve Fogera cattle and distribute crossbreeds (Fogera × HF) heifers to the smallholder farmers of the Amhara Region. Several studies have been conducted at the two sites to determine and estimate the pre-weaning growth and reproductive performance of Fogera cattle (Gebeyehu et al., 2005; Amuamuta et al., 2006; Melaku et al., 2011a; Almaz, 2012; Assemu et al., 2016). According to these reports, the reproductive and growth performances indicated a huge potential of Fogera breed if appropriate breed improvement programs and management strategies are in place. However, there is limited information on studies regarding the post-weaning growth and survival rates of Fogera and their crosses at the two sites. Hence the present research work was undertaken to evaluate the growth performance of Fogera calves and their crosses with Holstein Friesian and to evaluate the mortality rate of Fogera and their crosses with Holstein Friesian under on-station management conditions.

# MATERIALS AND METHODS

## Location and Description of the Study Area

The study was conducted at Andassa Livestock Research Center and Chagni Cattle Breeding and Improvement Ranch.

### Chagni Cattle Breeding and Improvement Ranch

Chagni Cattle Breeding and Improvement Ranch (**Figure 1a**) was established in 1988 under the Ministry of Agriculture, Ethiopia. The center is situated in the Guangua district of Awi Zone in Amhara National Regional State and is situated about 505 km North-west of Addis Ababa. The center lies at a latitude of 10°56′ North and 36°29′ longitude East of the meridian and an altitude of 1,829.5 m.a.s.l. The annual mean relative humidity is 61.7% and peaks from June to October (76.7–83.8%). The ranch receives an average annual rainfall of 1,730 mm; the temperature ranges from 13.7 to 29.5°C. The rainfall distribution is bi-modal (Almaz, 2012).

### Andassa Livestock Research Center

The center, hereafter abbreviated as ALRC (**Figure 1b**) was established during the regime of Haile Selassie in 1956 with the main objective of conserving and improving Fogera cattle in Ethiopia. The center is found 587 km Northwest of Addis Ababa, and 22 km south of Bahir Dar city, on the way to the Blue Nile Falls. The center is situated at 11°29′ North Latitude and 37°29′ East Longitude with an elevation of 1,730 m.a.s.l. It receives an average annual rainfall of 1,150 mm with temperatures ranging from 6.5 to 30°C. The topography of the area is marked by a flat-to-gentle slope that is bisected by the Andassa River, a permanent water source for the animals (Assemu et al., 2016).

## Animal Management

Chagni Cattle Breeding and Improvement Ranch have so far been engaged in maintenance of Fogera cattle population outside their adapted environment (*ex-situ* conservation). At both sites, cattle were herded based on breed, sex, and age with the required management level. Calves were weighed on the date of birth within 24 h using a spring balance and marked within 72 h of birth using an ear tag. Calves were weaned and weaning weights were taken at 8 months of age. The breeding program at both sites has two components *viz*., pure Fogera breeding (**Figure 2A**) and crossbreeding (**Figure 2B**) units. In the former unit, pure Fogera heifers were allowed for mating for the first time when they are 24 months of age and have attained a minimum body mass of 250 kg and the calves born were ran with their dam for milk feeding until they wean. In the crossbreeding program, artificial insemination with Holstein Friesian semen was used and produced heifers were distributed to the smallholder farmers and the calves born were separately managed (Melaku et al., 2011a,b; Assemu et al., 2016).

Unlike Chagni Cattle Breeding and Improvement Ranch, there was supplementation of concentrate feeds for milking, pregnant, and emaciated animals, and hay during the dry season for all animals in Andassa center. Newborns were helped to suckle immediately after birth and are left with their dams the first day and the calves are managed indoor by suckling their dams twice a day till they reach 3 months of age. Subsequently, they were allowed suckling throughout the lactation till they reach weaning age.

Vaccination is given annually for anthrax, blackleg, pasteurellosis, FMD, CBPP, and lumpy skin disease, and prophylactic treatment is given against trypanosomosis during high vector activity. Animals are also dewormed at the start of the rainy season, using broad-spectrum anthelminthic (albendazole), and are regularly sprayed with insecticides (diazinon) at the end of the rainy season to control ticks and other external parasites as

