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Calf mortality in Turkish dairy farms: Economic impact, regional disparities, and farm-level drivers

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ABSTRACT

This study investigates the economic burden of calf mortality in Turkish dairy farms and its impact on the national economy. We gathered research data by directly surveying dairy farms in seven provinces, each representing a distinct region of Turkiye. By conducting these surveys, we captured data on various aspects of calf mortality, including losses among non-pregnant cows aged two and older, pregnant cows, and those experiencing complications during birth, as well as losses within the 0–6 month age bracket. These figures were then amalgamated to establish the overall calf loss rate. Using a fractional probit model, we examined the empirical relationship between total calf loss rates and the socio-demographic characteristics of farm operators and their establishments. Our findings revealed that approximately 82 % of farms experienced some degree of calf loss, with the calf loss rate among dairy cattle farming accounting for nearly 20 %. Notably, regional disparities emerged as a key observation, alongside the identification of certain socio-demographic farm characteristics that proved statistically significant. Specifically, factors such as the prevalence of local cattle breeds, the proportion of crossbred bulls, as well as the numbers of heifers and calves, stood out as influential. Further scrutiny, fortified by ANOVA tests and relationships between the number of cows and total calf loss rate, underscored pronounced geographical disparities in post-estimation calf loss rates. Meanwhile, correlation heatmaps illuminated noteworthy relationships between specific cattle traits and the extent of calf losses. These findings not only underscore the severity of the issue but also highlight the urgency of preventive measures. In light of these insights, we offer pertinent policy recommendations to stakeholders and policymakers aimed at mitigating this considerable economic burden effectively.

1. Introduction

The global cattle meat industry holds significant economic importance, intricately linked to sustainability, profitability, and animal welfare, especially in the face of rising global population and income levels. A critical issue within dairy-cattle operations is calf mortality, which poses severe economic and multifaceted repercussions for nations with substantial livestock sectors. The loss of calves impacts herd health, genetic progress, and farm well-being, leading to decreased future productivity of cattle herds, delayed genetic progress, and reduced meat and dairy production, which results in financial losses for farmers and affects both domestic markets and international trade (Engelken, 2008; Motus et al., 2017; Martin et al., 2019; Hyde et al., 2019; Sedó et al., 2023; Tang and Lhermie, 2023). High calf mortality rates can destabilize the financial security of farming families, exacerbating poverty and inequality in rural communities reliant on livestock farming, while also undermining food security by reducing livestock productivity and decreasing the availability of meat and dairy products, potentially

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worsening malnutrition among vulnerable populations (Cornish et al., 2019; Debnath et al., 1995). Environmentally, calf losses also exacerbate the strain on natural resources and contribute to environmental degradation, including land degradation and water pollution. Livestock production is a notable contributor to greenhouse gas emissions, and increased calf mortality can intensify these environmental issues. Addressing calf mortality is crucial for the long-term sustainability of the agricultural sector (Engelken, 2008; Ortiz-Pelaez et al., 2008; Motus et al., 2017; Martin et al., 2019; Hyde et al., 2020; Sedó et al., 2023; Tang and Lhermie, 2023; Sedó et al., 2024). Implementing measures to reduce calf mortality, such as improved healthcare, nutrition, and management practices, can enhance the resilience of livestock farming systems. These efforts contribute to overall food security, economic stability, and sustainable development. Tackling this issue requires coordinated efforts from governments, farmers, researchers, and stakeholders to improve calf health and welfare. By mitigating calf losses, countries can strengthen their agricultural sectors, enhance food security, and promote sustainable development.

In contrast to studies elucidating calf mortality incidence in beef and dairy cattle enterprises across different countries based on calf characteristics (Bleul, 2011; Bunter et al., 2013; Motus et al., 2017; Ring et al., 2018), other research has linked calf mortality in dairy operations to herd-level risk factors (Mee et al., 2008; McConnel et al., 2015; Renaud et al., 2018; Tang and Lhermie, 2023) and explored the relationship between management practices in cow-calf operations and the prevalence of diseases such as respiratory ailments, alongside calf mortality (Schumann et al., 1990; Bendali et al., 1999; Hanzlicek et al., 2013; Woolums et al., 2013; Woolums, 2015). For example, in Canada, some research has associated calf mortality in cow-calf operations with herd management and environmental factors (Elghafghuf et al., 2014; Waldner, 2014; Murray et al., 2016; Pearson et al., 2019; Waldner et al., 2019; Tang and Lhermie, 2023). The gap in existing research underscores the need for further studies due to the lack of data for predicting herd-level mortality on a national scale and the absence of standardized case definitions for calf mortality (Waldner et al., 2010; Murray et al., 2016; Tang and Lhermie, 2023).

In developing countries such as Turkiye, the fundamental differences between beef and dairy calf management, coupled with the scarcity of research on cattle calf mortalities, underscore the necessity for further investigation in this area. This study aims to identify the key risk factors contributing to calf losses in dairy-cattle operations in Turkiye by comprehensively analyzing losses occurring before birth (including fetal loss), during birth, and up to six months after birth. By uncovering such risk factors and their impact on total calf losses at the farm level, the study aims to enhance the overall efficiency and sustainability of dairy farming in the country, while also providing reliable information to relevant public and private stakeholders. The research employs fractional probit regression as a methodological approach to analyze the complex dynamics contributing to calf losses within the Turkish dairy farming context, while various analyses of variance (ANOVA) will determine the joint interaction of regional differences and farm size on total calf loss. Through these analytical frameworks, including fractional probit regression, the study aims to provide nuanced insights into the factors influencing calf losses encompassing stages from pre-birth to post-birth occurrences, thereby offering a robust statistical foundation for understanding and mitigating calf losses and fostering improved practices and outcomes within the dairy farming sector in Turkiye. Moreover, the study delves into the intricate relationship between the socioeconomic characteristics of operators, business structure, and calf loss, fostering a deeper understanding of the challenges faced by farmers. From meeting nutritional requirements to driving industrial growth and ensuring food security, the multifaceted significance of dairy cattle breeding cannot be overstated. By embracing cutting-edge research and adopting a holistic approach to livestock development, we can foster a more prosperous and sustainable future, where the benefits of agriculture are equitably shared and enjoyed by future generations. Uncovering conclusions and formulating policy recommendations based on these findings can also pave the way for other nations similar to Turkiye, providing a compelling roadmap for their journey ahead.

2. Materials and methods

2.1. Data

The study was conducted through on-site surveys directly at dairy cattle farms spanning seven distinct geographical regions of Turkiye, with one representative province, possessing the highest number of livestock farms, carefully chosen from each, based on cattle units, as Turkiye's agriculture is divided into these regions. The selection of provinces took into consideration the livestock numbers and business statistics obtained from Provincial Animal Health Branch Directorate (PAHBD) officials, as well as data from the Ministry Veterinary Information System (MVIS). Information regarding the cattle numbers and farm statistics in provinces, districts, and villages where the survey will be conducted was sourced from the records of the Provincial Directorate of Agriculture and Forestry. The total number of livestock farms amounts to 265,187.[6]

This comprehensive research took place over a three-month season (June-August) in 2021. Erzurum province was chosen for the Eastern Anatolia region, Diyarbakir for the Southeastern Anatolia region, Adana for the Mediterranean region, Izmir for the Aegean region, Balikesir for the Marmara region, Konya for the Central Anatolia region, and Samsun for the Black Sea region (Fig. 1). These provinces were selected as they are considered representative of the country's diverse agricultural landscape. The necessary bovine and farm secondary data for the current research were obtained from the Turkish Statistical Institute (TURKSTAT), complemented by relevant information sourced from PAHBD and MVIS. Additional statistics concerning cattle and farms in the designated provinces, districts, and villages were also acquired from PAHBD officials, while further data were sourced from MVIS. Such an approach demonstrates its effectiveness in cases where sampling units are readily accessible and economically viable, particularly when dealing with a relatively moderate population size (Çiçek and Erkan, 1996). Moreover, in the course of this research, the utilization of a stratified sampling method will ensure the comprehensive representation of enterprises exhibiting diverse operational capacities within the target population (Güneş et al., 1988). Stratified sampling, as a random sampling technique, is especially valuable when exhaustive lists of units within the population are unavailable or when the units to be examined are geographically dispersed over a wide area (Orhunbilge, 2000). The determination of the number of dairy cattle enterprises to be included in the sample will adhere to the proportional stratified sampling method.

