Diagnosing and Mitigating the Risks of Lambs' Mortality in the Sheep Farms of Kuwait

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Abstract

A survey was carried out to diagnose the rates of mortality of lambs in the sheep farms of Kuwait. The survey results helped determine that the cause of high mortality rate in Kuwait of newborn lambs (≈35%) during the first three weeks of age is the certain infectious diseases affecting the sheep. Following the survey, a field experiment was carried out using a modified vaccination protocol (vaccination during pregnancy) to improve the immune status of the secreted colostrum. This new protocol has improved the immunity of newborn lambs after suckling the hyperimmune colostrum, and reduced mortality rate significantly, compared to the conventional protocol (vaccination before pregnancy). The results have proved the efficiency of the modified vaccination protocol. The experiment concluded that the vaccination during pregnancy has shown great promise to reduce the mortality rate of newborn lambs in sheep farms of Kuwait. Upscaling the tested vaccination protocol may set the scene for the betterment of sheep industry of Kuwait.

Keywords: Diseases; infection; lamb; mortality; newborn lambs; survey.

1. Introduction

Arabian Gulf region is known for its hot arid climate. Fat-tailed sheep in this region are well adapted to such harsh climatic conditions, and provide abundance of lean meat (Razzaque & Abbas, 2010). In Kuwait, Naeemi sheep breed represents 65 to 70% of the total sheep population, which are widely adapted to the harsh arid local climate (Mohammed *et al*., 2009; Razzaque & Abbas, 2010). The highly nutritious and tasty meat of the Naeemi sheep motivates the farmers to increase the local production. However, high disease incidences have led to high mortality rate in lambs, which has resulted in livestock producers suffering significant losses in their Naeemi sheep production. To address these losses and to set a way forward to improve the sheep industry in Kuwait, a field survey was carried out to diagnose the causes of high mortality rates lambs in both the private and public farms. Vaccination is considered a standard practice to reduce the incidence of various diseases affecting the sheep flocks. After completing the survey, a field experiment was carried out in the selected farms to compare vaccination protocols to control lambs' mortality rates. It was hypothesized that compared to conventional vaccination of ewes before pregnancy period, the vaccination during the pregnancy controls the newly born lambs' mortality through improving the quality of the colostrum secreted.

1.1 A. Survey Study

A farm survey was conducted in nine sheep farms in Kuwait and information was collected. The information was recorded using a scientifically designed questionnaire to establish the baseline data on lambs' mortality in Kuwait. The aim of the survey was to evaluate the rate of mortality in young lambs, especially during the first three weeks of age (Appendix-I) and make efforts to mitigate these losses. The selected farms were categorized into small (10-150 heads), medium (151-750) and large (751-1,000 heads) categories (Figure 1). The team visited the small and medium farms once and large farms twice a week to collect the information. The project leader coordinated with the farm managers to confirm the date and times to facilitate the survey and to assure that the farm staff is available to help fill the questionnaire. Data was collected during the peak lambing time of ewes.

1.2 B. Field Experiment

After completing the farm survey, a field experiment was carried out in the selected farms. The main objectives of the field experiment are: (1) to investigate the mortality rate (%) of lambs and causes of mortality; (2) to investigate and compare the effectiveness of the vaccination protocols used in the selected farms; and (3) to investigate the effect of the newly introduced vaccination protocol on the quality of secreted colostrum of ewes.

2. Materials and Methods

2.1 Experimental Design for the Field Experiment

Three flocks (F#1, F#2, F#3) were separated from each farm. A total of 27 flocks were used in the field experiment. Each flock was comprised of 6 ewes (27 flocks X 6 ewes =162 ewes), and the ear tags were used for the selected ewes to identify and monitor their performance. All selected ewes belong to Naeemi sheep breed (12-18 months old, live weight 38 ± 2.89 kg). During the field experiment, two vaccination protocols were used:

1) Conventional vaccination protocol used by the farmers, i.e., the ewes were vaccinated once before pregnancy and then a straight breeding program of mating Naeemi rams with Naeemi ewes.
2) KISR's vaccination protocol (ewes were vaccinated twice during the pregnancy period).

2.2 Vaccination Protocol Used in the Selected Farms

Ewes at Fuad Al-Ghanim, Al-Reham, Al-Terkeet, Al-Redab, Al-Hamaeid farms, and PAAFR, DEGTC, and BDTC's farms were vaccinated according to the vaccination protocol recommended by PAAFR. Thus, the flocks were vaccinated with 1. *Clostridial sp.*, which consists of seven species of the antigen [(*Cl. Septicum; Cl. Perfringens Types A, C, and D; Cl. Sordellii; and Cl. novy, Type B toxoids* (CZ Veterinaria S. A, Spain)]; 2. *Pasteurella sp.* (CZ Veterinaria S. A, Spain); 3. *PPR* (CZ Veterinaria S.A, Spain) and 4. *FMD* (CZ Veterinaria S.A, Spain) before pregnancy period and no intervention measures were taken during the pregnancy period. In contrast, ewes from KISR's farm were vaccinated with the

same vaccines as mentioned before, but ewes were vaccinated twice during the pregnancy period. The first vaccination was at the beginning of the pregnancy period, and the second booster dose was given four weeks prior to lambing. Ewes were given selenium and vitamin E as supplements during the pregnancy period.

2.3 Mortality Rate (MR) of Lambs

The MR is defined as the percentage of lambs died at the age between 1 and 21 days after birth. The mortality rate of lambs is calculated using the standard equatuion: MR=[(A-B)/A] X 100 (Hashemi *et al*., 2008), where A = Total number of born lambs, and B = number of survived lambs.