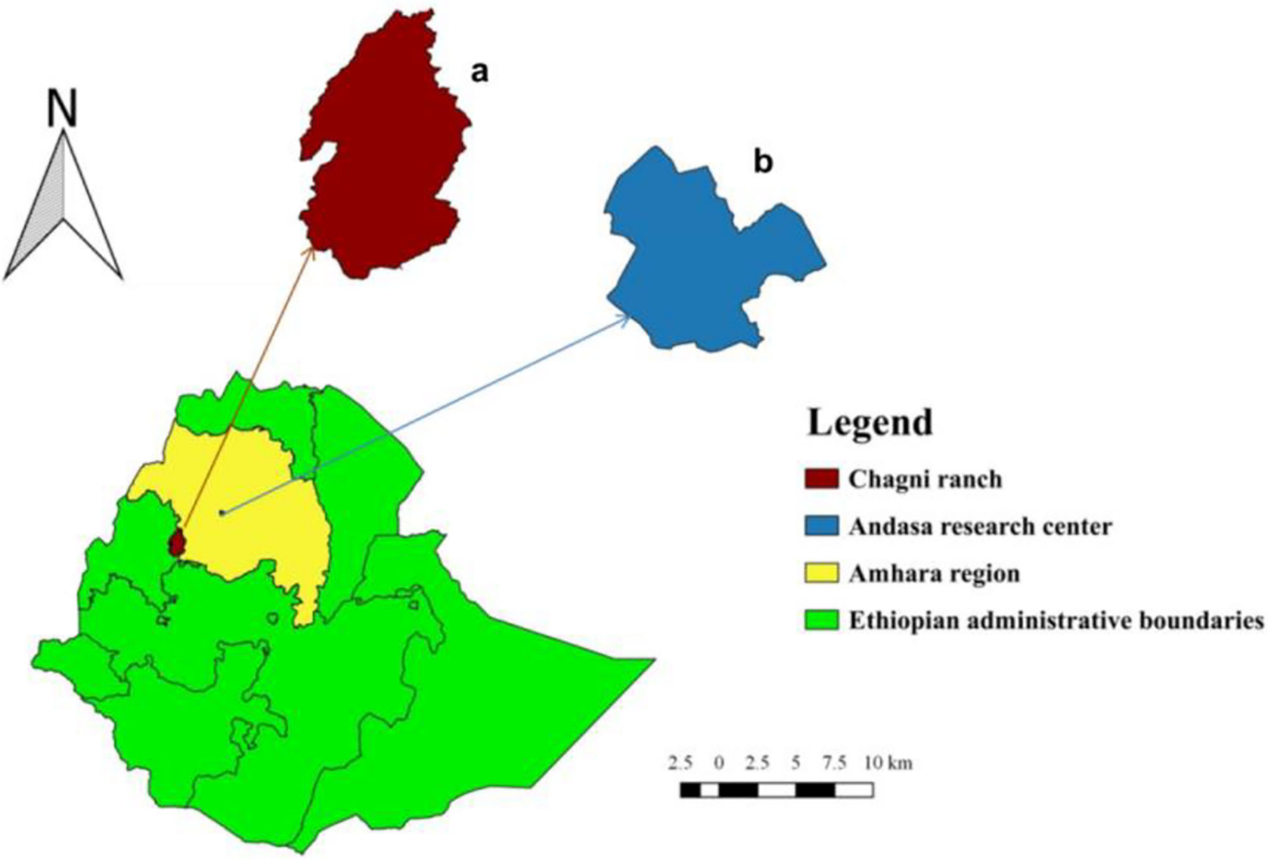


**FIGURE 1 |** Map of the study area: **(a)** Chagni Cattle Breeding and Improvement Ranch and **(b)** Andassa Livestock Research Center.

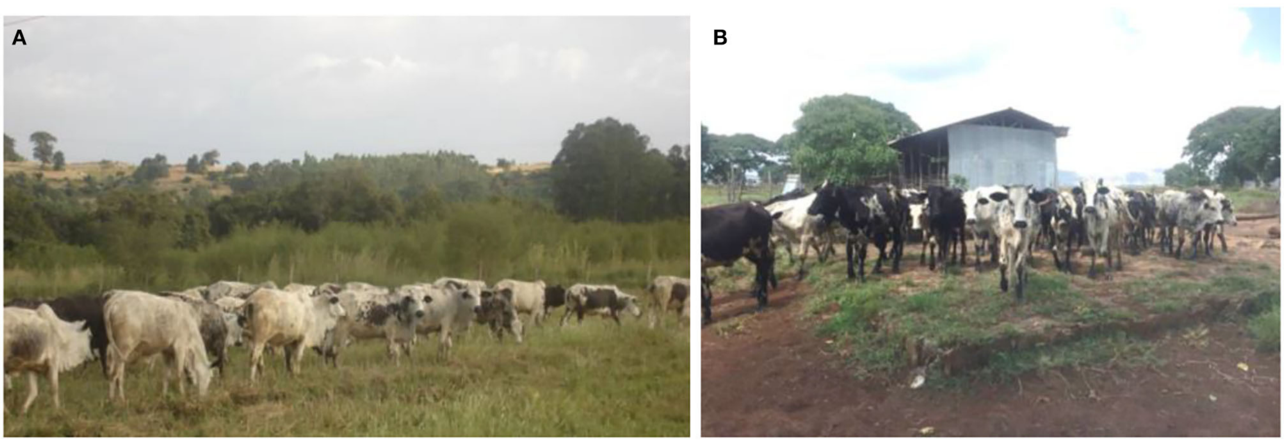


**FIGURE 2 |** Pure Fogera cattle herd at Andassa **(A)** and crossbred heifers at Chagni Cattle Breeding and Improvement Ranch **(B)**.

a routine disease prevention and control strategy (Almaz, 2012; Assemu et al., 2016). At both study sites, after weaning, calves were given special management as they are used for replacement in the pure Fogera breeding unit.