A total of 993 dairy cattle farms were randomly selected as a sample size, dependent on the dairy cattle population in each province based on three strata (e.g., presences of animals smaller than 10 heads, 10–30 heads, and 30 and above heads). Prior to conducting the official survey, a small number of dairy cattle enterprises within the survey area underwent a pretest to assess the adequacy of the survey instrument. Preceding the survey, enumerators fluent in the local dialect, particularly in eastern and southeastern provinces, were trained in data

[6] Despite the country's vast number of dairy farms, the scarcity of modern operations is stark. Most farms are small-scale, and many owners have limited education, making accurate record-keeping a daunting task. To tackle such challenges, the Turkish Ministry of Agriculture and Forestry has rolled out the Farmer Registration System (FRS) and the Animal Registration System (ARS) in recent years. These innovative systems are designed to precisely track livestock identification, land assets, agricultural products, and subsidies, marking a significant leap towards efficient and transparent agricultural management in the country.

Fig. 1. Cities where the study was conducted.

collection using a digitalized survey tool in Excel to ensure understanding and effective data capture. After excluding missing and outlier observations, a total of 924 cross-sectional observations remained for analysis. The analysis encompasses 924 dairy cattle farms, with 136 of them from Balikesir province, 152 from Izmir province, 136 from Konya province, 128 from Adana province, 115 from Samsun province, 124 from Erzurum province, and 133 representing Diyarbakir province.

2.2. Econometric method

In this study, we investigate the total calf mortality rate occurring in a cattle farm during a production season, which ranges between [0,1]. This rate comprises the cumulative losses from non-conception, loss during pregnancy, loss during birth, and losses within the last six months post-birth. Fractional regression models are essentially equivalent to classical binary choice models in terms of parameters, but they exhibit a structure where the standard deviations of parameters differ using the robust/sandwich estimators of the variance-covariance matrix for the fractional regression model. Initially proposed for examining 401(k) participation rates (Papke and Wooldridge, 1996), fractional regression models are extensively utilized for modeling continuous proportions of outcomes, ranging from economics to veterinary epidemiological and biomedical research (Meaney and Moineddin, 2014; Nienałtowski et al., 2021). This model type possesses several distinct advantages (Papke and Wooldridge, 1996), with the first being the absence of a parametric assumption about the distribution of the dependent variable, relying instead on two conditional moments: conditional mean and conditional variance. Another significant advantage is its ability, akin to classical binary choice models, to account for non-constant effects of unitary (marginal) changes in independent variables on the dependent variable of calf mortality rates (Green, 2012; Wooldridge, 2011). Lastly, it ensures that the estimated values derived from the specified regression remain within the closed interval of [0,1]. In the context of fractional regression modeling, a critical consideration lies in assuming a functional form that accommodates the bounded nature of the dependent variable, representing calf mortality rates, within the [0,1] interval. Ramalho et al. (2010) underscore the significance of such a functional specification, noting its imposition of desired constraints on the conditional mean of the dependent variable (y). Thus, $E(y|x) = G(x'\theta)$ is naturally confined within the same interval, where G(.) embodies a nonlinear function adhering to the constraint $0 \leq G(.) \leq 1$. In this equation, x denotes a vector encompassing control variables, while θ symbolizes a vector of parameters slated for estimation corresponding to these variables. Papke and Wooldridge (1996) advocate for diverse possible specifications of the nonlinear function, typically advocating for any cumulative distribution function commonly applied to binary data. Among these, the Logit and Probit functional forms reign as the most prevalent choices.

This innovative model in which we chose a probit model for the fractional regression model offered profound insights into the multifaceted nature of calf loss phenomena, making it a compelling research approach. A fractional probit model, a statistical framework, finds utility in the analysis of data characterized by a continuous dependent variable confined to the range between 0 and 1, typically denoting proportions or probabilities. This model serves as a robust alternative when conventional linear regression assumptions falter, as in cases involving binary, count, or bounded outcome variables. Notably, it extends the standard probit model to cater to fractional response variables.

Let us denote the fractional response variable for the ith farm as y_i, where $0 \leq y_i \leq 1$. The fractional probit model takes the functional form with the mean, $E(\mu_i)$, and the conditional variance, $Var(\mu_i)$, of the response variable:

$$\begin{aligned} E(\mu_i) &= E(y_i|x_i) = \Phi(x'_i\theta + \varepsilon_i) \quad \text{and} \\ Var(\mu_i) &= \sigma^2\Phi(x'_i\theta + \varepsilon_i)(1 - \Phi(x'_i\theta + \varepsilon_i)) \end{aligned} \tag{1}$$

where y_i represents the observed fractional response variable, Φ symbolizes the cumulative distribution function (CDF) of the standard normal distribution, θconstitutes a vector of coefficients representing the influence of independent variables x on the fractional response y, while x signifies the vector of independent variables or predictors. ε embodies a normally distributed error term characterized by a mean of 0 and a variance of σ^2. This model leverages the link function $\Phi(x'_i\theta)$ to transform the linear combination of predictors $(x'_i\theta)$ into values bounded within the interval [0,1], aligning it with the nature of fractional responses. The error term $\varepsilon_i$introduces stochasticity into the model. Notably, this model's relevance comes to the fore when dealing with data that deviate from linear regression assumptions, such as the presence of heteroscedasticity or non-normality in residuals. It offers a structured approach to model the relationship between predictors and fractional responses while accommodating the bounded nature of the response variable (Papke and Wooldridge, 1996; Ramalho et al., 2010).