2.4 Collection of Blood Samples

Blood samples were collected before the morning feeding from the jugular vein in 10–ml vacutainer tubes (Moore *et al*., 2005). Blood samples were incubated at room temperature for 2 hours (h), and then centrifuged at 2000 × *g* for 10 min at 4 °C (Universal 32 R, Hettich–Zentrifugen, Tuttlingen, Germany) to separate and collect the serum samples. The collected serum samples were stored at –20 °C until analysis.

2.5 Collection of Colostrum Samples

To collect the colostrum samples (6-12 hours after birth), teats were grasped between the thumb and forefinger and were gently squeezed to force the milk downward within the teat canal. Colostrum was collected in clean plastic screw-top containers. Colostrum samples were stored in a freezer at –20 °C until analysis by Enzyme-Linked Immunosorbent Assay (ELISA) kits.

2.6 Enzyme-Linked Immunosorbent Assay

The concentrations of immunoglobins (Ig's) in the colostrum and serum samples were determined by ELISA method using ELISA kits (SunLong, China), and the results were compared with purified sheep Ig's, as standard reference. Results were expressed as milligrams (mg) of Ig per milliliter (ml) of serum/ colostrum. Samples were individually analyzed in triplicate, and a valid result was considered when differences between obtained results were less than 10 % (Crowther, 2009).

2.7 Diagnosis of Diseases that Cause Lambs' Mortality

To diagnose the causes of lambs' mortality, tissue samples were collected from different organs of dead lambs by using Koch's Postulates. Koch postulated depends mainly on three rules: a) the isolated microorganism should be isolated from all animals infected with the same disease; b) the microorganism should be isolated from the infected animal and grown in pure culture; and c) this specific microorganism should be reproduced when inoculated into a healthy animal (Burezq *et al*., 2015**)**.

3. Results of Field Survey

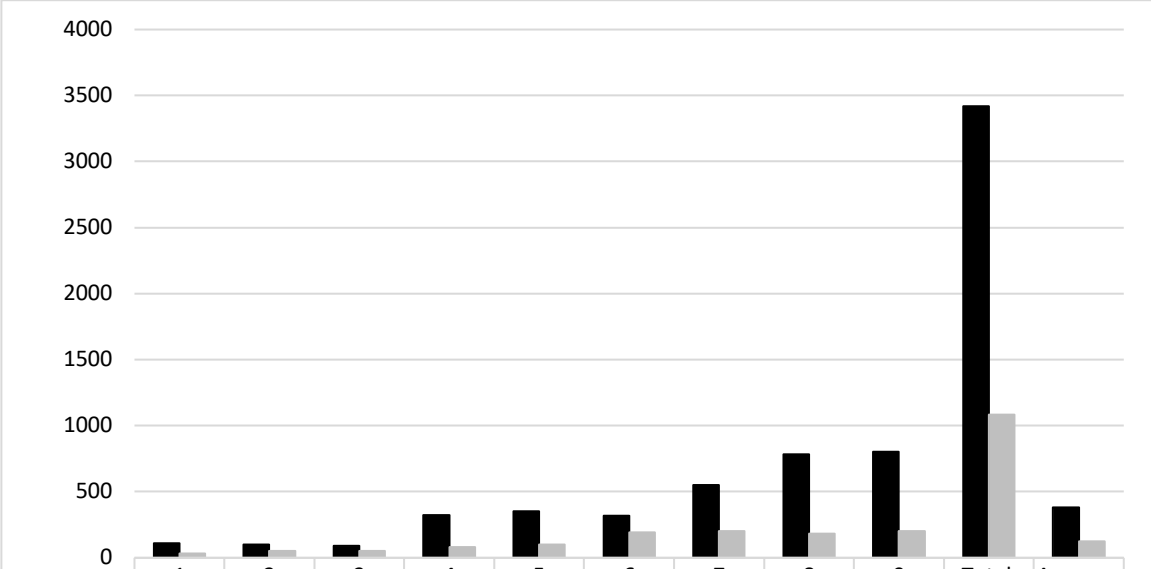
The descriptive statistics for data collected from survey work are listed subsequently:

3.1 Housing System

The housing system used in all visited farms was confined (zero grazing) because of hot weather and scarce vegetation cover in the deserts, which is not enough to meet the grazing requirements of the animals. Each farm was managed by a supervisor and three to five laborers. The pens are cleaned on daily basis, but the bedding is changed annually and replaced with clean sand. The animals are given free access to freshwater for drinking. All farms were surrounded with a fence to protect the herd from diseases transmitted from any wild animal. In contrast, pens in KISR and PAAFR farms were cleaned daily, and bedding was changed weekly and replaced with clean sand.

3.2 Management Level

Management level was one of the criteria recorded during the survey study, since it significantly affects the mortality rate of lambs. The main difference between the private farm and KISR/PAAFR farms is hygene related. The management level in seven out of nine farms was very good, but at KISR and PAAFR farms the management level was excellent. All farms have separate pens for ewes and their lambs after lambing and until weaning, except Al-Terkeet farm, where ewes were kept in the same pen with the other animals. Total number of lambs and ewes in each farm is shown in Figure 1, and the summary of the data collected is given Table 1.



