Diarrhea in Pre-Weaned Calves: Relative Risk Rates for Morbidity and Mortality in 13 Commercial Farms of Hot Arid Zone

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Abstract: Problem statement: In many hot arid countries, pregnant Holstein Friesian heifers are imported for herd replacement. The calves obtained from exotic cows are exposed to adverse climate in feedlot system resulting in very high morbidity and mortality rates. Diarrhea, dehydration and deaths are causing a major loss to the producers. This study examines the Risk Rates (RR) for morbidity and mortality in pre-weaned calves. **Approach:** Thirteen commercial dairy farms of small, medium and large sizes were surveyed using 1,280 newborn calves. A survey was conducted for calves from their birth to weaning at 90 day. Parameters of the study were birth weights, colostrum feeding, growth rate, incidences of diseases, clinical symptoms, post-mortem findings and results of laboratory investigations of samples obtained from sick and dead calves. Calf housing and feeding management of 13 farms were investigated. **Results:** RR for morbidity and mortality ranged from 0.3-1.00 and being highest during the first week. Most common disease was diarrhea representing 90.6% of the total calves affected. Common pathogens causing diarrhea were *E. coli*, *Salmonella* sp. *Klebsiella*, *Pasturella* and *rotavirus*. Relationship between calf management and morbidity RR for diarrhea was significant ($r^2 = 627$, $p = 0.01$) and the growth rate was positively correlated ($r^2 = 0.761$, $p = 0.1$). Diarrhea caused a significant negative impact on gross margins of the calf enterprises. **Conclusion:** Colostrum feeding and housing management were the key factors for causing a high RR for morbidity and mortality. Gross margin loss was significantly influenced by morbidity and mortality RR of calves.

Key words: Calf, diarrhea, morbidity, mortality, gross-margin, *E. coli*, pre-weaned calves

INTRODUCTION

In countries of hot arid zone, high calf morbidity and mortality risks represent a major economic loss to the dairy operations (Svenssson *et al*., 2006). The most common cause of calf-hood disease was diarrhea (Wudu *et al*., 2008) during their early ages, followed by pneumonia, joint ills, septicemia word (Razzaque *et al*., 2009a; Gulliksen *et al*., 2008). In addition to economic losses, calf-hood diarrhea has public health significance due to zoonosis associated with food borne diseases and antibiotics residues derived from treated calves. Recent studies of Razzaque *et al.* (2009b) showed that losses of profits due to calf mortality in hot arid zone was very high ranging from 12-61% of the gross revenue. The most common causes of diarrheal diseases in pre-weaned calves (Razzaque *et al*., 2009a) were bacteria (*E. coli*, *Salmonella* sp. and *Klebsiella*) and virus (*Coranovirus* and *rotavirus*). Razzaque *et al*. (2009c) found that individual hutch housing of calves played an important role in combating calf-hood diseases. On-time identification of causes of diarrhea and improvement of passive immunity, hygienic feeding and management of calves were found to be the key elements for reducing calf losses in the commercial dairy farms (Razzaque *et al*., 2009c). Present study examines the relative morbidity and mortality Risk Rates (RR) of commercial dairy farms of Kuwait and gross margins of calf enterprise in dairy farms affected by diarrhea through on farm survey studies.

MATERIALS AND METHODS

Study site and climate: The dairy farms were located in the Government assigned site at sulaibiya 25 km away from the Kuwait city. The climate in the country has four seasons: Summer, autumn, winter and spring. Summer extends over June to September, this season is mostly dry and the temperature can exceed 48°C at daytime with a low Relative Humidity (RH) ranging

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from 10-50%. RH increases after August to September and then temperature declines. During the Autumn season (October and November) temperature declines to 30 and 20°C respectively at daytime having a RH ranging 50-90%. Winter season extends from December to March and temperature can reach a low as -4°C in January at night and as high as 10-19°C at daytime. Spring season covers part of March to May with a temperature 20-30°C at daytime.