The likelihood function for the fractional probit model represents the joint probability density function of the observed responses $y_1, y_2, \ldots, y_n$

given the predictors $x_1, x_2, \ldots, x_k$, alongside the model parameters θ and σ^2. The estimation of these parameters (θ and σ^2) in the fractional probit model typically involves Bernoulli quasi maximum likelihood estimation (MLE) techniques, expressed as:

$$L(\theta, \sigma^2 | y_i, x_{ik}) = \prod_{i=1}^{n} [\Phi(x'_{ik}\theta + \varepsilon_i)]^{y_i} [1 - \Phi(x'_{ik}\theta + \varepsilon_i)]^{(1-y_i)} \tag{2}$$

where Φ represents the cumulative distribution function of the standard normal distribution (CDF). Taking the natural logarithm of this likelihood function yields the quasi log-likelihood function:

$$\log L(\theta, \sigma^2 | y_i, x_{ik}) = \sum_{i=1}^{n} [y_i{*}\log \Phi(x'_{ik}\theta + \varepsilon_i) + (1 - y_i){*}\log(1 - \Phi(x'_{ik}\theta + \varepsilon_i))] \tag{3}$$

The primary objective of maximum likelihood estimation is to determine values for θ and σ^2 that maximize this log-likelihood function. Numerical optimization techniques like the Newton-Raphson method or gradient descent algorithms are often employed for this purpose. Maximizing the log-likelihood yields parameter estimates (θ and σ^2) that best align with the observed data. To compute the marginal effects, one can differentiate the CDF,

$\Phi(x'_{ik}\theta)$, concerning the independent variables x_k. The marginal effect ($\frac{\partial y_i}{\partial x_k}$) for each independent variable x_k is expressed as:

$$\frac{\partial y_i}{\partial x_k} = \begin{cases} \phi(x'_{ik}\theta){*}\theta_k & \text{for a continuous variable} \\ \Phi(x'_{ik}\theta | x_k = 1) - \Phi(x'_{ik}\theta | x_k = 0) & \text{for a discrete variable} \end{cases} \tag{4}$$

where $\frac{\partial y_i}{\partial x_k}$ signifies the marginal effect of the k-th independent variable x_k on y_i, while ϕ represents the probability density function (PDF) and denotes the derivative of the standard normal CDF concerning $x'_{ik}\theta$. The Delta method is typically employed to compute the standard deviations of these marginal effects (Green, 2012).

3. Results

3.1. Descriptive statistics and ANOVA results

The descriptive statistics carefully presented in Table 1 shed light on factors contributing to calf losses across various farms under scrutiny. In Turkiye's dairy cattle sector, the total calf loss rate stands at a significant 19.30 %, wherein 9.80 % arises from non-pregnancy,[7] 3.20 % from abortions, a marginal 0.80 % from perinatal mortality, and a noteworthy 5.40 % from critical losses occurring in the 0–6 months postpartum period, revealing a concerning narrative. Regional disparities in calf loss rates add an intriguing dimension to the analysis presented in this study. Notably, Erzurum province emerges as a concern, boasting the highest calf loss rate attributed to non-pregnancy at 12.67 %, while, contrarily, Samsun province showcases a comparatively more optimistic scenario with a rate of 6.71 %, delineating a sharp contrast between these regions. In the wake of figures in Erzurum, Diyarbakir province emerges as a nexus of calf loss stemming from non-pregnant animals. Despite similar rates of dystocia across provinces, Diyarbakir and Erzurum consistently exhibit heightened levels of calf loss. Notably, while Diyarbakir reports the lowest calf loss at birth, the stark contrast of a 1.44 % rate in Izmir underscores the formidable challenges confronting farmers in that region. Moreover, the nuanced dynamics of calf losses within the 0–6 month period accentuate regional disparities, with Erzurum grappling with a staggering 9.72 % rate, while Samsun presents a comparatively promising figure of approximately 3 %, providing a glimmer of hope. Additionally, the prevalent trend of higher standard deviations above the mean across all loss categories denotes significant variability in calf losses. Of particular note is Erzurum province's distressing scenario, where nearly a quarter of total calf losses amount to 25 %, contrasted with Samsun province's more optimistic outlook, reflecting a rate of approximately 12 %. The comprehensive distribution of these findings is graphically illustrated in Fig. 2, highlighting the spatial heterogeneity and intricacies inherent in calf loss patterns across regions. From these findings, it is evident that calf losses are primarily influenced by environmental conditions and managerial understanding and practices within dairy farming operations, to the extent that these factors emerge as the fundamental driving forces behind such outcomes. Erzurum, located in the Eastern Anatolia Region, is known for its continental climate with harsh winters and the lowest average temperatures and rainfall in Turkey. In contrast, Samsun, situated in the Middle Black Sea Region, experiences the highest rainfall in winter and the lowest in summer, coupled with high humidity levels. With an annual rainfall of 700 mm, Samsun is the rainiest province in Turkey. The climate in Samsun features mild winters similar to the Mediterranean climate, with minimal daily and annual temperature variations, transitioning to colder conditions in inland and higher areas. This groundbreaking research significantly deepens our understanding of the complexities surrounding calf losses, leaving a lasting impact on livestock production. The extensive findings underscore the need for informed interventions to reduce these losses and enhance the welfare of these essential assets, which form the cornerstone of many farmers' livelihoods (Table 1 and Fig. 2). Moreover, it is striking to note from our analysis that nearly 82 % (81.71 %) of businesses experience calf losses. This statistic is a stark reminder of the significant economic toll at both the micro level for individual enterprises and the macro level for the nation. Addressing this issue is paramount, not only for the affected businesses but also for the overall economic future and resilience of the country.

In this study, we used ANOVA[8] to analyze the potential interaction effect on total calf losses between regions and designated strata. Although no interaction effect or significant stratum variable was found, regions showed a significant impact on total calf losses in dairy farming, supporting our previous discussion. Consequently, we reanalyzed only the effect of regions using ANOVA, with the Tukey pairwise mean differences provided in Fig. 3[9]. The graph confirms our earlier discussion and highlights the significant impact of environmental and managerial differences among regions on calf losses in Turkish dairy farming. In all seven provinces except Adana and partially Izmir,[10] we observe that as operational scale expands, calf loss rates increase, indicating diseconomies of scale. Even Samsun, with the lowest calf loss rate of 11 %, faces these challenges due to management complexities, coordination deficits, and suboptimal resource allocation in large-scale operations.Numerous studies (Gulliksen et al., 2009a; Silva del Rio et al., 2007; Seppa-Lassila et al., 2016) show that calf mortality rates tend to rise with herd size.

[7] In this study, we investigated infertility—a key factor leading to calf loss in dairy farms—through a detailed approach. A comprehensive survey was administered to farm owners to first establish the number of cattle aged two years and older. Then, the livestock owners or opperators were asked to report how many of these cows had failed to conceive in the past year, with their responses carefully recorded. To ensure accuracy, we cross-verified this data by inquiring how many cows of the same age group had given birth and successfully conceived within the same timeframe. Such meticulous records provide crucial insights into the reproductive challenges faced by dairy farms.

[8] We will not present the ANOVA results here, but we will share the results with those who are interested.

[9] According to the ANOVA results focusing solely on the strata, the difference between the strata was found to be statistically significant at the 10 percent level.

[10] To clarify the term "partial", as the calf losses in small-scale enterprises tend to initially increase to a certain extent when transitioning to medium-scale enterprises, followed by a noticeable calf loss rate surpassing that of small-scale enterprises in larger-scale operations.

Table 1
Percentage calf losses by provinces.

