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EVALUATION OF MORTALITY MAGNITUDE AMONG HOLSTEIN FRIESIAN CALVES AND ITS RISK FACTORS EVALUATION IN AN ORGANIZED FARM OF QUETTA PAKISTAN

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ABSTRACT

A 24-year (1999-2022) retrospective study investigated calf mortality and its causes in Holstein Friesian calves. Divided into eight periods, the data explored how time, season, sire, sex, age and cause of death impacted mortality. Female calves exhibited significant variation ($P<0.01$) across these periods. The highest mortality (28%) for females occurred during period 4 (2008-2010), while the lowest overall mortality (5% for both sexes) was observed in period 6 (2014-2016). Season also significantly affected ($P<0.01$) mortality in both sexes and overall. Spring had the highest rates (16% overall, 13% male, 21% female), while summer comprehended the lowest (4% overall, 2% male, 8% female). Interestingly, sire selection played a crucial role on mortality, calves from natural sires had the highest mortality (25%), whereas calves born via artificial insemination with imported semen from different bulls exhibited varying mortality rates. No clear pattern emerged in the overall mortality across different age groups. Finally, a significant relationship ($P<0.01$) was observed between calf mortality and occurrence of various diseases. Gastrointestinal diseases were the leading cause of death (44%), followed by a group of other diseases (25%) including lower mortality causes like respiratory (13%), Foot and Mouth Disease (10%) and the lowest mortality observed was attributable to tick-borne illnesses (8%). These findings highlight potential risk factors like season, sire selection and disease prevention strategies to reduce calf mortality and morbidity in Holstein Friesian herds.

Keywords: Calf mortality, Dairy cattle, Holstein Friesian, Risk factor, Quetta

INTRODUCTION

Peri-urban commercial milk production in Quetta has grown rapidly in recent years to meet the growing demand for fresh milk in the city. Dairy farms in Quetta typically have herds of 20 to 600 cattle, almost all of which are adult females. Cross breeding with exotic European dairy breeds has also helped to establish a significant number of herds of crossbred cows in and around Quetta, which produce two to three times more milk than the local cattle for the same cost.

In the late 1970s, Livestock and Dairy Development Department, Government of Balochistan devised a dual-purpose strategy to address the persistent milk shortage in the region. The strategy had two primary goals; to introduce modern commercial dairy farming practices including scientific feeding and management methods and to establish elite cattle herd for production of genetically superior young bulls for production of male germ plasm and its dissemination through artificial insemination. These practices were to be showcased on designated farms to educate progressive farmers about contemporary farming techniques, and to facilitate the accessibility of high-yielding livestock to farmers at the grassroots level.

The ultimate aim of this strategy was to boost milk production within the province, reducing its reliance on milk imports from other regions. This project proved successful, leading to continued growth and development in Balochistan's livestock sector, making a substantial contribution to its economy.

To fulfill this approach, provincial Livestock & Dairy Development Department established Holstein Friesian Cattle Farm with the funding of Asian Development Bank (ADB) during the years 1977–79 with the import of 100 pregnant heifers and 2 breeding bulls from Denmark, housing them at Government Dairy Farm in Quetta Balochistan. Nucleus stock at the farm has been raised effectively, environmental constraints have limited the exploitation of its genetic potential. Production data spanning the past twenty-four years is available for various categories of animals and is crucial to utilize this data to assess the herd performance.

The primary objectives of this study was to leverage the accessible data to monitor disease incidence and mortality rates, pinpoint underlying issues and propose strategies to rectify these challenges, thus improving herd health and productivity and economic outcomes.

MATERIALS AND METHODS

Study Area

Quetta, the capital of Balochistan is the largest province of Pakistan from land-stretch constituting approximately 43% of the entire country land, holds a significant place. It is Pakistan's tenth largest urban center, boasting a population of 2.595 million with a growth rate of almost 3% (Census, 2023)**.** Located between $30^0$12'34" N and $67^0$01'05" E absolute locations (Quetta Data, 2024), and nestled in the Southwestern region of Pakistan, Quetta finds itself cradled within a valley, hemmed in by towering mountains from all directions. Notably, Quetta stands as Pakistan's lone high-altitude major city, with an average elevation of 1680 meters (5510 feet) above sea level. The geographic landscape surrounding Quetta presents a challenging terrain, characterized by arid conditions and predominantly mountainous terrain. Here, rainfall remains scarce, typically falling within the range of 100 to 300 millimeters per year, and temperatures exhibit extreme fluctuations between the scorching summers and frigid winters. The city has endured recurring episodes of drought, sudden flash floods and seismic tremors (Quetta geography and climate data, 2023).