Survey study: Thirteen (13) commercial dairy farms were used out of a total 29 dairy farms of the country. These farms were of 3 main categories: 4 large (>500 adult cattle), 5 medium (250-499 cattle) and 4 small (<249 cattle). The dairy cattle population used in the study represented 56% of the total 11,760 adult herds. A survey format was designed to include important variables of calves from their birth to weaning at 90d. The records of a total of 1,280 newborn Holstein Friesian calves at their birth to the advancing ages were included. Those were mainly type of deliveries, colostrum feeding, diarrheal diseases, clinical symptoms of sick calves, calves died postmortem findings and laboratory investigation of the samples submitted from the sick calves and dead calves. Biological samples obtained from the sick and dead calves and fecal samples were used for identification of bacterial and viral infections according to Bruckner *et al.* (2007).

Criteria for scoring the calf management and feeding data were used for assessing the calf performance in the farms (Razzaque *et al.*, 2009d). Data of all calves born during the calving season were analyzed (Ross and Payne, 2002) for statistical analysis of risk rates for morbidity and mortality as well as for calf management scores.

Risk Rate (RR): RR cumulative incidence was calculated using the formula:

Number of calves acquiring the event of interest/initial number of animals at risk-half (1/2) the withdrawal (excluding the animals acquiring the event).

Case fatality rate (the risk of death in an animal with a specific disease): Case fatality rate was calculated using the formula: Total deaths within a specified time after diagnosis/total number of animals acquiring the disease.

Gross margin analysis of diarrheal diseases: All of the total 13 commercial dairy farms were surveyed for the diarrheal diseases. However calf enterprise variable costs were determined for feeds, labor and veterinary input costs for only 6 farms, farm IDs 2, 4, 6, 9, 11 and 13 could be obtained as these farms had incomplete records Table 6.

RESULTS

Risk Rate (RR) for morbidity and mortality: The RR for morbidity and mortality had ranged from 0.05-1.00 and 0.03-1.00 respectively Table 1. The risk of morbidity and mortality in calves was highest during the first two weeks calf life, when 89.2% of the total cases of morbidity and 50.3% of the total deaths occurred. Farm 12 lost all of its 27 calves born during the calving season. Most common disease was diarrhea resulting in dehydration of calves representing 53% of the total 1,280 calves surveyed. Combined mean case fatality rate was 48.9% and mean RR for morbidity and mortality were 0.59 and 0.29 respectively Table 1.

Causes of diarrhea: Enterogenic pathogens causing diarrhea and diarrhea combined with septicemia were *Escherichia coli* and *Salmonella* sp., Table 2.

Table 1: Diarrhea cases, disease-specific morbidity and mortality risk rates and case fatality rates on surveyed farms in 1998/99

Farm ID No.	Calves affected by disease (No.)*	Diarrhea cases (No.)**	Diarrhea deaths (No.)	Case fatality rate (%)	Risk rate for morbidity (0-1 scale)	Risk rate for mortality (0-1 scale)
1	293	275	91	33.09	0.96	0.32
2	140	129	45	34.88	0.60	0.21
4	10	10	5	50.00	0.40	0.20
5	9	5	3	60.00	0.05	0.03
6	7	6	4	66.67	0.05	0.03
7	9	9	8	88.89	0.33	0.30
8	13	6	4	66.67	0.10	0.06
9	62	61	53	86.89	0.79	0.69
10	31	27	8	29.63	0.77	0.23
11	36	31	25	80.65	0.54	0.44
12	27	27	27	1000	1.00	1.00
13	112	92	57	61.96	0.74	0.46
Total	749	678	330	48.67	0.59	0.29

*: Not including 15 calves that had a repeat attack of diarrhea; **: Not including an additional 15 repeat cases

Table 2: Bacteria and rotavirus isolations from individual farms

Farm ID	Total number examined	Rotavirus	E. coli/ Klebsiella/ Pastuerella	Salmonella B (*)	C	E
1	5	2	2		1	1
2	17	1	4	1		2
4	16	2	6			1
5	16	3	2			1
6	23	2	10		1	
7	3		2			1
8	5	2	1			1
9	28	3	14		3	2
10	3	1	1	1		
11	20		9		1	1
12	6	1	4			2
13	30	3	8	1	1	8