Period	Balikesir	Izmir	Konya	Adana	Samsun	Erzurum	Diyarbakir	Overall mean
Losses types:								
Inability to conceive	9.38 (9.78)	8.96 (8.88)	9.84 (11.35)	8.39 (10.18)	6.71 (11.12)	12.67 (13.52)	12.24 (12.76)	9.80 (11.20)
Miscarriage	3.22 (6.83)	3.68 (6.99)	3.32 (8.29)	2.39 (4.77)	2.01 (4.90)	3.91 (8.02)	3.94 (6.36)	3.20 (6.80)
Deaths at birth	1.16 (2.85)	1.19 (3.33)	0.82 (2.55)	0.56 (2.22)	0.57 (3.10)	1.06 (2.97)	0.27 (2.90)	0.80 (2.90)
Deaths in 0–6 months	5.00 (6.52)	4.89 (6.55)	5.70 (7.15)	5.83 (7.95)	2.60 (4.37)	7.48 (9.65)	6.50 (8.13)	5.40 (7.40)
Total calf losses	18.74 (14.14)	18.73 (14.15)	19.68 (15.04)	17.17 (13.46)	11.89 (12.90)	25.12 (17.34)	22.96 (16.32)	19.30 (15.30)

Note: Standard deviations are in parenthesis

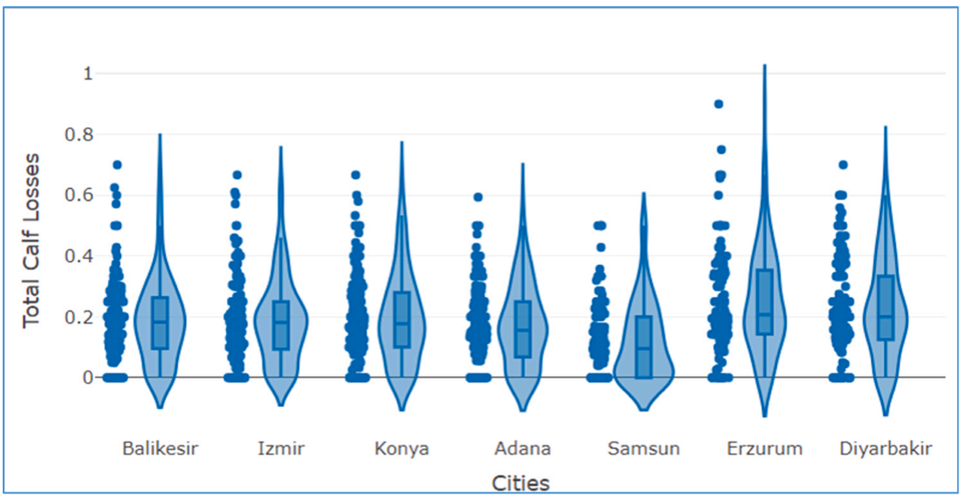

Fig. 2. Distributions of total calf loss rates by cities in Turkiye.

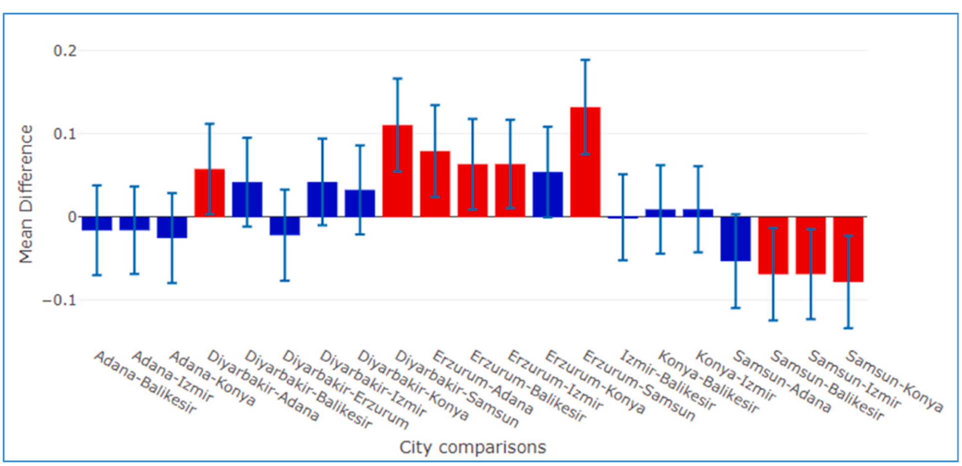

Fig. 3. Tukey HDS comparisons for actual total calf loss rates for cities.

Advancements in farm technology often reduce the time available for individual calf care, contributing to higher mortality rates. Factors such as the timing of initial colostrum feeding and other colostrum management practices are significantly associated with herd size, making effective colostrum feeding regimens more challenging in larger herds (Kehoe et al., 2007; Gulliksen et al., 2009b). Additionally, larger herds facilitate greater pathogen transfer among animals (Seppa-Lassila et al., 2016).In contrast, smaller herds may receive more intensive care for fewer, more valuable calves and often represent the primary income source for low-income families. These families can mitigate calf losses through effective management of stress, timely disease diagnosis, and calf welfare (Tang and Lhermie, 2023).

Table 2 presents compelling descriptive statistics regarding operator characteristics and the sociodemographic aspects of enterprises, chosen carefully to reflect the diversity of regions in Turkiye. Data distribution by province is detailed: Erzurum 13.4 %, Balıkesir 14.7 %, Izmir 16.5 %,

Table 2
Descriptive statistics for both dependent and independent variables.

Variables	Definitions	Units	Mean	Std. Dev.	VIF
Dependent Variable:					
Total calf loss rate	Total calf losses including non-pregnancy, miscarriages during pregnancy, calf deaths during birth, and deaths within 0–6 months	0–1 range	19.30	15.30	
Independent Variables:					
Dummy Variable Coding:					
Regions:					
Erzurum	1 if the livestock farm is within the borders of Erzurum province, 0 otherwise (Reference group)	1/0	13.40	34.10	-
Balikesir	1 if the livestock farm is within the borders of Balikesir province, 0 otherwise	1/0	14.70	35.40	4.04
Izmir	1 if the livestock farm is within the borders of Izmir province, 0 otherwise	1/0	16.50	37.10	5.58
Konya	1 if the livestock farm is within the borders of Konya province, 0 otherwise	1/0	14.70	35.40	5.04
Adana	1 if the livestock farm is within the borders of Adana province, 0 otherwise	1/0	13.90	34.60	4.11
Samsun	1 if the livestock farm is within the borders of Samsun province, 0 otherwise	1/0	12.40	33.00	3.08
Diyarbakir	1 if the livestock farm is within the borders of Diyarbakir province, 0 otherwise	1/0	14.40	35.10	3.89
Gender	1 if the owner of the livestock farm is male, 0 otherwise	1/0	93.60	24.50	1.04
Marital status	1 if the owner of the livestock farm is married, 0 otherwise	1/0	96.00	19.60	1.10
Education types:					
Primary school	1 if the livestock business owner has primary school education or lower, 0 otherwise (Reference group)	1/0	56.70	49.60	-
Secondary school	1 if the livestock business owner has secondary school education, 0 otherwise	1/0	20.20	40.20	1.28
High school	1 if the livestock business owner has high school education, 0 otherwise	1/0	17.20	37.80	1.31
College graduate	1 if the livestock business owner has at least college school degree, 0 otherwise	1/0	5.40	22.60	1.26
Social Security	1 if the livestock business owner has social security, 0 otherwise	1/0	87.20	33.40	1.24
Breeders association	1 if the livestock business owner is a member of the breeders' association, 0 otherwise	1/0	47.70	50.00	1.57
Cooperative membership	1 if the livestock business owner of the enterprise is a member of any agricultural cooperative, 0 otherwise	1/0	47.40	50.00	1.30
Credit usage	1 if the livestock business owner uses agricultural loans, 0 otherwise	1/0	47.90	50.00	1.46
Land classification:					
Landless	1 if the livestock farm does not have agricultural land, 0 otherwise (Reference group)	1/0	10.30	30.40	-
<50 da land	1 if the livestock farm has 50 decare (da) or less of land, 0 otherwise	1/0	45.60	49.80	3.35
50–100 da land	1 if the livestock farm has 50–100 da of land, 0 otherwise	1/0	23.80	42.60	3.10
>100 da land	1 if the livestock farm has 100 da of land or more, 0 otherwise	1/0	20.30	40.30	3.98
Herd size classification:					
<30 animals	1 if the holding has less than 30 total animals, 0 otherwise (Reference group)	1/0	46.60	49.90	-
30–60 animals	1 if the holding has 30–60 total animals, 0 otherwise	1/0	18.60	38.90	1.43
>60 animals	1 if the holding has 60 or more total animals, 0 otherwise	1/0	34.70	47.60	4.70
Big business	1 if the holding has 60 or more animals and 100 or more decare of land, 0 otherwise	1/0	11.50	31.90	2.91
Foreign workforce	1 if the holding employs foreign workers, 0 otherwise	1/0	11.80	32.30	1.52
Pasture use	1 if the holding benefits from pasture, 0 otherwise	1/0	37.20	48.40	3.11
Milk marketing	1 if milk is sold to a dairy or factory, 0 otherwise	1/0	16.00	36.70	1.99
Animal insurance	1 if the holding insures its animals, 0 otherwise	1/0	19.80	39.90	1.26
Open barn	1 if the holding has semi-open and open barns, 0 otherwise	1/0	45.70	49.80	2.11
Artificial insemination	1 if the holding conducts natural insemination, 0 otherwise	1/0	25.30	43.50	1.91
Continuous Variable Coding:					
Age	Age of the farm business owner	Years	47.97	10.61	1.36
Family size	family size	Number	5.15	20.07	1.38
Province distance	The distance from the livestock farm to the city center	Kilometer	71.74	49.13	2.34
County distance	The distance of the livestock farm to the district center	Kilometer	15.87	11.28	1.31
Family labor rate	The ratio of family workforce to total family size	Ratio	64.20	25.50	1.27
Calf unit	The number of calf units on the holding	Number	30.66	54.06	2.06
Milking machine	The number of milking machines in the holding	Number	2.09	0.68	2.02
Native breed cows	The number of native breed cows in the holding	Heads	0.53	4.17	1.25
Crossbreed cows	The number of crossbreed cows in the holding	Heads	5.15	11.18	3.27
Heritage breed cows	The number of heritage breed cows in the holding	Heads	17.02	24.16	5.15
Domestic breed bull	Native breed bull heads per female cattle in the holding	Ratio	0.70	6.40	1.16
Crossbreed bull	Crossbreed bull heads per female cattle in the holding	Ratio	3.40	15.60	1.17
Heritage breed bull	Heritage breed bull per female cattle in animal husbandry operations	Ratio	8.80	24.70	1.15
Number of heifers	The total number of heifers on the farm	Heads	8.01	10.41	1.06
Number of calves	The total number of calves on the farm	Heads	6.12	8.78	1.31
Index variable	The index variable reflects the technological presence of the enterprise. For example, it considers the sum of the presence of a milking unit, milk cooling tank, manure scraper, automatic drinker, belter, calf unit, infirmary and delivery room, safety measures regarding diseases, ventilation, feed storage, and the use of silage and factory feed	Index	6.76	20.99	1.95