Data Collection

In this study, raw data regarding death of Danish Holstein Friesian cattle calves stationed at Government Dairy Farm in Quetta Balochistan, Pakistan were taken from the record sheets and annual reports of the farm over a period of twenty-four years i.e. from January 1999 to December 2022 while excluding stillbirths and abortions.

At the farm newly born calves were identified by ear tagging, placed in individual pens and fed colostrum at the rate of 10% of body weight (twice / day) for consecutive three days and later on milk is offered for 90 to 106 days of age along with offerings of other feed ingredients (green fodder / corn silage, wheat straw and concentrates). While timely vaccination and routine deworming are performed as per schedule.

Calves were reared without any preference of sex, male calves are also remaining on high demand from progressive farmers and different local / national level organizations for breeding purposes whereas female calves play a crucial role in future herd replacement, progeny testing and / or production of superior class male production.

The dataset consisted of precise details about individual animals, including but not limited to their date of birth, date of demise, gender, genetic lineage (relative sire / dam), seasonal attributes and the causative factors leading to mortality. Rough data for pre-processing were undertaken to ensure its suitability and subsequent statistical analysis. The main objective of this analysis was to explain mortality patterns within distinct age cohorts present within the herd.

Data Classification

Over a duration of twenty-four years, the data collection period was divided into eight distinct periods, each spanning three years. These periods were characterized as P1 (1999–2001), P2 (2002–2004), P3 (2005–2007), P4 (2008–2010), P5 (2011–2013), P6 (2014–2016), P7 (2017–2019) and P8 (2020–2022). Furthermore, each year was characterized into four seasons: Spring (March to May), Summer (June to August), Autumn (September to November) and Winter (December to February), respectively.

Moreover, to investigate the effects of different diseases on calves of different ages, the calf data were divided into five age groups: 1–7 days, 8–21 days, 23–60 days, 60–106 days and young stock up to one year of age.

The data encompass information about calf births, which resulted from either bull service performed at the farm and / or the use of imported semen as indicated in the relevant table.

To facilitate a meaningful comparison of mortality rates associated with various diseases, the data were classified into several categories; including *Gastro-intestinal* conditions (primarily diarrhea or complex syndromes involving diarrhea), Respiratory ailments (mostly Pneumonia or complex respiratory illnesses), Tick-borne diseases (encompassing *Babesiosis*, *Anaplasmosis* and *Theileriosis*), Foot & Mouth Disease and other fewer common diseases / conditions such as Navel ill, Anaphylactic shock, *Sepsis*, *Colibacillosis*, liver *cirrhosis* and lumpy skin disease.

Statistical Analysis

The data were entered and compiled in Microsoft Excel spreadsheet and analyzed using the procedure described by Snedecor and Cochran (1991). The mean values and proportions were calculated using the descriptive statistical functions in Microsoft Excel.

RESULTS AND DISCUSSION

Incidence of mortality by time period

The data regarding mortality incidence across various time periods is presented in Table 1. A chi-square test of independence was conducted to investigate the relationship between time periods and the mortality of male calves, female calves, and overall mortality for both genders.

The results of the chi-square test demonstrated that there was no substantial association between the mortality of male calves and different time periods ($p>.05$). Likewise, no significant relationship was observed between mortality among all calves and varying time periods ($p>.05$). However, a significant relationship was detected between the mortality of female calves and different time periods ($p<.05$).

The highest percent overall mortality observed was (14% in P4), mortality of male calves (12% in P1) and mortality of female calves (28% in P4), while the lowest percent overall mortality, mortality of male calves and mortality of female calves happened as 5% in P6; 3% in P7 and P8 whereas 5% in P6, respectively.

Our findings align with the observations of Haley et al. (2016); Gupta et al. (2016); Hossain et al. (2013); Khattab et al. (2013); De Vries and Veerkamp (2011); George et al. (2010); Prasad et al. (2004); Somavanshi (1995); Rawal and Tomear (1994) and Debnath et al. (1990), all these workers reported a higher incidence of mortality in female calves compared to their male counterparts. This increased mortality in female calves can be attributed to their smaller size and weaker constitution at birth, making them more susceptible to hypothermia, Pneumonia, and other diseases. It may also be linked to the prevailing environmental conditions, including climatological and management features.