	1	2	3	4	5	6	7	8	9	Total	Average
Ewes	110	100	90	320	350	318	551	780	800	3419	379.89
Lamb	30	50	50	80	100	193	200	180	200	1083	120.33

1: Fuad Al-Ghanim Farm, 2: Al-Reham Farm, 3: Al-Terkeet Farm, 4: Al-Redab Farm, 5: Al-Hamaeid Farm, 6: KISR's Farm, 7: DEGTC's Farm, 8: PAAFR's Farm, 9: BGTC's Farm.

Fig. 1. Total number of lambs and ewes in sheep farms

Table 1. Summary of data collected from sheep farms of Kuwait

Farm's Name	Mortality Rate (%)	Still Birth (%)	Lambs Born Alive/ Year	Abortion Rate (%)	Weaned Lambs (3 months) (n)	C:R for Ewes and Rams	C:R for Lambs
Small Farms							
1	40	2	130	30	80	70:30	80:20
2	30	2	130	10	80	70:30	80:20
3	50	10	130	30	70	70:30	80:20
Medium							
4	50	2	130	2	110	70:30	80:20
5	35	2	180	2	120	70:30	80:20
6	0	0	193	2	193	70:30	80:20
Large Farms							
7	15	3	180	2	110	70:30	80:20
8	8	2	180	2	140	70:30	80:20
9	15	3	130	30	80	70:30	80:20

1: Fuad Al-Ghanim Farm, 2: Al-Reham Farm, 3: Al-Terkeet Farm, 4: Al-Redab Farm, 5: Al-Hamaeid Farm, 6: KISR's Farm, 7: DEGTC's Farm, 8: PAAFR's Farm, 9: BGTC's Farm, C: Concentrate, R: Roughages

3.3 Feeding and Nutrition

Table 2 presents the composition of rations for ewes and lambs. Each ration consists of: 1) roughages (i.e., alfalfa hay and wheat straw), and 2) concentrates (i.e., barely, wheat bran, corn, soya bean meal), vitamins, and minerals. Two different, concentrates: roughages (C: R) rations were used in the present study. Rams and ewes were fed with ration of C: R 70:30 and young lambs were given a ration of C: R 80:20 (Abbas *et al*., 2015). A daily feed rate of 1.0 kg/head was provided to rams and 1.25 kg/head was given two weeks before joining ewes. Dry ewes (i.e., not pregnant) were provided daily with 0.8 kg/head of the same feed to rams, which was amplified steadily during the last month of pregnancy to 1.25 kg/head/day (NRC, 2001, 2007; Razzaque, 1995). All the selected farms were using the aforementioned rations for ewes, rams, and young lambs (3 months and above).

Table 2. Ingredients of rations on dry basis, vitamin, and mineral composition

Ingredients	(70C:30R) (Used for Ewes and Rams in	(80C:20R) (Used for Young Lambs in
Concentrates		
Barley	40.5	51.0
Wheat bran	10.0	10.0
Corn	10.0	10.0
Soybean meal	6.5	6.0
*Premix (vitamins and	1.0	1.0
Limestone	1.0	1.0
Salt	1.0	1.0
Total A	**70.0**	**80.0**
Roughages		
Alfalfa Hay	15.0	10.0
Wheat Straw	15.0	10.0
Total B	**30.0**	**20.0**
Total A + B	**100**	**100**

*Premix (vitamins and minerals): Phosphorus (5.00 %), calcium (18.00 %), sodium (5.00 %), magnesium (5.00 %), manganese (500 mg/kg as manganese oxide), cobalt (100 mg/kg as cobaltous sulfate), zinc (2000 mg/kg as zinc oxide), iodine (125 mg/kg as calcium iodate), selenium (10 mg/kg as sodium selenite), vitamin A (400000 IUkg), vitamin D3 (100000 IU/kg), vitamin E (Alpha–Tocopherol) (400 IU/kg).

3.4 Mortality Rate (%) of Lambs (MRL).

Data collected on lambs' mortality was for two years (2017–2018). The mortality rate of newborn lambs (3 weeks of age) was determined. The highest mortality rate (50 %) of newborn lambs was recorded in both the Al-Redab and Al-Terkeet farms, following by 40% mortality rate in Fuad Al-Ghanim farm. The mortality rate in Al-Reham and Al-Hamaeid farms is lower than the aforementioned farms, but still it is high and reaches to 30% and 35%, respectively. The MRL of DEGTC'S and BGTC farms was significantly lower than that of the previous farms but still considered high (15%). The PAAFR farm has relatively lower mortality rate (8%), and the lowest was at KISR Research Station (2%) (Table 1).

3.5 Abortion Rate (%) of Ewes (AR).

The highest abortion rate was recoded in farm nos. 1, 3, and 9 (30%), other farms present 2% except farm no. 2 (10%) as shown in Table 1.

3.6 Stillbirth Rate (%) of Ewes (SBR)

The stillbirth rate reaches 2% in the Fuad Al-Ghanim, Al-Reham, Al-Redab, Al-Hamaeid, KISR, and PAAFR's farms, while it was slighty higher in the DEGTC and BGTC's farms reaching 3%. In contrast, SBR was apparently higher in Al-Terkeet farm and reaches 10% (Table 1).

4. Results and Discusion of Field Experiment

The concentration of Ig's in the blood samples of ewes in seven farms ranged between 18.343±0.052 and 23.31±0.058 (i.e., Fuad Al-Ghanim, Al-Reham, Al-Terkeet, Al-Redab, Al-Hamaeid, DEGTC's farm, and BGTC's farms). The serum Ig's in the blood samples collected from the ewes at PAAFR farm was recorded as 37.3 ± 0.058 mg/ml, whereas the highest Ig's was recorded in blood samples from ewes in KISR's farm (45.786 ± 0.01 mg/ml). The higher Ig's at KISR farm can be due to vaccination given twice during the pregnancy period, which is also supported by Gilbert *et al*. (2014). This concludes that the vaccination during pregnancy period can improve the immunity of ewes (Table 3).