## Data Source and Management

Fogera and their 50% Holstein Friesian crosses were the study animals. Age of calves ≤8 months for pre-weaning growth determination and 8–12 months of determining the post-weaning growth and 1 year for mortality rates was used. Furthermore, 7 years of data (2011–2017) was used. Parity was classified as 1, 2, 3, 4, and ≥5. Birth weight for post-weaning measurement was grouped as 1 = 12–17, 2 = 18–19, 3 = 20–23, and 4 = 24–27 kg as indicated by Amuamuta (2004). The fixed effect of the season of birth was classified as wet (June–September) and dry (October–May) (Gebeyehu et al., 2005; Addisu et al., 2010).

## Study Design and Source of Data

The data were collected from the individual animal cards of the centers. Fixed factors such as sex (1 = male and 2 = female), parity (1, 2, 3, 4, and ≥5), breed (1 = Fogera and 2 = cross breed), year of birth (2011–2017), location (1 = ALRC and 2 = Chagni Cattle Breeding and Improvement Ranch), and season of birth (1 = wet and 2 = dry) were used to determine birth weight and weaning weight. All calves post-weaning weights were measured using cattle weighing scale.

## Statistical Analysis

The collected data were managed by Microsoft Excel (MS Excel, 2010) and the final data were analyzed by SAS (Statistical Analysis System) (2002) (version 9.1) for growth and Stata (SE 14) (1996–2021) for survival analysis. Tukey Kramer multiple comparison tests were used to identifying the presence of significant differences between production factors. Models 1 and 2 were used to summarize the effect of fixed factors on pre and post-weaning measurements. Before running the model, all variables were checked for the presence of any interaction between them. It was nonetheless fortunate that there was no significant interaction between them and the interaction effect was not included in the model.

The average pre-weaning daily gain (ADG) was computed as:

$$ADG = (WW - BW)/AGE,$$

where WW is weaning weight, BW is the actual birth weight, and AGE is the age of the calf at weaning.

Model 1: For pre-weaning growth performance and pre-weaning average daily gain (PrADG) traits

$$Yijklmno = \mu + Yi + Sj + Kk + Bl + Pm + Ln + eijklmno$$

where Yijklmno is the observation on birth weight, weaning weight, and PrADG

$\mu$ = overall mean
Yi = effect of $i^{th}$ year of birth (i = 2011–2017)
Sj = effect of $j^{th}$ season of birth (j = 1, 2)
Kk = effect of $k^{th}$ sex (k = 1, 2)
Bl = effect of $l^{th}$ breed (l = 1, 2)
Pm = effect of $m^{th}$ parity (m = 1, 2, 3, 4, and ≥ 5)
Ln = effect of $n^{th}$ location (n = 1, 2)
eijklmno = random error associated with each observation.

Model 2: For post-weaning weight and post-weaning average daily gain (PoADG) traits

$$Yijklmn = \mu + Bi + Sj + Zk + Pl + Lm + eijklmn$$

where Yijklmn is the observation on post-weaning weight and PoADG

$\mu$ = overall mean
Bi = effect of $i^{th}$ grouped birth weight (I = 1, 2, 3, 4)
Sj = effect of $j^{th}$ sex (j = 1, 2)
Zk = effect of $k^{th}$ breed (k = 1, 2)
Pl = effect of $l^{th}$ parity (l = 1, 2, 3, 4, and ≥ 5)
Lm = effect of $m^{th}$ location (m = 1, 2)
eijklmn = random error associated with each observation.

### Survival Analysis

Survival of calves at the time period was calculated using a follow-up life table/survivorship curve (Stata SE 14). The proportion of calves dying up to 1 year was compared for calves of different breeds, sex, varying birth weight, year of birth, age of calf, and calves born at different seasons and locations. Additionally, the effect of age of the dam, categorized by parity classes, on the mortality rate of calves was determined using Wilcoxon (Gehan) Kaplan-Meier curve, wherein a log-rank statistical model was used for comparison of proportions for single factor and Cox proportional hazards model (Cox, 1972) for multiple factors or variables. In all the analyses for both growth and mortality, the significance level was set at 0.05.

The purpose of the model was to evaluate simultaneously the effect of several factors on survival. In other words, it should allow us to examine how specified factors influence the rate of a particular event happening, e.g., death, at a particular point in time. This rate was commonly referred to as the hazard ratio. Predictor variables (or factors) are usually termed *covariates* in the survival analysis.

In summary,
HR = 1: No effect
HR < 1: Reduction in the hazard
HR > 1: Increase in Hazard.

# RESULTS

## Birth Weight

The least-squares mean and SE (LSM ± SE) for birth weight are presented in **Table 1**. The overall mean birth weight was 23.45 ± 0.1 kg. Crossbred calves were heavier than pure Fogera calves which were due to differences in breeds. Male calves weighed heavier than female calves which were attributed to the hormone difference during gestation.