(*): Including unspecified *Salmonella* positive; Including 13 multipositives sample; Including 1 sample positive to *Pseudomonas* sp. in farm ID12

Table 3: Effects of calf-herd size on mortality Risk Rates (RR) and daily liveweight of preweaned calves daily growth rate of calves on surveyed farms

Farm ID	Calf herd size	No. calves sampled	RR 0-1 scale	Mean (±SE) daily Live-weight gain (g day^{-1})
1	386	6	0.34	644±51.9
2	215	50	0.24	409±18.0
4	25	12	0.20	418±37.2
5	106	38	0.07	552±32.9
6	133	21	0.04	414±15.9
7	29	3	0.30	476±30.7
8	65	14	0.15	522±33.1
9	77	4	0.70	465±55.0
10	35	0	0.31	N/A
11	57	10	0.51	475±45.5
12	27	0	1.00	N/A
13	125	29	0.58	404±23.9
				*460±11.3

*: Overall mean

In diarrhea cases, 76.2% of (16/21) of the *E. coli* isolates occurred in young calves of ages from birth to 10d, while *Salmonella* sp., occurred in a wider range of ages from birth to 26d. *Rotavirus* was the most commonly found pathogen in all farms on average 10% of the total sample examined. *Klebsiella* occurred along with *E. coli* in diarrheal calves. *Pasteurella* sp. occurred only 6.5% of total sample examined (table not presented). *Salmonella* sero types B, C and E were isolated and combinedly represented 15% of total samples. Unidentified cause of diarrhea accounted for 3.3% of the diarrhea affected calves.

Relative calf-herd size and growth rate: Daily growth rate varied widely within individual farm and between the farms with a range from 404±11.3-644±51.9 g h^{-1} day^{-1} with a mean ± SD of 460±11.3 g h^{-1} day^{-1} Table 3. Calf-herd sizes had no significant effect on mortality RR and daily live weight gain.

Calf housing and feeding management: The analysis showed a negative correlation between calf management and morbidity and mortality RR Table 5. The relationship between diarrhea morbidity and management score was significant ($r^2 = 0.627$, $p = 0.01$). The feeding was also positively correlated with the growth rate ($r^2 = 0.761$; $p = 0.01$).

Gross margin analysis: The variable costs/calf ranged from KD 3.85 (US$ 13.32)-KD 18.34 (US$ 63.45) for labor and KD 21.52 (US$ 74.46)-KD 30.44 (US$ 105.32) for feeds depending on the management and number of calves in the farms Table 6. The gross margin Table 6 ranged widely between the calf farms ranging KD 52.17 (US$ 180.50)-KD 92.70 (US$ 320.74). These differences in the gross margin were primarily due to differences in losses of pre-weaned calves Table 1.

DISCUSSION

The calves from their birth to weaning at 90 d of hot arid region are mostly raised under feedlot management system. They are housed in metallic crates in the confined closed type environment, therefore, chances of pathogen spread are very high. A crude mortality rate (43.6%) was reported in Kuwait (Razzaque *et al.*, 2009a). Most of the deaths in young calves found in Kuwait were due to diarrhea Table 1. Out of 749 calves affected by the diseases, 90.6% were caused by diarrhea, therefore, it was considered as a killer disease. Besides arid zone, in many other countries like Pakistan and Ethiopia, severe problems of diarrheal diseases in young calves were observed (Wudu *et al.*, 2008).

Causes of diarrhea in young calves: Most pathogens isolated were *E. coli*, *Pastuerella, Salmonella* sp. (types B, C and E), *Klebsiella* and *Rotavirus* Table 2. Farm to farm variations of pathogens were large depending on the calf housing and feeding and management practices Table 4. Among the *Salmonella* strains B, C and E represented 10, 23.4 and 66.7% of the total identified strains respectively. The dairy farms under our study were close to one another (5-50 m apart only) and the rodents, birds and humans were found to be the carriers of the *Salmonella* sp.