Table 3. Concentration of Ig's in ewes' blood serum

	IgG mg/ml			
Farms' Name	**Flock–1**	**Flock–2**	**Flock–3**	**Mean ± Standard Deviation**
Fuad Al-Ghanim	19.963	20.198	17.862	19.341±0.013
Al-Reham	20.483	30.388	19.057	23.31±0.058
Al-Terkeet	19.115	18.033	17.883	18.343±0.052
Al-Redab	20.787	19.961	20.555	20.434±0.026
Al-Hamaeid	19.803	19.185	18.052	19.013±0.038
*KISR	46.136	45.138	46.083	45.786±0.01
****DEGTC	20.733	19.828	21.722	20.761±0.05
**PAAFR	37.495	36.607	37.747	37.3±0.058
***BGTC	19.999	19.095	18.411	19.168±0.026

*: Kuwait Institute for Scientific Research, **: Public Authority for Agricultural Affairs and Fish Resources, ***: Brand General Trading & Contracting Co., **** Diamond Expertise for General Trading and Contracting Co.

4.1 Ig's Concentration of Colostrum.

Concentration of Ig's in the colostrum samples collected from the ewes at eight farms (Fuad Al-Ghanim, Al-Reham, Al-Terkeet, Al-Redab, Al-Hamaeid, DEGTC, PAAFR, and BGTC's farms) ranged between 50.43±0.028 and 54.21 ±0.045 mg/ml. The highest concentrations (65.96±0.005 mg/ml) of Ig's in the colostrum samples in the ewes at KISR's farm was recorded. These results clearly showed that vaccinating the ewes at KISR's farm during pregnancy period increased the concentration of Ig's in the colostrum compared to the Ig's concentration in the colostrum samples collected from other farms. These results showed that improved immunity of the ewes by vaccinating twice during pregnancy period helped in elevating the concentration of Ig's both in the blood and secreted colostrum, which have led to increase in the survival rate of newborn lambs. Thus, the vaccination protocol used in KISR was found to be more efficient than that in PAAFR. The high concentration of Ig's in the colostrum would help in improving the immune status of lambs feeding on the colostrum; as a result, the lambs would have enough immunity especially in the first 3 weeks of lives, until their immune system becomes fully activated. Increasing the quality of the colostrum is crucial to increase the survival rate of newborn lamb because colostrum is the only source of both nutrition and antibodies (Martín–Gómez *et al*., 2006). Based on these results, it can be confidently stated that increasing the immunity status of colostrum as feed of newborn lambs not only decreases the mortality rate but may also improve the sheep industry in Kuwait and increase the livelihood of the farm owners (Table 4).

Table 4. Concentrations of Ig's in colostrum samples

Farms	**IgG mg/ml ± S.D.**			
	F#1 (n=6)	**F#2 (n=6)**	**F#3 (n=6)**	**Mean ± SD**
*KISR	65.15	66.76	65.97	65.96±0.005
**PAAFR	54.30	54.13	54.20	54.21±0.045
Al-Reham	53.01	54.04	52.14	53.06±0.051
Al-Redab	52.11	51.21	50.33	51.22±0.040
Al-Hamaeid	50.09	50.23	51.33	50.55±0.049
Fuad Al-Ghanim	51.45	52.53	51.88	51.95±0.043
***BGTC	50.33	50.98	51.06	50.79±0.018
****DEGT C	49.85	50.88	50.57	50.43±0.028
Al-Terkeet	50.54	52.07	51.77	51.46±0.011

*: Kuwait Institute for Scientific Research, **: Public Authority for Agricultural Affairs and Fish Resources, ***: Brand General Trading & Contracting Co., **** Diamond Expertise for General Trading and Contracting Co.

4.2 Mortality Rate of Newborn Lambs (MR)

The results in Table 5 shows that the mortality rate of newborn lambs at KISR's farm (born lambs n=23) was apparently lower than that in the rest of the farms. This is because no incidence of mortality of newborn lambs was recorded at KISR farm during the field experiment. Although the MR at PAAFR farm (born lambs n=25) was 4% was higher than

the MR of lambs in KISR, it was lower than the MR of all other farms. Only one lamb was recorded as dead in the field experiment due to the infection with FMD disease.

The number of newborn lambs was n=18 in the 4 farms (Fuad Al-Ghanim, Al-Reham, Al-Redab, and Al-Hamaeid farm), where the mortality rate was recorded as 22.23 %, for young lambs especially in the first 3 weeks of lives. In each of these farms, 4 lambs were dead due to different diseases. For example, in Fuad Al-Ghanim farm, the young lambs died due to the infection by *E. Coli* (2 lambs), *Pasteurella* (1 lamb), and *Salmonella* (1 lamb), while the cause of lambs' death in Al-Reham farm was the infection by *Salmonella* (2 lambs) and *E. Coli* (2 lambs). In contrast, the main cause of lambs' death in Al-Redab farm was the infection with *Clostridia* (3 lambs) and *Pasteurella* (1 lamb) diseases. The mortality of young lambs in Al-Hamaeid farm was due to the infection by *FMD* (4 lambs) disease. The main reason could be the similar management in these 4 farms. These farms were managed by the same owner, supervisor, and by the same management. Thus, animals in these farms have received the same type of vaccination (Table 4) and at same time; in these farms, the ewes were vaccinated before pregnancy and no intervention measures were taken during the pregnancy.