While contrary to this Kharkar et al. (2017) and Islam et al. (2005) noted higher mortality in male calves, more likely it may be due to the experience dystocia or difficult birth, which can further increase their risk of mortality.

Season-wise incidence of mortality

The data concerning mortality incidence across various seasons is presented in Table 2(a). A chi-square test of independence was conducted to investigate the relationship between different seasons and the mortality of male calves, female calves, and overall mortality for both genders. The findings obtained from the chi-square test revealed a statistically significant association among the variables

under investigation, specifically in relation to the mortality rates of male calves, female calves, and overall mortality, across different seasons ($p<.05$).

Highest mortality rates were observed during the spring season, with an overall mortality rate of 16%, while 13% in male and 21% in female calves. Conversely, the lowest mortality rates were recorded during the summer season, with an overall mortality rate of 4%, while 2% in male and 8% for female calves. Our data analysis revealed a significantly higher incidence of calf mortality during early spring, as 44% of spring season's mortality, this was followed by mid-spring with 36% and late spring with 20% of the total mortality **Table 2(b)**. These findings corroborate those reported by NAHMS (2017); Kharkar et al. (2017); Kumar et al. (2017); Heuser and Green (2013); De Vries et al. (2007) and Kemp et al. (2002), further strengthening the consistent observation of increased calf mortality in early spring. This pattern may be attributed to the unpredictable weather conditions specific to this season, posing a greater challenge to calf resilience and survival. Early spring in Quetta is characterized by alternating periods of cold and occasional wet conditions, interspersed with sudden warm spells. These abrupt climatic shifts can disrupt the thermoregulatory processes of newborn calves, impairing their ability to maintain a stable internal body temperature. This, in turn, increases their susceptibility to hypothermia, pneumonia and other respiratory infections.

Influence of Sire on calves' mortality incidence

The data pertaining to the impact of sire on the incidence of mortality in calves is presented in Table 3. A chi-square test of independence was conducted to explore the relationship between various sires and the mortality of the total calf population. The results of the chi-square test unequivocally revealed a statistically significant relationship among these variables ($p<.05$), affecting both the mortality rate and percentage of mortality in these calves.

The highest overall survival percentage (94%) was observed in the off springs of naturally sired animals. Similarly, survival was consistently low in the calves from dams conceived through artificial insemination with imported semen from different bulls. The data revealed these figures as 97% and 92% in male calves born from bull service and artificial insemination respectively. Same consistent trend was observed in the survival of female calves with 91% and 80% survival rate in female calves sired from natural mating and artificial insemination, respectively.

The data revealed overall mortality rates of 12% and 29% for calves born from bull service and those born from artificial insemination respectively. Study

findings are in agreement with Yeshwas et al. **(**2022) and Wudu et al. **(**2008) who reported that exotic genetic influence is also one of the major risk factors that affects calf morbidity, these findings are also in line with findings of Gunawan et al. (2011) whose data revealed an overall pre-weaning calf mortality of 8.99% in calves produced from artificial insemination than 7.05% in calves produced from natural mating system.

Table 1. Period wise mortality in exotic Holstein Friesian calves in Quetta

Period	Male calves' mortality			Female calves' mortality			Overall mortality		
	No. of Birth	No. of Death	Mortalit (%)	No. o Birth	No. of Death	Mortality (%)	No. of Birth	No. of Death	ortality (%)
P1 (1999–2001)	60	7	12	61	10	16	121	17	8
P2 (2002-2004)	93	4	4	68	12	18	161	16	10
P3 (2005–2007)	99	7	7	62	7	11	161	14	9
P4 (2008–2010)	76	7	9	25	7	28	101	14	14
P5 (2011–2013)	56	2	4	50	11	22	106	13	12
P6 (2014–2016)	69	3	4	62	3	5	131	6	5
P7 (2017–2019)	80	2	3	60	6	10	140	8	6
P8 (2020–2022)	64	2	3	57	7	12	121	9	7
Chi-Square Statistics		**21.78**			**51.71**		**22.73**		
P–Value		**0.083NS**			**0****		**0.073NS**		
NS = Non-Significant				*Significant at P <0.05			**Significant at P <0.01		