Note: One decare (da) is equivalent to 1000 square meters. Std.Dev. and VIF refer to the standard deviation and variance inflation factor, respectively.

Konya 14.7 %, Adana 13.9 %, Samsun 12.4 %, and Diyarbakır 14.4 %. Notably, the average age of these industrious business owners is 47.97 years, suggesting a seasoned and experienced leadership. The varied educational achievements among operators provide an intriguing insight: 55.1 % have completed primary school, 20.2 % have attained secondary education, 17.2 % possess a high school diploma, and 5.4 % hold higher education degrees, reflecting a cohort of well-educated individuals driving agricultural progress. Additionally, 47.9 % utilize agricultural loans, demonstrating their commitment to growth. Foreign labor is employed by 11.8 % of enterprises, fostering cultural exchange, while 25.3 % have adopted modern reproductive technologies like artificial insemination. At the core of these enterprises are their bovine populations, which tell a compelling story: cultural breed cows average 17.02, showcasing dedication to traditional breeds. Cross-breeds, averaging 5.15, embody a harmonious blend of traits, while native breed cows, averaging 0.53, symbolize heritage. Heifers, averaging 8.01, promise continuity, and vitality, while 6.12 calves hint at a promising future. Each piece of descriptive data provides a panoramic view of

Table 3
Probit model results and its marginal estimates for total calf losses.

Variables	Probit Model			Marginal Impact		
	Coefficient		Std. Dev.	Coefficient		Std. Dev.
Constant	-52.09		21.81	-		-
Dummy Variables:						
Regions:						
Balikesir	-38.13	***	10.48	-10.17	***	2.78
Izmir	-41.40	***	11.45	-11.04	***	3.05
Konya	-35.77	***	11.23	-9.54	***	2.99
Adana	-37.10	***	10.46	-9.89	***	2.79
Samsun	-57.28	***	9.88	-15.27	***	2.61
Diyarbakir	-32.66	***	9.15	-8.71	***	2.44
Gender	11.86		8.21	3.16		2.19
Marital status	0.75	*	10.91	5.53	*	2.91
Education types:						
Secondary school	-1.89		4.70	-0.50		1.25
High school	3.67		5.08	0.98		1.35
College	-13.78		8.42	-3.67		2.24
Social Security	-4.25		5.99	-1.13		1.60
Breeders association	11.69	***	4.11	3.12	***	1.09
Cooperative membership	-0.06		3.77	-0.02		1.01
Credit usage	1.91		4.17	0.51		1.11
Land classification:						
<50 da land	-5.31		6.55	-1.42		1.75
50–100 da land	-2.11		6.96	-0.56		1.85
>100 da land	-8.15		9.05	-2.17		2.41
Herd size classification:						
30–60 animals	-0.98		5.04	-0.26		1.34
>60 animals	-7.07		6.54	-1.89		1.75
Big business	5.25		8.76	1.40		2.34
Foreign workforce	-16.55	***	5.32	-4.41	***	1.42
Pasture use	0.23		6.73	0.06		1.80
Milk marketing	-10.03		6.41	-2.67		1.71
Animal insurance	-7.90	*	4.36	-2.11	*	1.16
Open barn	-6.27		5.35	-1.67		1.42
Artificial insemination	-0.50		5.14	-0.13		1.37
Continuous Variables:						
Age	-0.44	**	0.21	-0.12	**	0.06
Family size	1.95	*	1.00	0.52	*	0.27
Province distance	0.07		0.06	0.02		0.01
County distance	-0.03		0.19	-0.01		0.05
Family labor rate	4.85		7.90	1.29		2.11
Calf unit	-0.05		0.35	-0.01		0.09
Milking machine	-2.68		3.04	-0.72		0.81
Native breed cows	0.92	***	0.32	0.24	***	0.08
Cross breed cows	0.17		0.25	0.04		0.07
Heritage breed cows	0.13		0.14	0.04		0.04
Native breed bull	-31.82		57.08	-8.48		15.21
Cross breed bull	-30.33	*	16.15	-8.09	*	4.30
Heritage breed bull	-10.58		9.66	-2.82		2.57
Number of heifers	-10.36	**	4.07	-2.76	**	1.08
Number of calves	-60.24	***	10.29	-16.06	***	2.75
Index variable	0.51		1.21	0.14		0.32
Important Statistics:						
$R^2 = 0.17$						
$\chi^2 = 409.90$, sd = 43, and $p = 0.000$						
$\chi^2 = 58.20$, sd = 8, and $p = 0.000$						
Predicted total calf losses rate = 19.27						

Note: *, **, *** stand for statistical importance at%1, %5, and %10, while sd stands for standard deviation.