In addition, the mortality rates of newborn lambs in the Al-Terkeet farm (born lambs n=10) was higher than that in the aforementioned farms, where the MR reaches to 30%, which is significantly (P<0.05) higher than that in the other farms; the main reason of lambs' mortality was the infection of *PPR* disease. Finally, the highest MR of lambs was reported from DEGTC (n=17) and BGTC farms (n=23), where the MR reaches 41.5 % and 43.5 %, respectively. The main cause of lamb's mortality was the infection with *Pasteurella* and *Salmonella* in DEGTC farm, while the cause of death of young lambs in BDTC farm was the infection of *Coronaviruse*, *rotaviruse* (5 lambs), *E. coli* (3 lambs) and *Clostridia* (3 lambs). The MR in these two farms was significantly (P<0.05) higher, as compared to the aforementioned farms (Table 5).

Table 5 shows that the total number of born lambs in the selected farms was 170, from which 132 (77.6%) survived. The number of dead lambs due to the infection by *E. coli* is 7, same as *Salmonella* (n=7), and *Clostridia* (n=6). Collectively these three diseases caused the death of young lambs by 11.77 %. Furthermore, the percentages of the lambs' death due to the infection with *Pasteurella (n=5)* and *FMD* (n=5) were 2.9% each. In contrast, the percentages of lambs' death due to the infection with *PPR* (n=3) and corona/rotaviruses (n=5) were 1.76 % and 2.94 %, respectively. To conclude, for a total number of 170 newborn lambs, 22.35 % (n=38) of lambs died due to different diseases and only 77.6% remained alive during the field experiment and could reach weaning and adult stage.

These results show that vaccinating ewes during pregnancy period can help in boosting the immunity of ewes during pregnancy, and as a result improves the quality of the secreted colostrum. In addition, lambs feeding on the high-quality colostrum will have more chance for survival. Colostrum is the only source for antibodies and nutrition for the newborn lambs. Thus, improving the quality of colostrum through vaccination would help boost the immunity of young lambs and reduce the lambs' mortality rate (Burezq *et al*., 2015**)**. Thus, this may help mitigate the infections of diseases and improve the sheep industry in Kuwait, and bridge the gap between locally produced meat and the importation for food security.

4.3 Diagnosing the Causes of Lambs' Mortality

Biological samples were collected from the dead lambs (for example, tissues from liver, or spleen, or small intestine, or heart), and sent to PAAFR laboratories for disease diagnosis. The results showed that the mortality of the lambs at the age of less than one to seven days of age was commonly because of being infected with *enterotoxigenic Escherichia coli* from *enteric or septicemic* forms. The main symptoms observed in these lambs were fever, diarrhea and in some cases sudden death. Other diseases diagnosed to cause the death of lambs at 7–21 days of age include the following:

- *Clostridia. Clostridia* is a disease caused by the two different strains of bacteria, stains *C and D*, which are found in the gastrointestinal tract of the sheep. Lambs infected with *Clostridia* suffers from high fever, swollen areas, and death due to toxaemia (that is blood poisoning) caused by the bacteria (Scholes & Edwards, 2009).
- *Pasteurella.* This disease is caused by the bacteria that could move from tonsil to lung, and then to the blood. This disease can cause severe fibrin necrotic pneumonia, fever, listlessness, poor appetite, and sudden death.
- The *Foot–and–Mouth Disease (FMD).* Typical symptoms of the FMD are fever lasting two to three days, painful lesions in the mouth due to which the animal would eat less, weight loss, high mortality rate of new born lambs, and feet lesions.
- Infection with *Salmonella.* This is a disease caused by the proliferation of *Salmonella* bacteria in the gastrointestinal tract and other organs. The known symptoms of Salmonellosis are diarrhea, decreased appetite, fever, blood poisoning, and death.
- *PPR. PPR* is an acute and highly contagious viral disease that causes illness and mortality of the young lambs. The symptoms observed on the infected lambs are diarrhea, sores in mouth, pneumonia, and death (Aziz–Ul–Rahman *et al*., 2016; Wernike *et al*., 2016).
- *Coronavirus* and *Rotavirus*. The symptom observed on lambs infected with *Coronavirus* and *Rotavirus* is diarrhea, and in some cases, diarrhea is associated with some pathogens, for example, *Cryptosporidium* (Durham *et al*., 2011; Bjorkman *et al*., 2003).

Table 5 shows that the total number of newborn lambs in selected farms was 170; and only 132 lambs managed to survive and grow until reach weaning age. Thus, out of 170 born lambs, only 77.6% remained alive during the field experiment and reached weaning phase, which means that 22.35% of the lambs are dead.

4.4 Proximate Analysis and Calculation of Energy Values of Experimental Rations

A balanced feed ration is essential for normal health, growth and reproduction of the sheep. Nutrients in the feed are utilized by the sheep to meet their nutritional requirements. It is not the feed itself that meets these needs but the components (concentrates and roughages) that make up the feed. Nutrient requirements vary during the production cycle as the body has difference demands. Ewes, rams, and lambs and replacement all have varying nutritional needs. Testing the feed is important, as nutrient levels vary depending on the quality of the feed (Abbas *et al*., 2015).