## Weaning Weight

The overall mean weaning weight was 102.43 ± 0.76 kg (**Table 1**). The weaning weight of Fogera and their crossbred calves were 93.25 ± 0.85 and 111.63 ± 0.84 kg, respectively. By making birth weight a co-variant for weaning weight analysis, male calves were found to be superior to female calves ($P < 0.001$), and sex was observed as an important source of variation at weaning. The effect of parity on weaning weight was also significant ($P < 0.001$) as calves born in first parity had lighter weight than calves born in other parities. Season also had a significant ($P < 0.001$) effect on weaning weight where higher weight was recorded in the

**TABLE 1** | Least square means and SE (LSM ± SE) of birth weight, weaning weight, and pre-weaning average daily gain.

| Factors | Birth weight (kg) | | Weaning weight (kg) | | Pre-weaning average daily gain (g) | |
|---|---|---|---|---|---|---|
| | *N* | LSM ± SE | *N* | LSM ± SE | *N* | LSM ± SE |
| Overall | 3,239 | 23.45 ± 0.10 | 3,090 | 102.44 ± 0.76 | 3,240 | 244.38 ± 4.07 |
| CV | | 11.80 | | 16.71 | | 34.10 |
| Breed | | *** | | *** | | *** |
| Fogera | 1,760 | 22.33 ± 0.12 | 1,691 | 93.25 ± 0.85 | 1,760 | 224.59 ± 4.84 |
| Cross | 1,479 | 24.56 ± 0.12 | 1,399 | 111.63 ± 0.84 | 1,480 | 264.18 ± 4.38 |
| Sex | | *** | | *** | | ** |
| Male | 1,560 | 23.74 ± 0.11 | 1,486 | 103.93 ± 0.82 | 1,560 | 248.81 ± 4.47 |
| Female | 1,679 | 23.16 ± 0.11 | 1,604 | 100.95 ± 0.82 | 1,680 | 239.95 ± 4.45 |
| Parity | | *** | | *** | | *** |
| 1 | 928 | $23.12 \pm 0.11^{c}$ | 837 | $98.65 \pm 0.88^{c}$ | 928 | $214.52 \pm 4.59^{c}$ |
| 2 | 796 | $23.79 \pm 0.12^{ba}$ | 761 | $104.92 \pm 0.89^{a}$ | 796 | $251.06 \pm 4.90^{b}$ |
| 3 | 649 | $23.83 \pm 0.14^{ab}$ | 633 | $104.73 \pm 0.97^{a}$ | 650 | $257.03 \pm 5.57^{a}$ |
| 4 | 459 | $23.54 \pm 0.16^{a}$ | 452 | $103.25 \pm 1.10^{ab}$ | 459 | $254.60 \pm 6.40^{a}$ |
| ≥5 | 407 | $22.96 \pm 0.18^{ba}$ | 407 | $100.65 \pm 1.19^{b}$ | 407 | $244.70 \pm 7.07^{ab}$ |
| Season | | *** | | *** | | *** |
| Dry | 2,544 | 23.19 ± 0.10 | 2,425 | 106.27 ± 0.75 | 2,545 | 258.75 ± 3.95 |
| Wet | 695 | 23.71 ± 0.13 | 665 | 98.61 ± 0.94 | 695 | 230.01 ± 5.29 |
| Year | | *** | | *** | | *** |
| 2011 | 254 | $22.43 \pm 0.20^{d}$ | 242 | $113.28 \pm 1.34^{a}$ | 254 | $278.55 \pm 7.87^{a}$ |
| 2012 | 422 | $22.79 \pm 0.17^{c}$ | 406 | $108.50 \pm 1.15^{a}$ | 422 | $266.03 \pm 6.71^{a}$ |
| 2013 | 426 | $23.06 \pm 0.16^{b}$ | 415 | $101.21 \pm 1.11^{cb}$ | 426 | $239.39 \pm 6.47^{b}$ |
| 2014 | 395 | $23.78 \pm 0.17^{b}$ | 391 | $104.34 \pm 1.13^{b}$ | 410 | $245.62 \pm 6.44^{ab}$ |
| 2015 | 534 | $24.32 \pm 0.15^{a}$ | 491 | $100.09 \pm 1.07^{cd}$ | 519 | $225.03 \pm 5.99^{d}$ |
| 2016 | 578 | $24.19 \pm 0.12^{a}$ | 524 | $97.87 \pm 0.88^{d}$ | 578 | $227.62 \pm 4.85^{cd}$ |
| 2017 | 630 | $23.58 \pm 0.13^{b}$ | 621 | $91.80 \pm 0.87^{e}$ | 631 | $228.42 \pm 5.09^{c}$ |
| Location | | *** | | *** | | *** |
| Chagni | 2948 | 21.85 ± 0.06 | 2903 | 99.98 ± 0.39 | 2948 | 319.56 ± 2.41 |
| Andassa | 291 | 25.05 ± 0.18 | 187 | 104.10 ± 1.40 | 292 | 169.20 ± 7.26 |

*N, number of observations. Means with the same superscript in columns are not a significant difference. ***Highly significant (p < 0.001).*

dry season. There was a significant variation in weaning weight during the 7 years considered in the present study.

## Pre-Weaning Average Daily Gain

The overall PrADG to the Fogera and their crosses were 244.38 ± 4.07 g (**Table 1**). The PrADG to the Fogera breed was 224.59 ± 4.84 g and their crosses with Holstein Friesian was 264.18 ± 4.38 g. The overall average daily gains of male calves were heavier than females by 9 g.