Turkiye's diverse dairy farming practices, where operators, embracing modernity while rooted in tradition, foster a flourishing cattle enterprise poised for the future. Finally, multicollinearity among explanatory variables in the Probit model was scrutinized using Variance Inflation Factors (VIFs), all of which were well below the critical threshold of 10, indicating an absence of multicollinearity concerns throughout the estimation process (Chatterjee and Hadi, 2006).

3.2. *Results from the fractional probit model*

The empirical investigation employed a robust fractional probit regression, incorporating a comprehensive set of 43 independent variables (excluding the constant), to explore the complex determinants of total calf losses in dairy farming in Turkiye. The compelling results from the Chi-square test (Wald statistic (χ^2) = 409.9, degrees of freedom (df) = 43, $p = 0.000$) underscore the model's substantial explanatory power, thereby confirming the strong association between the independent variables and the dependent variable. Crucially, the null hypothesis—suggesting no simultaneous contribution of key indicators such as native breed cows, cross breed cows, culture breed cows, native breed bull, cross breed bull, culture breed bull, number of heifers, and number of calves to the total calf loss rate—has been decisively rejected at a significant level (χ^2= 58.20, df = 8, $p = 0.000$). As anticipated, the R^2 value derived from the binary probit model ($R^2 = 0.017$) aligns with typical outcomes, further substantiating the phenomenon under scrutiny. Notably, 17 of the independent variables emerge as statistically significant contributors to the model's efficacy, as highlighted in Table 3.

Focusing on statistically significant variables, our aim is to succinctly correlate them with the total calf loss rates observed in dairy farming enterprises. Marginal effects derived from the model are open for discussion. A captivating revelation emerges as we compare provinces to the reference province of Erzurum, shedding light on a notable disparity in calf losses. Cattle enterprises in other regions exhibit significantly lower calf loss risks. For instance, Izmir province demonstrates an impressive 11.0 % reduction in total calf loss risk compared to Erzurum, while similar patterns are observable in other provinces. Intriguingly, enterprises with single owners reveal a 5.5 % reduction in total calf loss risk, suggesting the profound impact of undivided focus and heightened care provided by such dedicated operators. Consistent with previous models, the study underscores diminished calf losses in enterprises led by experienced and elderly business owners. Additionally, while the initial benefits of cattle association membership may appear negative, it is anticipated that these outcomes can be reversed if the support provided by the association is strategically and effectively integrated into the production process by the livestock producers. Enterprises employing foreign labor experience a commendable 4.4 % mitigation in calf loss risk, indicating the potential benefits of a diverse workforce in dairy cattle husbandry. Notably, an intriguing relationship with animal insurance comes to light, with insured enterprises boasting lower calf loss rates. This finding underscores the protective measures undertaken by business owners, especially in cases involving pedigree and high-value animals, accentuating their foresight in safeguarding valuable assets. In contrast, the study highlights higher total calf loss rates in larger families and farms housing local cows. Conversely, the presence of crossbreed bulls and a greater number of heifers in farms correlates with minimized calf losses, reflecting the merits of embracing modern and hybrid breeding practices. Fascinatingly, an inverse association is observed, whereby an increase in calf numbers yields a remarkable 16 % reduction in calf loss risk. This intriguing observation suggests that enterprises with higher calf counts tend to be large-scale, modern establishments, benefiting from lower risk due to their advanced and sophisticated husbandry practices.

4. Discussion

Our study, utilizing a comprehensive cross-sectional analysis, delves into the intricate dynamics of calf loss rates in Turkish dairy farming, capturing not only operational traits but also seven distinct geographic variations. Unveiling that these geographical nuances stand as pivotal

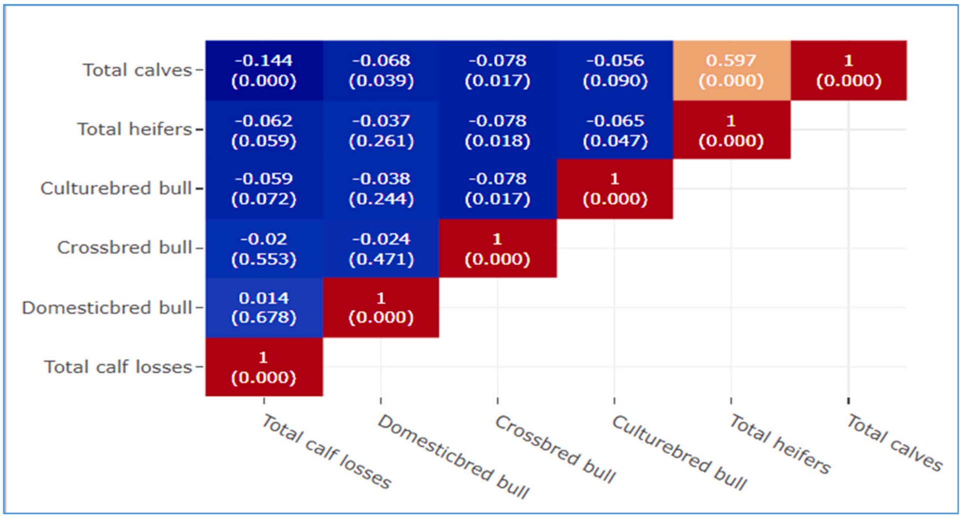

Fig. 4. The correlation heatmap between the total calf loss rate and some cattle traits.

determinants alongside other operational factors in total calf losses.[11] Cold stress due to climatic conditions poses a well-documented challenge for both lactating cows and their offspring. For instance, ensuring the maintenance of homeothermy in young dairy calves necessitates a minimum ambient temperature of 10°C for eight-week-old calves (Webster et al., 1978). Particularly in regions such as Eastern and Southeastern Anatolia in Turkiye, where winter temperatures coincide with the calving or reproduction season, temperatures often plummet below this critical threshold. Consequently, despite being housed in enclosed barns, both dams and calves are exposed to severe winter conditions lasting six months, compounded by adverse factors like snow and wind. Calves exhibit heightened sensitivity to cold stress compared to mature cattle due to their larger surface area-to-mass ratio, leading to increased heat loss (Van Os et al., 2023). Moreover, their developing rumen, which generates minimal heat through fermentation, exacerbates this susceptibility (Collier et al., 1982). Recent scientific inquiries have shed light on the intricate relationship between cold stress and physiological or biological functioning. In environments characterized by cold stress, animals experience heightened maintenance requirements (Scibilia et al., 1987; Larson and Tyler, 2005) and elevated feed intake (Brouce et al., 2009; Roland et al., 2016), coupled with diminished growth performance (Scibilia et al., 1987; Brouce et al., 2009; Hill et al., 2011). Concurrently, cold stress suppresses immune function (Olson et al., 1980a), resulting in elevated rates of morbidity (Olson et al., 1980) and, regrettably, mortality (Godden et al., 2005; Tang and Lhermie, 2023). On the other hand, in regions with temperate climates, the mortality rate of dairy calves within the initial 16 weeks shows notable variation across herds, typically falling between 8 % and 12 % (Tyler et al., 1999; Magalhaes et al., 2008; Torsein et al., 2011; Mellado et al., 2014). This rate tends to escalate in areas where newborn calves struggle to regulate their core body temperature effectively (Spain and Spiers, 1996; Mellado et al., 2014). The potential deficits observed in the performance of neonatal calves under severe heat stress not only underscore the impact of maternal heat stress during the dry period on fetal development but also highlight its adverse effects on the immune functionality of calves until weaning (Tao et al., 2012; Mellado et al., 2014). In the literature, various preventive measures have been suggested to minimize the effects of cold stress in calves. These encompass not only nutritional interventions to meet the increased maintenance requirements but also heating methods as preventive factors. For instance, strategies such as providing higher milk allowances (Anderson and Bates, 1984) and supplementing fat in the liquid diet (Nonnecke et al., 2009) are highlighted, alongside measures aimed at reducing heat loss in calves, such as providing deep bedding (Nordlund, 2008) or outfitting them with calf jackets (Scoley et al., 2019). Observations conducted in a barn revealed that three-day-old calves predominantly spent their time near heat lamps (Borderas et al., 2009), while calves gathered together in group pens in barns showed no significant changes in heat loss (Webster et al., 1978; Hänninen et al., 2003), with the degree of this behavior being inversely related to ambient temperatures (Bøe and Havrevoll, 1993)