Table 2(a): Season wise mortality in exotic Holstein Friesian calves in Quetta

Season	Male calves' mortality			Female calves' mortality			Overall mortality		
	No. of Birth	No. of Death	Mortality (%)	No. of Birth	No. of Death	Mortality (%)	No. of Birth	No. of Death	Mortality (%)
Winter	227	11	5	151	26	17	378	37	10
Spring	86	11	13	67	14	21	153	25	16
Summer	195	3	2	162	13	8	357	16	4
Autumn	89	9	10	65	10	15	154	19	12
Total	**597**	**34**		**445**	**63**		**1042**	**97**	
Chi-Square Statistics		**43.42**			**28.96**		**42.53**		
P–Value		**0.00000010****			**0.000061****		**0.0000014****		
*Significant at P <0.05				**Significant at P <0.01					

While these findings were found contrary to those reported by other workers like Philip et al. (2011) and further Lardner et al. (2015) who advocated artificial insemination system more beneficial than that of natural mating system. It is inferred from their studies that natural mating systems often involve the use of older bulls, which are more likely to produce calves with genetic defects that can lead to death. Nevertheless, definitive conclusions regarding the cause of the increased mortality rate cannot be drawn without further investigation and access to more comprehensive data.

Effect of age on calf mortality

The data relating to the mortality in calves of different age groups is shown in Figure 1. A chi-square test of independence was conducted to explore the relationship between mortality and different age groups. The results of the chi-square test did not expose a statistically significant relationship among these variables ($p>.05$), both the total mortality and percentage of mortality in these calves. No legible pattern was visible in overall mortality percent among different age groups.

According to present study, the first 21 days of age was the most critical period of calf life with 62% of the neonatal mortality occurring during this time only. Results in the current study revealed a higher mortality during first 21 days of neonatal life. The results of the present study correspond to the findings of **Mishra et al. (**2015) **and** Gusbi and Hird **(19**83); who reported a mortality incidence of 12.5–26% in cow calves at four weeks of age.

Table 2(b). Effect of early, mid and late spring season on mortality in exotic Holstein Friesian calves, Quetta

Season	Mortality	
	No. of Death	Mortality (%)
Early Spring (March)	11	44
Mid Spring (April)	9	36
Late Spring (May)	5	20
Total	25	100
P–Value	0.32***	0.01*
*Significant at P <0.05;	**Significant at P <0.01	***Nonsignificant P<0.05

The robustness of the findings from the present study is further reinforced by the observations of Moran (2011) and Ahrar and Khan (1991). In their review papers, they reported that neonatal calf mortality within the first month of life accounts for approximately 84% of total mortality, with a particularly high incidence during the third week of life.

Table 3. Birth, mortality and survival data in progenies of both natural and artificial inseminated bulls

Particular	Birth Data	Number Died	Number Survived	% cent Survived	Chi-square Statistics	P value	% cent Died	Chi-square Statistics	P value
Male									
Bull Service (BS)	301	9	292	97	18.24	0.0001 **	3	21.32	0.000 **
Artificial Insemination (AI)	296	25	271	92			9		
Total	**597**	**34**	**563**						
Female									
Bull Service (BS)	249	23	226	91	17.29	0**	9	25.03	0**
Artificial Insemination (AI)	196	40	156	80			20		
Total	**445**	**63**	**382**						
Overall									
Bull Service (BS)	550	32	518	94	31.17	0**	12	35.77	0**
Artificial Insemination (AI)	492	65	427	87			29		
TOTAL	**1042**	**97**	**945**						
NS = Non-Significant				*Significant at P <0.05			**Significant at P <0.01		

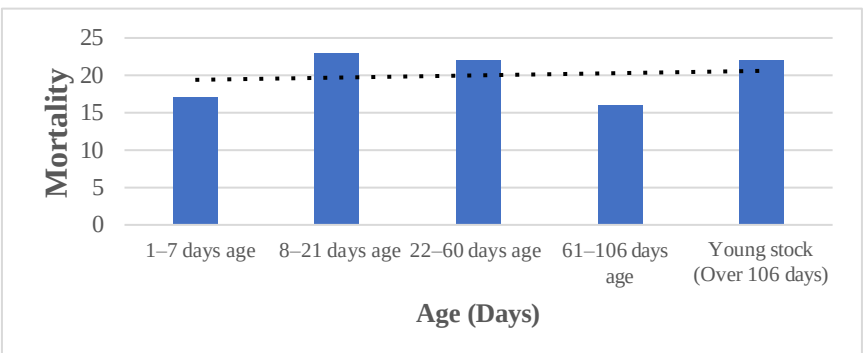

Figure 1. Incidence of total mortality in different age groups of calves (%)

Influence of diseases on Calves Mortality

The data relating to the mortality of calves due to various diseases is shown in the Table 4 (a) and (b) below. A chi-square test of independence was conducted to explore the relationship between mortality and different diseases.