## Post-Weaning Weight

The LSM for post-weaning weight is presented in **Table 2**. The overall post-weaning weight was 106.06 ± 1.62 kg. The post-weaning weights of crossbred calves were higher than Fogera calves ($P < 0.001$). The study also showed weaning weights of calves were correlated to birth weight in which calves born with greater weight at birth had a higher weaning weight. There was no significant difference ($P > 0.05$) between parities in the weaning weight of calves. Location was also a significant ($P < 0.01$) source of variation for calves at weaning age in which calves raised at the Andassa site were heavier than those calves in the Chagni site.

## Post-Weaning Average Daily Gain

The overall PoADG of the two breeds of the calf was 298.66 ± 14.71 g (**Table 2**) on which PoADG for crossbreed and Fogera calves was 308.32 ± 14.72 and 288.99 ± 24.01 g, respectively. All fixed factors considered had no significant influence on PoADG.

## Mortality Rate

Based on univariate analysis of cox-regression, among the explanatory variables, season, breed, and birth weight have a significant ($P < 0.05$) association with the incidence of mortality (**Table 3**). For mortality rate factors, the season, breed, and birth weight were significant with the hazard ratio of 1.6, 0.55, and 0.88, respectively. Among the significant risk factors investigated, birth weight (HR = 0.88, $P = 0.000$) was found to be a very important determinant of calf mortality. According to the model, the mortality rate of calves born with lower birth weight was

**TABLE 2 |** Least square means and standard error (LSM ± SE) of post-weaning weight and post-weaning average daily gain.

| Factors | Post-weaning weight (kg) | | Post-weaning average daily gain (g) | |
|---|---|---|---|---|
| | *N* | LSM ± SE | *N* | LSM ± SE |
| Overall | 107 | 106.06 ± 1.62 | 106 | 298.66 ± 14.71 |
| CV | | 9.68 | | 30.83 |
| Breed | | *** | | NS |
| Cross | 24 | 111.08 ± 2.65 | 24 | 308.32 ± 14.72 |
| Fogera | 83 | 101.02 ± 1.62 | 82 | 288.99 ± 24.01 |
| Sex | | * | | NS |
| Male | 51 | 108.30 ± 1.93 | 50 | 308.09 ± 17.55 |
| Female | 56 | 103.81 ± 1.90 | 56 | 289.23 ± 17.16 |
| Parity | | NS | | NS |
| 1 | 28 | 110.07 ± 2.50 | 28 | 267.55 ± 22.61 |
| 2 | 24 | 104.50 ± 2.79 | 24 | 275.62 ± 25.23 |
| 3 | 30 | 105.35 ± 2.41 | 29 | 310.38 ± 22.09 |
| 4 | 16 | 111.68 ± 2.68 | 16 | 323.84 ± 24.21 |
| ≥5 | 9 | 98.68 ± 3.53 | 9 | 315.90 ± 31.92 |
| Birth weight | | ** | | NS |
| 12–17 | 6 | 103.81 ± 4.52[ab] | 6 | 283.36 ± 40.87 |
| 18–19 | 19 | 100.84 ± 2.42[b] | 19 | 283.25 ± 21.92 |
| 20–23 | 63 | 107.22 ± 1.51[ab] | 63 | 295.96 ± 13.68 |
| 24–27 | 19 | 112.36 ± 2.67[a] | 19 | 332.05 ± 24.44 |
| Location | | ** | | NS |
| Chagni | 57 | 96.62 ± 1.94 | 56 | 297.10 ± 17.52 |
| Andassa | 50 | 115.49 ± 2.01 | 50 | 300.21 ± 18.27 |

*N, number of observations; NS, non-significant. Means with the same super script in columns are not significant difference. ***Highly significant ($p < 0.001$). **Significant ($p < 0.01$). *Significant ($p < 0.05$).*

**TABLE 3 |** Summary of Cox-regression analysis of factors impacting the risk of dying at any point in time, Prob > $\chi^2 = 0.0000$.

| Factor | Hazard Ratio | SE | *P* > \|Z\| | [95% Con. Interval] |
|---|---|---|---|---|
| Breed | 0.55 | 0.15 | 0.026 | 0.33–0.93 |
| Sex | 0.94 | 0.19 | 0.761 | 0.64–1.38 |
| Parity | 0.96 | 0.09 | 0.667 | 0.81–1.11 |
| Year | 1.02 | 0.06 | 0.653 | 0.92–1.14 |
| Season | 1.60 | 0.35 | 0.033 | 1.03–2.46 |
| Location | 1.38 | 0.46 | 0.365 | 0.69–2.79 |
| BW | 0.88 | 0.03 | 0.000 | 0.82–0.94 |

*$\chi^2$, Qi square; SE, standard error; BW (birth weight) = grouped birth weight (i = 1*, 2, 3, 4); Breed = Fogera* and Fogera × Holstein Friesian; Sex = male* and female; Parity = 1*, 2, 3, 4, and ≥5; Season = Wet* and dry; Location = Andassa Livestock Research Center* and Chagni Cattle Breeding and Improvement Ranch. *Indicated the reference factor of comparisons.*

0.88 times higher than those had higher birth weight. A high calf mortality rate was observed among Fogera and their crossbreeds in which holding the effect of other variables constant, the risk of mortality were higher (HR = 0.55, $P < 0.05$) on Fogera cattle than their cross. However, other factors such as sex, parity, year, and location were not significantly associated with calf survival ($P > 0.05$) (**Table 3**).