For the first time in this study, the operator's characteristics within the managerial framework of dairy farming enterprises have been identified as determinants of total calf losses, eliciting a significant correlation between the operator's age and total calf loss rates at the 5 % statistical significance level. As the operator's age advances, undoubtedly, so does their depth of experience and knowledge, empowering them to mitigate past setbacks and seize opportunities. As time progresses, such kind of accumulated expertise may serve as a powerful asset in the development of improved and effective management strategies, aimed at generating added value in animal husbandry from an economic standpoint. Moreover, it could lead to better managerial identification and management of health issues in their livestock. Our findings are in line with previous research results suggesting that elderly cattle producers often report fewer calf health issues compared to their younger counterparts (Martin et al., 2019; Tang and Lhermie, 2023). In contrast to such a positive outcome, there exists a statistically significant relationship between the variable of married household head and increasing calf loss in dairy farming enterprises. Such a result likely stems from the necessity for a married household head to attend to other household needs, including agricultural production, thereby potentially creating additional workloads, leading to lapses in care from the pregnancy of the dam to the weaning period of the calves. While not directly pertinent to our findings, certain studies (Holloway, 2001; Hanzlicek et al., 2013; Tang and Lhermie, 2023) suggest that herd operations involving primary decision-makers engaged in part-time or full-time non-agricultural employment, or those focused on hobby-farm production, align with lower mortality rates. Interestingly, membership in the Breeding Cattle Breeders' Union (BCBU) in fact triggers an increase in calf losses in dairy farming enterprises, rather than preventing them. In Turkiye, these unions offer a range of services to their members,

[11] Accounting for the region-specific birth cycles, along with their distinctive topography and vegetation, which entail varying nutritional needs, is also essential. Moreover, factoring in the region-specific barn structures and administrative characteristics adds a dynamic layer to our understanding of regional differentials.

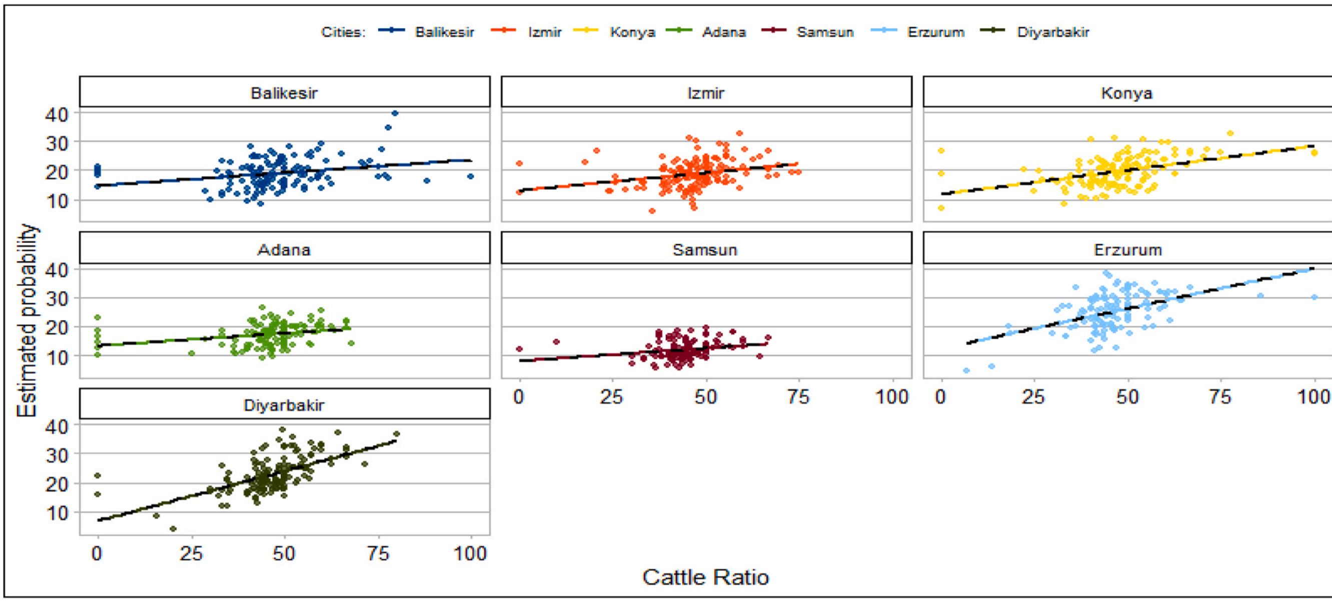

Fig. 5. The relationship between the estimated calf losses rates and the cow ratio among cities.

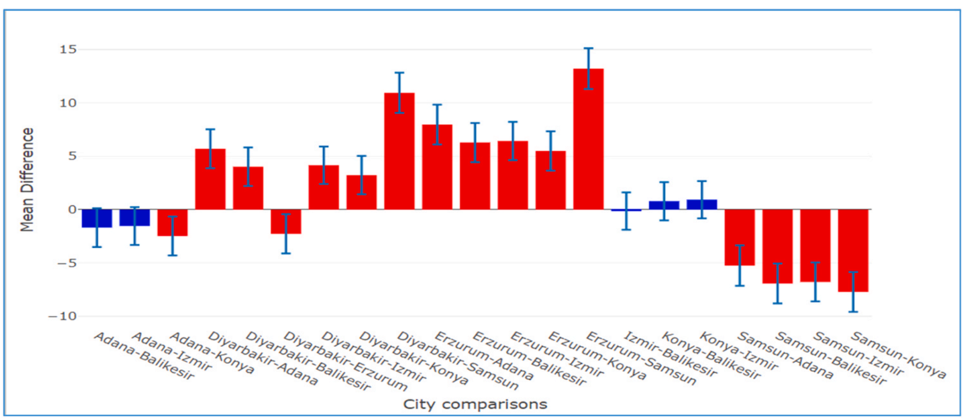

Fig. 6. Tukey HDS comparisons for predicted total calf loss rates for cities.

including tagging newborn calves and cattle with ear tags, maintaining monthly milk yield records and conducting milk measurement inspections, registering new enterprises, providing assistance with calving, insemination, and herd movement records, as well as offering consultation on breeding and feeding. They also facilitate classification of cattle based on external characteristics, procurement of inputs, animal health services, artificial insemination, and provision and sale of breeding animals (Terin et al., 2022). It is highly probable that the period from pregnancy to weaning of calves in cattle has resulted in such an outcome due to the increased complacency stemming from member operators feeling overly secure. Conversely, we observe a decline in the incidence of calf loss risk in enterprises utilizing foreign labor. Evaluated from the standpoint of foreign workers, motivations such as the fear of job loss, the anticipation of financial improvement through diligent work, and specialization in the field can all serve to mitigate calf losses. Given the high likelihood of being a commercial enterprise employing foreign workers, they may aim to maximize calf production throughout the entire process from conception to weaning including health and welfare of calves (Hanzlicek et al., 2013; Tang and Lhermie, 2023).