Feed samples were collected for quantitative analysis to determine the percentages of the components including moisture, crude protein, crude fat, neutral detergent fiber, acid detergent fiber (ADF), and ash (%) (Table 6). The actual intake of DM (dry matter) is shown in Table 7 from both C and R, and it was calculated based on the analytical data of DM contents of total feeds intake (Table 7) for ewes, rams and lambs (Abbas *et al*., 2015). In the field study, two different R:C rations were used, according to KISRs' nutritional and feedlot recommendations (Abbas *et al*., 2015). Although the team used two different R:C rations, the concentrations of CP, NDF, ADF, and other minerals in the used rations were not significantly different (Table 7). The ration used for the ewes and rams was with a C:R ratio of 70:30, and was found to be the best feeding regime for complete production cycle of ewes, in Kuwait's feedlot system, irrespective of the season (Abbas *et al*., 2015). Using a ration with C: R 80:20 for lambs was reported to be the best for lambs during the pre-weaning, suckling and post-weaning periods, and for the best average daily gain (ADG) (i.e., the efficiency with which the bodies of livestock can convert feed into more body weight) and feed conversion ratio (FCR) for lambs (Abbas *et al*., 2015). ADG can be defined as the rate of weight gain per day over a specified period of time, and FCR is a ratio measuring the efficiency of the animals' body to convert the feed into the desired output (e.g., sheep raised for meat) (Abbas *et al*., 2015). It is the energy that provides fuel to enable the body to maintain normal functions. The energy can be derived from carbohydrates, fats, oils and protein, and is generally measured as total digestible nutrients (TDN) or as digestible energy (DE) (Abbas *et al*., 2015).

Therefore, carbohydrates, fats and excess proteins in the ration together contribute to provide the energy requirements of ewes. Concentrates are considered a rich source of energy, while forages contain high fibers instead, but low energy content (roughages). Meeting the energy requirements of sheep is one of the biggest challenges for sheep producers. Insufficient energy intake can lead to malnutrition, weight loss, reproductive failure, and decreased milk production, lower resistance to parasites and disease and increased mortality due to decreased efficiency of immune system.

Thus, animals become more susceptible to diseases, especially gastrointestinal worms, and eventually to death. In contrast, excess of energy consumption could cause obesity of sheep, impair reproductive function in both rams and ewes, and during late gestation, fat ewes become more likely to have ketosis (pregnancy toxemia). Energy could be quantified in the ration in many ways, by measuring the total digestible nutrients (TDN) or metabolizable energy (ME) and net energy (NE) (Table 8). The TDN was used to formulate rations for breeding animals, while the net energy system is usually used to calculate diets for growing lambs (Abbas *et al*., 2015).

5. Discussion

The idea of the present study came from the unpublished data of PAAFR about the mortality rate of newborn lambs in Kuwait farms. The PAAFR reports had highlighted that the mortality rate of the newborn lambs could be as high as 25 to 35% (PAAFR unpublished data). Therefore, the producers suffer from significant economic losses.

A survey study was carried out to diagnose the causes of high mortality of lambs in the representative small, medium and large sheep farms, and to mitigate these causes of death to improve the survival of the newly born lambs. The results from the survey confirmed that the sheep farms in Kuwait suffer from high mortality rate of newborn lambs, especially in the first three weeks of age, and it is a serious problem since the mortality rate ranges between 25 and 35%. At present, the number of lambs produced in sheep farms could meet about 11–12% of total red meat demands of the country. Therefore, controlling the mortality rate of young lambs could have a significant positive effect on the sheep industry in Kuwait (Burezq *et al*., 2015). In addition, the data collected from survey study recommend vaccinating animals during pregnancy period to improve the quality of secreted colostrum.

5. 1 Field Experiment

A field experiment was carried out where ewes from eight farms were vaccinated according to conventional PAAFR vaccination protocol, before pregnancy period, and no intervention measures were carried out during pregnancy. In contrast, the ewes from KISR's farm were vaccinated twice during pregnancy period. To study the effectiveness of KISR and PAAFR's vaccination protocols on lambs' mortality during the field experiment, some factors were unified, such as feeding/nutrition, care of lambs after lambing, age, and body condition score (BCS). After unifying these factors, the second step was to evaluate the vaccination protocol used in the selected farms, by measuring IgG in the blood and colostrum samples, and to find the causes of mortality and determine the mortality rates.

5.2 Impact of Vaccination of Pregnant Ewes on Ig's Concentration of Blood of Ewes.

The present study proves the efficiency of vaccinating ewes during pregnancy. Farms adopted the modified vaccination protocol to control the mortality of young lambs. (Gilbert *et al*., 2014; Hashemi *et al*., 2008).

5.3 Impact of Vaccination of Pregnant Ewes on Ig's Concentration of Colostrum

Vaccinating the ewes during pregnancy period in KISR's farm increased the concentration of Ig's in the colostrum significantly ($P<0.05$), as compared to the concentration of Ig's in colostrum samples collected from other farms. These results showed that improving the immunity of ewes by vaccinating them twice during pregnancy period would help elevate the concentration of Ig's in their blood and consequently in the secreted colostrum, which could have a significant effect in improving the survival rate of newborn lambs. Having high concentrations of Ig's in colostrum would help improve the immunity of newborn lambs significantly, especially in the first 3 weeks of lives, until their immune system becomes fully activated (Moore *et al*., 2005).