# DISCUSSION

## Birth Weight

Calves born in the wet season were significantly heavier than those calves born in the dry season. The birth year had a significant ($P < 0.001$) effect on the birth weight of calves and the highest and the lowest weight was recorded in the year 2015 and 2011, respectively. The variations of season and year might be attributed to the availability of pasture feed in the wet season and management differences across years, respectively. Due to the availability of rain in the wet season, there is green feed availability for grazing, as the two working sites follow grazing as a major source of feed. The management differences across the year were to indicate the differences in green feed (grazing) availability due to rainfall (climatic variability) differences and the mitigation measures implemented by the working sites to fill this feed scarcity across the working years. The birth weight of Fogera calves recorded in this study was similar to the findings of Addisu (1999) (22.5 ± 0.17 kg), while relatively higher than the value of 21, 21.5, and 21.35 ± 0.09 kg found by Almaz (2012), Metekel Fogera Breed Conservation Multiplication Ranch (MFBCMR) (2013), and Assemu et al. (2016), respectively for the same breed. The higher result obtained in the current study was due to the continuous selection made on the breed. However, the value is higher than those reported by Asheber (1992). The deviation of birth weight of the present study from values of other studies probably might be due to differences in management and feeding practices done in different years. The birth weight obtained in the current study was consistent with the result of Aynalem et al. (2009). On the contrary, the result was lower than that of Borena (Yohannes et al., 2001; Amsalu, 2003), and higher than Ogaden (Getinet et al., 2009) and Horro (Demissu et al., 2013). This difference across different breeds was mainly due to breeding objective differences in the utilization of the breeds, wherein breeds like Boran were known for the beef breed and others, such as Horro and Ogaden, were milk types on which they had lighter birth weight.

The birth weights of the Fogera-Holstein Friesian crossbred calves found in this study were comparable with the findings of Addisu and Hegde (2003) and higher than Belay (2014). The result was also lower than crossbred calves (Amsalu, 2003; Demeke et al., 2003; Hailu and Tadele, 2003; Ababu et al., 2006) but higher than the report of Habtamu et al. (2010) for Horro–Friesian cross and Obese et al. (2013) for Sanga X Friesian calve. The lower birth weight of the current study that the mentioned authors were due to crossbreeds in other sites was the main activity, while in the study sites it was a secondary objective over the conservation and improvement of the Fogera breed. Significant differences in birth weight between sexes were in agreement with previous findings by Giday (2001), Addisu and Hegde (2003), Aynalem et al. (2009), Melaku et al. (2011b), Almaz (2012), and Assemu et al. (2016) on which male calves are heavier than females due to hormonal differences receiving during gestation (Rezende et al., 2020). Parity had also affected significantly ($P < 0.001$) calf birth weight, wherein weight increase until parity four and decreased in parity five and above, this might be the merged values of parities above five and decreasing of reproductive tract activities of the cows related to age. Significant effect of parity (Habtamu et al., 2010; Almaz, 2012; Bayou et al., 2015) and year of birth (Getinet et al., 2009; Habtamu et al., 2010; Melaku et al., 2011b; Almaz, 2012; Yaylak et al., 2015; Assemu et al., 2016) was reported. Effect of management differences across different years on birth and weaning weight was also reported (Almaz, 2012; Rezende et al., 2020).

## Weaning Weight

The estimated weaning weight of Fogera calves was lower than the reported value by Addisu (1999), Giday (2001), Amsalu (2003), Metekel Fogera Breed Conservation Multiplication Ranch (MFBCMR) (2013), and Assemu et al. (2016). However, the recorded value was higher than the weaning weight for the same breed (Almaz, 2012), Boran breed (Aynalem et al., 2009), Horro breed (Habtamu et al., 2012), and Ogaden breed (Getinet et al., 2009). This difference arose due to breed and management variations among and within breeds, respectively. Besides, the weaning age and calf management practices applied in different centers and sites contribute to the difference between the current finding and mentioned authors. Sex had a highly significant effect on weaning weight, and it was consistent with the reports for the Fogera breed (Almaz, 2012; Assemu et al., 2016) and other breeds (Renata et al., 2014). However, the study of Melaku et al. (2011b) reported that the sex of calves had no significant effect on weaning weight. Similar to the present study, lighter weaning weight on other breeds at parity one than the other parities were reported by the findings of Habtamu et al. (2010), Melaku et al. (2011a), and Almaz (2012). However, the study of Assemu et al. (2016) reported that parities of the dam had no significant effect on weaning weight. The significant influence of season on weaning weight was consistent with previous reports (Habtamu et al., 2010; Almaz, 2012; Manzi et al., 2012; Assemu et al., 2016). The present study also reported that year had a significant effect on weaning weight, which agreed with the report of Habtamu et al. (2010), Melaku et al. (2011a), Almaz (2012), Manzi et al. (2012), and Assemu et al. (2016). The weaning weight of crossbred had high performances than the Fogera breed. Crossbred calves attain higher weaning weight than local Fogera breeds (Belay, 2014).