Table 4: Criteria and scores awarded for assessing calf housing and feeding management

Housing variables	Farm ID											
	1	2	4	5	6	7	8	9	10	11	12	13
Separate facility precalving/calving	0	0	0	1	1	0	0	0	0	0	0	0
Low stocking rate<5/Pen	0	0	0	1	1	0	0	0	0	0	0	0
Regular cleaning of calving pen	0	0	0	1	1	0	1	0	0	0	0	0
Colostrum feeding removal of calf after delivery	1	1	1	1	1	0	1	0	0	1	1	1
Individual calf crate or< 10/pen	1	1	1	1	1	1	1	0	0	0	0	0
Cleaning system with disinfection	0	0	0	1	1	0	1	0	0	0	0	0
Effective heating	0	0	0	1	1	0	0	0	0	0	0	0
Isolation of sick calf and disinfection	0	0	0	0	0	0	1	0	0	0	0	0
Total score for housing	2	2	2	7	7	1	5	0	0	1	1	1
Feeding												
Colostrum feeding supervised/forced	1	1	1	1	1	0	1	0	0	1	0	0
Individual calf feeding method	1	1	1	1	1	1	1	0	0	1	0	0
Whole milk/milk replacer quality	1	1	1	1	1	1	1	1	0	1	1	1
Amount 5% BW×2 Daily or 5 l/d	1	0	0	1	0	0	0	0	0	0	0	0
Concentrate from few days of age	1	1	1	1	1	1	1	1	1	1	1	1
Freshwater available	1	0	0	1	1	1	1	1	1	1	1	1
Weaned from milk on>2 kg conc. day^{-1}	1	1	1	1	1	1	1	1	1	1	1	1
Hay fed from a few days of age	1	0	0	0	0	0	0	1	1	0	0	0
Total score for feeding	8	5	5	7	6	5	6	5	4	6	4	4

Table 5: Linear correlation between calf management scores and morbidity, mortality and growth rates

Variable	Calf management (r^2)	Feeding management (r^2)
Morbidity RR*	0.633 (p<0.01)	-
Mortality RR	0.460 (p<0.05)	-
Morbidity RR (Diarrhoea)	0.627 (p<0.01)	-
Mortality RR (Diarrhoea)	0.428 (p<0.05)	-
Growth rate/d	-	0.761 (p<0.01)

*: RR = Risk Rate

The bacteria identified in Kuwait Table 2 were mainly enteric, enterotoxigenic K-99 strain *E. coli* and septicemic *Salmonella*. Over 50% of the calves had low level of immunoglobulins and serum proteins than acceptable levels and standard recommended by Orro *et al*. (2008). Colostrum composition and its management were found to play a major role in preventing calf diarrhea (Kehoe *et al*., 2007). Post-mortem examinations revealed gross pathological changes of Peyr's patches and ileum as observed by Zhang *et al*. (2002). The *Salmonella* serotype B was found to be the main cause of diarrhea and mostly spread by the rodents, bird, humans and vehicles. These findings were consistent with the observations of Costello (2010) who found that above means of transmission of *Salmonella* were very common in dairy operations in other countries.

Diarrhea associated with mild to severe dehydration was very common in our calves, therefore, electrolyte therapy was used for the dehydrated calves. The calves with mild diarrhea and septicemia survived, yet the mortality RR was found to be very high Table 1.

Gulliksen *et al*. (2008) noted that calf diarrhea was a major ailment caused by several pathogens and the predisposing factors were mainly the lack of colostrum, failure to absorb cloistral antibody (Razzaque *et al*., 2009d) adverse nutritional and adverse environmental effects. All these factors were found to be common in hot arid zone including Kuwait (Razzaque *et al*., 2009a) and in the farms of similar management practices (Trotz-Williams *et al*., 2008). The results of our study suggest that housing and feeding management of calves of Kuwait's dairy herds played major role in predisposing young calves to a high morbidity and mortality RR Table 1 and 4.