Livestock insurance serves as a successful tool for managing price risk among a variety of large-scale livestock producers. However, it remains a well-documented reality in Turkiye, particularly among small and medium-sized dairy cow-calf producers, that the majority continue their livestock production without seeking any form of price risk protection. We observe that dairy farming enterprises equipped with livestock insurance tend to experience lower calf losses compared to their uninsured counterparts. Typically, those investing in such insurance are commercial-scale enterprises, motivated by the desire to safeguard their operations from potential risks while upholding professional breeding practices on their farms.

As the count of native breed cows (head) rises within the enterprise, so does the incidence rates of calf losses. In Turkiye, indigenous animal breeds exhibit lower productivity in terms of meat, milk, and calf yield. Despite efforts to enhance them over the past two decades, the proportion of indigenous breeds within the overall animal population has steadily dwindled, plummeting to 10.1 % by 2017 from a share exceeding 40 %. Differences in neonatal calf and cattle mortality rates among breed types in animal husbandry have been previously documented in different countries such as France, Germany, Finland, and Estonia (Raboisson et al., 2014; Pannwitz, 2015; Seppa-Lassila et al., 2016; Mõtus et al., 2017), with researchers often attributing this divergence to management practices rather than inherent species traits (Raboisson et al., 2014). While increased dystocia may suggest a higher mortality risk in cattle crossbreeds (Raboisson et al., 2014), our findings parallel a study indicating a decline in calf losses among dairy animals (Raboisson et al., 2014; Pannwitz, 2015; Seppa-Lassila et al., 2016;

Mõtus et al., 2017; Hyde et al., 2019).

The remaining three significant variables, namely the count of crossbred bulls, the number of heifers, and the quantity of calves, exhibited a negative and significant correlation with the overall calf loss rates in dairy farming enterprises. In our study, while the artificial insemination variable aligned with the effect of the crossbred bull variable, it was deemed statistically insignificant. Both artificial insemination and crossbreeding stand out as a potent strategy, amplifying reproductive efficiency and pre-weaning performance in both beef and dairy cattle. Beyond merely augmenting the quality and gross weight of produced calves, they bolster the resilience and productivity of the herd compared to native breeds, thereby exerting a positive influence on the farm's profitability. The findings of these variables align with the results depicted in the cross-correlation heatmap presented in Fig. 4. Upon closer inspection of the heatmap, it becomes evident that the total calf loss rates exhibit a negative but statistically significant correlation solely with the ratio of culture breed bulls, as well as with the numbers of heifers and calves. These results are in line with expectations, as an increase in the number of bulls, heifers, and calves relative to a certain herd size is anticipated to decrease the number of calves lost, particularly due to the reduction in the number of animals eligible for calving. Seppa-Lassila et al. (2016) found in their study conducted in Finland that calf losses were statistically significant but inversely related to the proportion of breeds other than Holstein or Ayrshire. In a parallel vein, Raboisson et al., (2014) elicited in their research conducted in France that the percentage of both beef crossbred calves and males born mitigated the mortality rate among dairy heifers aged 3 days to 1 month. Also, the most intriguing finding in our study is the substantial impact of an increase in calf numbers on reducing calf losses, surpassing all other variables.

Fig. 5 illustrates the correlation between the estimated (e.g., predicted) total calf mortality rates and the proportion of cows in the herd across selected provinces representing the 7 geographical regions of Turkiye. The estimated total calf mortality rate is derived from probit regression analysis. As depicted in the graph, there is a clear trend where an increase in the proportion of cows in the herd corresponds to higher calf losses. This observation corroborates our previous discussions and aligns with findings in the existing literature (Raboisson et al., 2014; Pannwitz, 2015; Seppa-Lassila et al., 2016; Mõtus et al., 2017; Hyde et al., 2019). Notably, Diyarbakir and Erzurum stand out with the steepest slopes in estimated calf losses, while Balikesir, Izmir, and Konya exhibit nearly identical slopes. Similarly, Adana and Samsun show comparable slopes. Furthermore, the relationship between estimated calf losses and provinces was further analyzed through ANOVA tests (Fig. 6). Tukey's mean difference tests revealed significant differences in mean estimated calf loss rates among almost all pairwise comparisons of provinces, except for Adana-Izmir, Adana-Balikesir, Izmir-Balikesir, Konya-Izmir, and Konya-Balikesir. Such findings suggest a clustering effect among Adana, Izmir, Balikesir, and Konya, indicating similar patterns likely due to shared geographical features possessing Mediterranean and Aegean climates. Therefore, when formulating strategies to mitigate calf losses through improvement or rehabilitation programs, policymakers should consider this structural aspect, aiming to achieve optimal outcomes with minimal economic costs.

5. Conclusion

This comprehensive study utilizing the fractional probit model has shed light on the significant factors influencing calf losses in large-scale cattle farms in Turkiye. It delves into the intricate interplay among sociodemographic dynamics, geographic disparities, and managerial strategies, offering compelling insights aimed at crafting interventions to mitigate calf losses and stimulate growth in both traditional and contemporary bovine enterprises. Despite Turkiye's burgeoning population, the inadequacy of domestic production has led to a dependency on imports to meet the demand for both beef and breeding cattle. However, tackling calf mortality, which represents the most straightforward and immediate solution to bridging this gap, holds promising potential for reversing this trend. The alarmingly low fertility rates and prepartum calf losses in the country necessitate collaborative efforts to establish conducive rearing conditions, bolster hybrid and indigenous breed populations, and enhance profitability. Additionally, crafting region-specific management protocols is paramount. One pivotal determinant of fostering healthy calves is ensuring optimal maternal nutrition, particularly during periods of drought and transition. Moreover, disease prevention during these critical phases is imperative for the well-being of both dams and their progeny. Also, raising awareness among farm proprietors regarding crucial aspects such as animal nutrition, effective colostrum management in calves, disease prevention strategies, pasture management, and efficient herd supervision is of paramount importance. Agricultural extension and educational initiatives should be meticulously devised in partnership with local stakeholders, governmental bodies, and academic institutions, considering the unique priorities, circumstances, and agricultural policies prevalent in rural areas. By embracing these concerted endeavors, the country can strengthen its position in achieving sustainable crop and livestock production, fortifying food security, and fostering socio-economic advancement in the agricultural sector. Future research conducting province-level investigations correlating calf losses, encompassing non-pregnancy, ante-partum, peri-partum, and post-partum losses, with the distinctive characteristics of farm proprietors and enterprises, could provide stakeholders and national policymakers with a richer insight into the issue.

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Ethical statement

This study was carried out after the animal experiment was approved by Atatürk University Faculty of Agriculture Ethics Committee (Decision number: 2021/2).

CRediT authorship contribution statement

Adem Aksoy: Writing – original draft, Methodology, Conceptualization. **Ümit Avcıoğlu:** Writing – original draft, Project administration, Data curation, Conceptualization. **Muhammet Ali Tunç:** Writing – original draft, Conceptualization. **Mustafa Sinan Aktaş:** Writing – original draft, Data curation, Conceptualization. **Abdulbaki Bilgiç:** Writing – original draft, Methodology, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

Data availability

The data supporting this study's findings are available from the corresponding author upon reasonable request.

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