## Pre-Weaning Average Daily Gain

As shown in **Figure 3**, the trends of weaning weight had shown a decreasing trend as the birth year advances. This might be due to the absence of constant management practices year after year in both working sites. Besides, expansion of the thorny shrubs in the grazing land and increasing ambient temperature during the dry season are attributed to higher effects in Chagni Cattle Breeding and Improvement Ranch. Whereas, inconsistence management practices contributed to the declining trend at Andassa livestock research center.

The PrADG of the current study had a decreasing trend across the advancement of the birth year (**Table 1**). The result for PrADG was lower than the result obtained for the same breed by Addisu (1999), Giday (2001), and Melaku et al. (2011a). Significant influence of all factors was also reported by Addisu (1999) and Melaku et al. (2011b), except the sex of calves. Calves born $\geq$5 parity have lower PrADG which might be due to the old age of the dams that leads to a reduction in milk yield for the nourishment of the calf. This result agreed with the findings of Getinet et al. (2009) and Melaku et al. (2011b). The trend across years in **Table 1** shows a decreasing trend which might be due to the deterioration in the general management of cattle and the variations in climatic conditions and management situations (Getinet et al., 2009; Melaku et al., 2011b).

## Post-Weaning Weight

As noted in the current study, the weight of crossbred calves at post-weaning age was higher than the values reported by Demeke et al. (2004), Obese et al. (2013), and Zeleke and Getachew (2017). However, the weaning weight of crossbred calves recorded in this study was lower than the range values (124–140 kg) reported for local-Holstein Friesian crossbreds (Demeke et al., 2003; Hailu and Tadele, 2003; Ababu et al., 2006). The post-weaning weight for Fogera calves was close to those previously reported for the same breed (Asheber, 1992; Addisu, 1999; Giday, 2001). Post-weaning weight obtained for Fogera calves in the present study was heavier in comparison with Ogaden (Getinet et al., 2009) and Boran breed (Yohannes et al., 2001).

Fogera-Friesian crossbred calves were heavier than the Fogera calves at post-weaning age. This is probably due to the heterosis

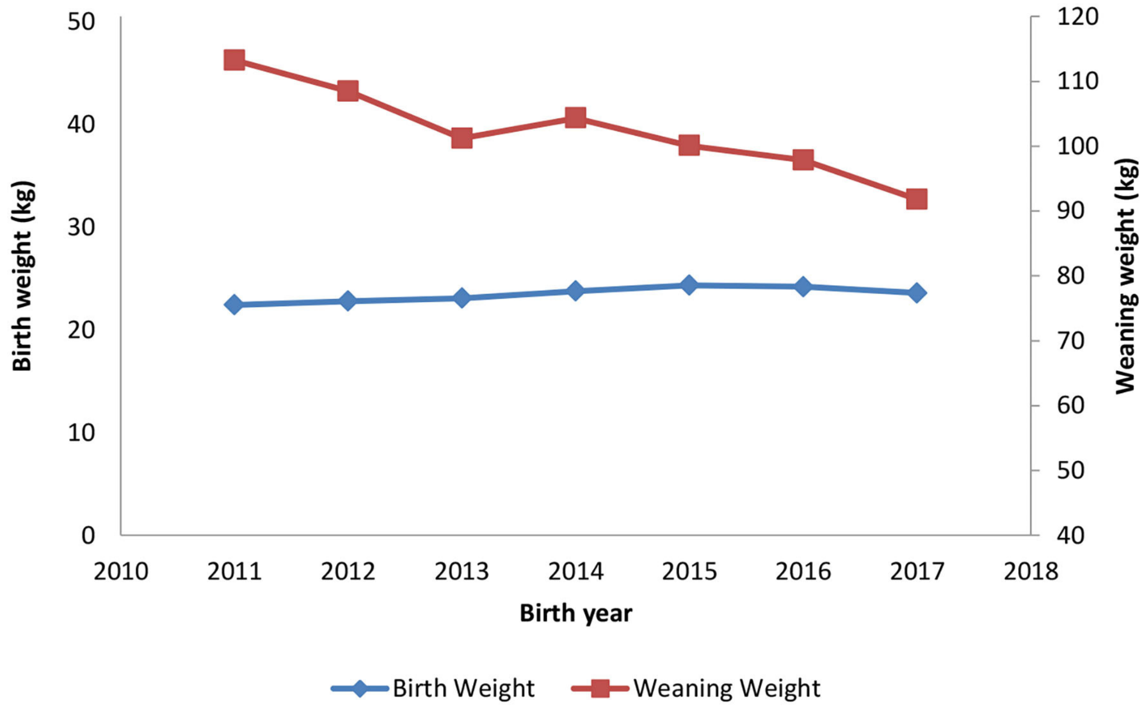


**FIGURE 3 |** Trends of birth weight and weaning weight across years.

exhibited by the crossbred calves. Another important factor that affects post-weaning weight was birth weight and sex. Many types of research have confirmed that male calves were heavier than females (Hailu and Tadele, 2003; Wasike, 2006; Habtamu et al., 2010; Almaz, 2012). On the contrary, the studies of Asheber (1992), Giday (2001), Jiregna et al. (2006), Aynalem et al. (2009), Addisu et al. (2010), Habtamu et al. (2010), Melaku et al. (2011a), and Obese et al. (2013) indicated that calf sex had no significant effect on post-weaning weight. The effect of dam parities on post-weaning weight was not significant on which management difference was majorly contributing for differences. These results were consistent with the result reported by Addisu et al. (2010) and Aynalem et al. (2011). However, the studies of Giday (2001) and Getinet et al. (2009) found that the dam parities significantly affected weights from birth and until post-weaning weights for the local breed. The post-weaning weight of calves raised in the Andassa site was higher than in calves raised in Chagni. Differences in post-weaning weight between working sites were attributed to the variation in housing, management, health follow-up, and availability of pastures, forage, and other feeds. The effect of location on post-weaning weight was also reported by Moran (2005).