Table 5. Mortality and Weaning Rates of Young Lambs

Farms	Lambs Born Alive (n)	Weaned Lambs (n)	Weaning Rate (%) of Lambs at 2 months of Age	Mortality Rate (%) of Lambs at 1–21 days of Age	Number of Dead Lambs	Causes of Mortality of Newborn Lambs
Fuad Al-Ghanim	18	14	77.77	22.23	4	2 lambs by *E. coli,* 1 lamb by *Pasteurella*, 1 lamb by *Salmonella*
Al-Reham	18	14	77.7	22.23	4	2 lambs by *Salmonella*, 2 lambs by *E.coli,*
Al-Terkeet	10	7	70	30.00	3	3 lambs by *PPR*
Al-Redab	18	14	77.77	22.23	4	4 lambs by *Clostridia* 1 lamb by *Pasteurella*
Al-Hamaeid	18	14	77.77	22.23	4	4 lambs by *FMD*
*KISR	23	23	100	0	0	0
****DEGTC	17	10	58.82	41.18	7	3 lambs by *Pasteurella* 4 lambs by *Salmonella*
**PAAFR	25	24	96	4.0	1	1 lamb by *FMD*
***BGTC	23	12	52.17	47.83	11	5 lambs by *Corona virus* and *rotaviruse*, 3 lambs by *E. Coli*, 3 lambs by *Clostridia*
Total	**170**	**132**			**38**	

*: Kuwait Institute for Scientific Research, **: Public Authority for Agricultural Affairs and Fish Resources, ***: Brand General Trading & Contracting Co., **** Diamond Expertise for General Trading and Contracting Co. Data in Table 5 were collected during the field experiment (18 months)

Table 6. Proximate Analysis of Concentrate and Roughage Composition Used for Rations Formulation

*Parameters (%)	Barley	Wheat Bran	Soybean	Corn	Alfalfa	Wheat Straw
Moisture	6.07 ±0.14	8.95 ±0.15	8.5 ±0.09	7.83 ±0.17	5.67 ±0.06	–
Ash	2.32 ±0.2	3.93 ±0.07	9.33 ±0.07	1.14 ±0.06	11.99	8.3 ±0.34
CP	10.88 ±0.7	15.42 ±0.03	52.07 ±0.44	7.73 ±0.12	14.75 ±1.1	3.1 ±0.15
CF	–	7.45 ±0.37	5.87 ±0.47	1.64 ±0.06	32.3 ±0.12	–
NDF	24.5 ±0.7	16.8 ±0.6	13.2 ±0.43	40.8 ±0.53	45.2 ±0.28	47.5 ±0.09
ADF	5.6 ±0.06	2.4 ±0.8	9.6 ±0.03	11.9 ±0.11	35.3 ±0.3	44.5 ±0.05

*CP: crude protein; CF: crude fiber; NDF: neutral detergent fiber; ADF: acid detergent fiber.

Table 7. Composition of Experimental Rations (Combined Concentrate and Roughages)

Component (%)	Composition of Rations	
	(70C:30R) (For Ewes and Rams)	(80C:20R) (For Young Lambs)
Moisture	8.03 ±0.13	9.37 ±0.24
DM	90.98 ± 0.1	90.64 ±0.25
Ash*	5.48 ±0.18	2.64 ±0.07
CP*	13.32 ±0.29	12.45 ±0.12
EE*	1.56 ±0.84	2.85 ±01.61
NDF	20.11 ±0.56	19.86 ±0.30
ADF	4.95 ±0.28	4.55 ±0.45
Ca*	0.37 ±0.051	0.43 ±0.20
P*	1.26 ±0.04	–

*: % of dry matter; CP: crude protein; EE: ether extract; ADF: acid detergent fiber; NDF: neutral detergent fiber; Ca: calcium; P: phosphorous; –: not available.

Table 8. Calculated Energy Values of Experimental Rations (On DM Basis) *

	70C:30R (For Ewes and Rams)	80C:20R (For Young Lambs)
*DE MCal/kg	3.38 (14.150)	3.47 (14.528)
**ME MCal/kg	2.77 (11.597)	2.85 (11.932)
***TDN %	76.74	78.94

*DE: Digestible energy; **ME: Metabolizable energy; ***TDN: Total digestible nutrients were calculated according to (Linn & Martin, 1999). TDN% = 88.9 – (0.779 × ADF %), Values in parenthesis are MJ/kg. DE and ME values were calculated according to equations/program of the University of Minnesota and the Ontario Ministry of Agriculture, Canada.

Colostrum absorption usually occurs through the intestinal cells by the neonatal receptor FcRn and endocytosis using transport vacuoles (Smith & Foster, 2007). This absorptive capacity starts to decrease 6 to 12 h after birth and ends by 48 h after birth (Smith & Foster, 2007). The concentration of Ig's in serum increases significantly shortly after colostrum ingestion. Sometimes, lambs fail to get the sufficient amount of colostrum. They would get trace amounts of Ig's during the first three days of life; therefore, lambs become more susceptible to diseases and death. Lambs should get sufficient amount of good quality colostrum between 1 and 6 h of birth, because the gut ability to absorb the antibodies decreases significantly after this period. The quality of colostrum varies depending on the animal species; some can secrete better quality colostrum than the others. The amount needed for each lamb is about 100–200 ml per feeding, which is about 600 ml for three times feeding in the first 12 hours of life, and lambs should be fed for three to four days after lambing. In case the lambs cannot suckle the colostrum directly from the teat, colostrum could be collected and fed to them via a stomach tube (Smith & Foster, 2007). In some cases, such as ewes having weak twins, or in case of orphan lambs, dams having no milk, and in case of quadruplets and triplets, where lambs could not have enough colostrum, the only way is to establish a colostrum bank with high-quality colostrum. Feeding young lambs with high quality colostrum would help them get enough immunity especially in the first three weeks of life, and help increase their survival rate.