Diarrhea can be caused by both non-infectious and infectious agents (Costello, 2010). Noninfectious causes of diarrhea in young calves are dietary changes, overfeeding and changing of milk replacer brands. In our study non-infectious diarrhea was rare, as the milk replacers used were from the same source and of the same brand. The calf starters were farm made, using common feed ingredients and overfeeding was avoided.

Growth rate of pre-weaned calves: Due to the adverse effects of diarrheal diseases and presumably environment factors as well such as housing/feeding management had significantly (p = 0.05) affected the growth rates of calves Table 3. A mean daily gain of calves was 460 ± 23.9 g h^{-1} which was well below the expected daily gain ranging from 600 g-950 g h^{-1} depending on the type and quality of milk replacers and calf starter fed (Yarlagadda and Lee, 2008; Bach *et al*., 2007).

Table 6: Calf enterprise income and expenditure (KD**): gross margin analysis of six   farms

Economic variable	Farm ID					
	2	4	6	9	11	13
Income (KD) mortality**						
Number of calves born	278.00	133.00	380.00	218.00	108.00	179.00
Number of calves reared	181.00	66.00	249.00	55.00	41.00	85.00
No. of calf deaths<1 wk	78.00	22.00	31.00	147.00	48.00	32.00
No. of calf deaths 2 wk-3 mo	19.00	12.00	10.00	16.00	19.00	62.00
Total death	97.00	34.00	41.00	163.00	67.00	92.00
Calf value @ 1 wk	50.00	50.00	50.00	50.00	50.00	50.00
Calf value @ 3 mo	100.00	100.00	100.00	100.00	100.00	100.00
Income calf sales	18,100.00	8,250.00	29,400.00	5,500.00	4,100.00	8,500.00
Calf enterprise variable costs						
Labor: Total	960.00	840.00	958.00	719.00	712.80	1559.00
(Cost/calf)	(5.30)	(12.73)	(3.85)	(13.07)	(17.39)	(18.34)
Feed: Total	4,064.40	1,940.90	5,358.30	1,626.50	1,248.00	2,157.9
Cost/calf	(22.45)	(29.41)	(21.52)	(29.44)	(30.44)	(25.39)
Animal health, Power*, Water*	60.45	61.31	445.71	103.950	54.69	155.55
Cost/calf	0.33	0.93	1.79	1.89	1.33	3.79
Administration, Rep, maintenance of buildings	212.31	94.84	362.65	191.02	89.05	153.32
Total cost	5,297.16	2,937.05	7,124.66	2,640.47	2,104.54	4,025.77
Gross margin: Total	12,802.84	5,312.95	22,275.34	2,859.53	1,995.46	4,474.23
Gross margin/calf reared	70.72[b]	80.50[a]	89.46[a]	51.99[c]	48.67[c]	52.64[c]

**: KD 1.000 = US$ 3.46; Different superscripts a, b, c in different columns are significantly different (p = 0.05)

Gross profit/margin: Diarrhea caused a significant adverse economic impact on gross margin of all 13 dairy farms Table 6.These adverse effects were directly related to the magnitude of calf mortality rate. Due to very high costs of labor and animal health for taking care of sick calves in farm nos. 9, 11 and 13 had significantly lower gross margin/calf reared Table 6. Feed cost ranged from KD 21.52 (US $ 74.46)-KD 30.44 (US $ 105.33) per calf from birth to weaning Table 6. These costs are much higher than those reported for other countries due to high costs of imported milk replacers and feed ingredient cost for calf starters in Kuwait (Razzaque *et al*., 2009b).

CONCLUSION

Major cause of high Risk Rates (RR) for morbidity and mortality in pre-weaned calves was diarrhea. On-time colostrum feeding and housing management interventions were the key factors in reducing calf losses in feedlot farms of hot arid zone. Gross margin loss was significantly influenced by morbidity and mortality RR of calves.

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