## Post-Weaning Average Daily Gain

The PoADG for Fogera cattle was lower than previous studies on the same breed (Melaku et al., 2011a); for Nguni breed calves of South Africa (Mpofu et al., 2017) and higher than the report of the same breed (Addisu et al., 2010); Sheko breed (Bayou et al., 2015); Horro and their crosses (Habtamu et al., 2012). In the present study, there were no influences of breed, sex, parity, location, and birth weight on PoADG. Similar results regarding sex were found by Aynalem et al. (2009), Getinet et al. (2009), Addisu et al. (2010), and Melaku et al. (2011a). However, the studies of Mekonnen et al. (2012) and Bayou et al. (2015) found a significant effect of sex on the trait.

## Mortality Rate

The overall calf mortality of the current study was 3%, which is comparable with the 3–5% calf mortality rate set as a minimum standard (Heinrichs and Radostits, 2001). The current finding was lower than the report in Ethiopia (Wudu et al., 2007; Ferede et al., 2014), in Britain (Ortiz-Pelaez et al., 2008). This mortality rate finding was also comparable with other studies in Sweden (Svensson et al., 2006), Norway (Gulliksen et al., 2009), Britain (Ortiz-Pelaez et al., 2008), and Australian farmers surveys report (Moran, 2005). This finding is also lower than the report of Amuamuta et al. (2006) for Fogera calves and their F1 Friesian at ALRC. The Cox regression provided the significant effect of birth weight on survival of calf, on which calves born with heavier weight have better survival rate. Similarly, the studies of Amamuata et al. (2006), Kim et al. (2013), Schmidek et al. (2013), Bangar et al. (2016), and Kebamo et al. (2019) reported that birth weight had a significant effect on the mortality rates of calves.

A significant influence of the season of birth on the mortality rate of calves with a hazard ratio of 1.6 was observed. Calves born in the wet season had suffered from excessive rain and are exposed to death than dry season births. The association between calf mortality and season of birth is also reported by Riley et al.

(2004) and Boitsime (2006). Breed had a significant effect on calf mortality rate with the hazard ratio of 0.55, and the calf mortality rate was higher for Fogera than F1 calves and this might be the reason that F1 calves were managed indoors through bucket feeding while Fogera calves were directly fed on their dam and herded together with her dam. This finding was also supported by Mekonnen et al. (1993), Amuamuta et al. (2006), and Muluken et al. (2017) those who confirmed that F1 calves had a lower mortality rate than local breeds.

## CONCLUSION AND RECOMMENDATIONS

The present study has revealed that the performance level and mortality rate of the Fogera and × Holstein Friesian cross breeds were comparable with results from other zebu and their crosses. The result of this study showed that crossbreeds were superior to Fogera in growth performance. This superiority could be exploited to increase the number of F1 calves to distribute to smallholder farmers. However, the Fogera breed is a country wealth that needs conservation of the adaptive and unique characteristics. All the fixed factors considered in the study had a significant ($p < 0.001$) effect in all pre-weaning weights of both breeds. Among all non-genetic factors, year and season had a great influence on performance levels of the Fogera and its crosses which might be due to the declined management practices. This study has also investigated a multitude of determinant factors that are significantly involved in calf survival ability. Among the potential risk factors, breed, season, and birth weight were found significantly associated with mortality rates. The present study has also found higher mortality rates in the early age of the calves in which F1 calves are superior in most of the survival traits than Fogera calves. Therefore, the impact of mortality should be accounted for and take appropriate interventions against these determinant factors to improve calf survival ability in both farms. This could be achieved through understanding and manipulating risk factors associated with mortality with subsequent application of improved calf management practices. Generally, from the result of the present study, the following recommendations were indicated:

- For smallholder farmers, selective breeding could be recommended since the results showed performance level of Fogera could be increased effectively if appropriate genetic improvement schemes are designed.
- The result revealed that management-associated factors significantly affected both productivity and survival rates in both centers. Therefore, management practices should be improved to avoid variability in productivity and survival rates.
- A further detailed study in investigating the impacts of each factor and their interaction effect on productivity and survival traits should be done.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The animal study was reviewed and approved by Andassa Livestock Research Center. Written informed consent was obtained from the owners for the participation of their animals in this study.

## AUTHOR CONTRIBUTIONS

AT contributed to data analysis and writing of the original draft of the article. TG contributes to developing the project, data collection, and development of draft paper writing with the corresponding author. YD and SA had contributed to comment on the draft paper. All authors have read and approved the final manuscript.

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