6. Conclusions

The survey study showed that the mortality rate of young lambs varies between 25 and 35% in 7 of the selected farms, while in KISR and PAAFR farms, the mortality rate of lambs was 2 and 8%, respectively. The field experiment showed that (1) Ig's concentration in the serum and the colostrum samples in the ewes of KISR farm were significantly higher (P<0.05) than that of the other farms. Also, the mortality rate of lamb ranges between 22.23 and 47.83% in other sheep farms, while there was no incidence of lambs' mortality reported in KISR's farm. In addition, the main cause of lambs' mortality was the infection with some diseases such as *Clostridia, Pasteurella, FMD, PPR, Salmonella, Coronavirus and Rotavirus sp*. It was concluded from the present study that vaccinating ewes during pregnancy period resulted in significantly higher (P<0.05) Ig's in ewes' blood and colostrum, which have a positive effect on decreasing the mortality rate of young lambs, and could be beneficial to livestock industry in Kuwait. Therefore, the hypothesis of improving the immune status through vaccinating during pregnancy is confirmed.

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References

Abbas, S. Razzaque, M. A., Elsaid, A., Albert, S., Gelan, A., Khalil, F., Al-Bahouh, M., Naseeb, A., Burezq, H. (2015) The effect of nutrition and season of breeding on reproductive performance of Naeemi ewes. Final Research Report, KISR No. 12848, Kuwait Institute for Scientific Research, Kuwait.

Aziz–Ul–Rahman, M., Abubakar, M.H., Rasool, S., Manzoor, M., Saqalein, M., Rizwan, M., Munir, Q., Ali, J., Wensman, J.J. (2016) Evaluation of risk factors for peste des petits ruminants virus in sheep and goats at the wildlife–livestock interface in Punjab province. BioMed Research International, 2016: 7826245.

Bjorkman, C., Svensson, C., Christensson, B., de Verdier, K. (2003) Cryptosporidium parvum and Giardia intestinalis in calf diarrhoea in Sweden. Acta Veterinaria Scandinavica. 44(3–4):145.

Burezq, H., Khalil, F., Razzaque, M., Albert, S., Ali, S., Al-Ballam, Z., Al-Qalaf, W. (2015) Biochemical and humoral evaluations of normal colostrum and hyperimmune colostrum of sheep and goats. Final Research Report for Project FA118K, KISR NO. 13466, Kuwait Institute for Scientific Research, Kuwait.

Crowther, J.R. (2009) The ELISA guidebook, 2nd Ed. Humana Press, Totowa (NJ).

Durham, P.J.K., Stevenson, B.J., Farquharson, B.C. (2011) Rotavirus and coronavirus associated diarrhea in domestic animals. New Zealand Veterinary Journal, 27(3): 30-32.

Gilbert, R.P., Gaskins, T.C., Hillers, J.K., Parker, C.F., McGuire, T.C. (2014) Genetic and environmental factors affecting immunoglobulin G concentrations in ewes' colostrum and lambs serum. Journal of Animal Sciences, 66: 863.

Hashemi, M., Zamiri, M.J., Safdarian, M. (2008) Effects of nutritional level during late pregnancy on clostral production and blood immunoglobulin levels of Karakul ewes and their lambs. Small Ruminants Research, 75: 209.

Linn, J.G., Martin, N.P. (1999) Forage quality tests and interpretations. http://www.extension.umn.edu/distribution/livestocksystems/D12637.html (Accessed August 28, 2008).

Martín–Gómez, S., Alvarez–Sánchez, M.A., Rojo–Vázquez, F.A. (2006) Obtaining hyperimmune anti–cryptosporidium parvum ovine colostrum. A study of the humoral immune response in immunized sheep. Parasitology Research, 98:129.

Mohammed, I. B., Nikhaila, A., Abdel Moneim, M. (2009) Effect of parity on the productivity of Taggar goats. International Journal of Arts and Science Research, 8: 278.

Moore, M., Tyler, J.W.M., Chigerwe, M.E., Dawes, M.E., Middleton, J.R. (2005) Effect of delayed colostrum collection on colostral IgG concentration in dairy cows. Journal of the American Medical informatics Association, 226: 1377.

NRC (2001) Nutrient requirements of dairy cattle, 7th ed. National Research Council. National Academy Press, Washington D.C.

NRC (2007) Nutrient Requirement of small ruminants. Washington, DC: The National Academic Press.

Razzaque, M.A. (1995) Intensive lamb production using local and imported sheep. Final Research Report. KISR No. 1763, Kuwait Institute for Scientific Research, Kuwait.

Razzaque, M.A., Abbas, S. (2010) Three-breeds of fat tail sheep: productive performance in Arabian Gulf Region. The Indian Journal of Small Ruminants, 16(2): 183-189.

Scholes, S. F., Edwards, G. T. (2009) Tyzzer's disease (Clostridium piliforme infection) and possible copper toxicity in a lamb. Veterinary Record, 164(15):470-471.

Smith, G.W., Foster, D.M. (2007) Short communication: Absorption of protein and immunoglobulin g in calves fed a colostrum replacer. Journal of Dairy Science, 90: 2908.

Wernike, K., Eschbaumer, M., Breithaupt, A., Maltzan, J., Wiesner, H., Beer, M., Hoffmann, B. (2014) Experimental infection of sheep and goats with a recent isolate of Peste des Petits ruminant's virus from Kurdistan. Veterinary Microbiology. 172(1–2):140-145.

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