The results of the chi-square test revealed a statistically significant relationship among these variables ($p<.05$), both on the mortality and percentage of mortality due to various diseases in these calves.

Occurrence of gastro-intestinal diseases was found as the main cause of mortality with highest mortality rate (44%), it was followed by group of other diseases – including diseases that erupted in minor numbers (25%), which was followed by respiratory diseases (13%), FMD (10%) and Tick-borne diseases (8%). Obviously, gastrointestinal diseases were the main cause of mortality which was followed by respiratory diseases.

Previous findings also agreed with our findings whom stated the two most common causes that affect calves' mortality are gastrointestinal disorders and respiratory disease from birth to 3 to 6 months of age group life; and these causes were influenced by housing conditions, colostrum intake and feeding management of calves (Abebe et al. 2023; Ahmedin and Assen 2023; Alemu et al. 2022; Yeshwas et al. 2022; Gomes et al. 2021; Hadgu et al. 2021; Hordofa et al. 2021; Tsegaw et al. 2020; Sarita et al. 2020; Pathak et al. 2018; Kharkar et al. 2017; Kranti et al. 2017; Fentie et al. 2016; Islam et al. 2015; Mishra et al. 2015; McCorquodale et al. 2013; Bhat et al. 2012, Torsein et al. 2011; Balvir et al. 2009; Wymann et al. 2006; Islam et al. 2005; Verma et al. 1996; Rao and Nagarcenkar 1980).

Table 4 (a). Incidence of total mortality in calved due to different diseases

Diseases	**Mortality**	**Mortality (%)**
Gastro-intestinal	83	44
Tick Borne	16	8
Respiratory	24	13
Others	48	25
Foot and Mouth Disease	18	10
Chi-Square Statistics	84.78	44.7
P–Value	0.00**	0.00**
*Significant at P <0.05		**Significant at P <0.01

In accordance with earlier research by Ahrar and Khan (1991), the current study demonstrates a clear association between neonatal calf mortality and various infectious agents, including rotavirus, coronavirus, Entero-pathogenic *Escherichia coli*, *Salmonella* species, and *Cryptosporidium*. These findings offer further support for the established link between these pathogens and calf death. Ahrar and Khan (1991) also identified several other significant contributors to calf mortality, including immunodeficiency, seasonal variations, difficult parturition, and inadequate management practices. These factors highlight the multifaceted

nature of calf mortality and emphasize the dire need for comprehensive preventative strategies.

Table 4 (b). Mortality due to different diseases as % calf mortality due to various diseases in different age groups

Diseases	**Age at death**				
	1–7 Days	**8–21 Days**	**22–60 Days**	**61–106 Days**	**Young Stock (Over 106 Days)**
Gastro-Intestinal	17	30	25	9	19
Tick Borne	6	6	6	38	44
Respiratory	29	29	4	17	21
Others	19	15	32	17	17
Foot & Mouth Disease	5	22	17	28	28
Chi-Square Statistics	123.94				
P–Value	0.00*				
*Significance at P <0.05		**Significant at P <0.01			

CONCLUSION

Young stock management is a major concern in many small dairy farms of the area. Age group from birth up to one year age receive insufficient care due to their non-income generation character for many months. Especially from birth to three months age which is the most expensive period of a dairy animal's life. And emphasis on prevention is critical, limiting need for subsequent intervention, particularly in the management of gastrointestinal and respiratory system diseases.

Mortality in early age of calf not only decreases milk and meat production, but also lowers the genetic pool by making problems in the breeding programmes. Furthermore, to run a profitable dairy business, it is an utmost need of the situation to control mortality in calves and young stock. Study shows different causes of calf mortality which can be minimized so that economic losses shall also be decreased. If we lower down the calf mortality rate in these days we can get a better opportunity for economic and genetic improvement in the herd.

To achieve these objectives, a strict dairy management plan including biosecurity and prophylactic measures along with a balanced nutritional plan should be

devised and implemented to control mortality in their early age period, particularly considering the prevailing dairy practices in this enterprise.

In general, for a successful dairy farming development programme and particularly in livelihood initiative, information sharing regarding the risk factors of calf morbidity and mortality among dairy farmers is dire need of this enterprise.

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