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Original article

Risk factors of lamb mortality in Pakistan

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Abstract – This study was carried out to investigate lamb mortality in 528 Pak-Karakul and 423 Thalli in Pakistan during 1998–1999. Mortality was 9 and 12% in the lambs of the two breeds, respectively. In Pak-Karakul lambs, pneumonia rendered the highest morbidity and mortality and all mortalities recorded were in the first week, whereas in Thalli lambs diarrhoea was at the peak, with 82 and 18% mortalities in the first and second week of life respectively. Birth weight of neonates that died was lower ($P < 0.05$) than that of the lambs that had survived. The correlation revealed a positive and significant ($P = 0.000$) relationship between birth weights of Pak-Karakul lambs and serum Ig, total proteins and globulin concentration. In Thalli lambs such a relationship was found in serum Ig and globulin concentration. Parity of ewes and sex of lambs in both breeds did not affect mortality rates. Lambs with Ig levels less than 20 zinc sulphate turbidity (ZST) units died while those with more than 20 ZST-units survived. Dams that lost their lambs had significantly ($P < 0.05$) lower values of colostral Ig than those with live neonates. Serum Ig concentration in survived neonates of both breeds had significant ($P = 0.000$) and positive correlation with colostral Ig of their dams.

lamb mortality / Pak-Karakul and Thalli sheep / risk factors / Pakistan

Résumé – **Facteurs de risque de la mortalité des agneaux au Pakistan.** Cette étude a été réalisée pour étudier la mortalité des agneaux de races Pak-Karakul (n = 528) et Thalli (n = 423) au Pakistan au cours des années 1998 et 1999. La mortalité était respectivement de 9 et 12 % pour les deux races. Pour les agneaux Pak-Karakul, la cause de morbidité la plus élevée a été la pneumonie et tous les cas de mortalité ont été enregistrés durant la première semaine de vie. Concernant les agneaux Thalli, la diarrhée a été à l'origine du plus grand nombre de décès, avec des mortalités de 82 et 18 % la première et la deuxième semaine de vie, respectivement. Le poids de naissance des nouveau-nés morts était inférieur ($P < 0,05$) à celui des agneaux qui ont survécu. La corrélation de Pearson a permis d'établir ($P = 0,000$) une relation positive et significative entre les poids à la naissance des agneaux Pak-Karakul et les immunoglobulines (Ig) du sérum, les protéines totales et la concentration en globulines. Chez les agneaux Thalli, une telle relation a été trouvée entre les Ig du sérum et la concentration en globulines. La parité des brebis et le sexe des agneaux dans les deux races n'ont

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pas affecté les taux de mortalité. Les agneaux avec des niveaux d'Ig de moins de 20 unités ZST (Zinc Sulphate Turbidity) sont décédés tandis que ceux avec plus de 20 unités ZST ont survécu. Les brebis ayant perdu leurs agneaux ont eu de manière significative (P < 0,05) un colostrum plus pauvre en Ig que celles avec des nouveau-nés vivants. Pour les deux races, il existe une corrélation significative et positive (P = 0,000) entre la concentration sérologique des Ig chez les nouveau-nés qui ont survécu et la teneur en Ig du colostrum de leur mère.

agneau / mortalité / Pak-Karakul / Thalli / facteurs de risque / Pakistan

1. INTRODUCTION

Sheep population in Pakistan is estimated to be 24.9 million heads which are producing 225.7 and 40.2 million tons of mutton and wool, and 9.7 million numbers of skins annually [5]. Pak-Karakul and Thalli are dual purpose (meat and wool) breeds in Pakistan.

Though the sheep contributes significantly to the economy of this country, it is imperative to increase its productive performance to meet the ever increasing demand for animal proteins. This objective can be achieved by increasing the number of lambs successfully reared per ewe in a given season. Lamb mortality is a major dilemma that makes this goal difficult [27]. Reductions in lamb mortality can be achieved only by identifying and targeting its specific causes [28]. The important causes of lamb mortality are similar in all countries [8], and include pneumonia, diarrhoea and pneumo-enteritis [31]. The non-infectious conditions that can affect lamb mortality include starvation/chilling exposure complex [20], stillbirths/dystocia, mis-mothering, low birth weight [12, 27], breed [16, 35], age of ewe [31], immunity acquired by the neonate through colostrum [47], parity of the dam and sex of the lamb [8]. Moreover, the health and nutritional status of the ewes can also influence lamb mortality. Work on the factors affecting lamb mortality are scanty in Pakistan; therefore, the objective of this study was to identify the major causes and risk factors contributing to lamb mortality in Pak-Karakul and Thalli breeds of sheep in Pakistan.

2. MATERIALS AND METHODS

2.1. Animals and management

This study was carried out on 525 Pak-Karakul and 412 Thalli ewes, and their lambs born during the lambing seasons (February–April) of 1998 and 1999 at the Sheep and Goat Development Centre, Rakh Khairewala, District Layyah, Pakistan. Prior to parturition (2–3 days), each ewe was kept in a separate barn to ensure that the lambs had ingested colostrum within the specified period (first 10–12 hours of life). Parity of dam, litter size, sex and birth weight of lambs were recorded. The birth weights were grouped into the following categories: <3, 3–4 and >4 kg. The health of all lambs under study was monitored twice daily up to pre-weaning age (60 days).

All ewes and lambs were kept under identical feeding and management conditions. The ewes were housed together in sheds covered on three sides and one side was open. In the winter, the open side was covered with curtains to protect ewes and lambs from the cold. Sheep were put on pasture (green fodder *Trifolium alexandrinum*; Barseem) early in the morning and returned in the evening. No concentrate or fodder was provided in the shed at night, however, water was available ad libitum. The ewes were vaccinated against pleuropneumonia and enterotoxaemia and dewormed twice a year. The lambs were allowed to suckle the dams in the morning and evening daily. After one week, in addition to milk, green fodder was also offered to the lambs.

2.2. Collection of samples

Blood samples without an anticoagulant were collected from 100 dams of each breed selected randomly 10–15 days before and within 24 hours post lambing by jugular venipuncture. Similarly, blood samples were collected from the lambs of these ewes at 24–36 hours after colostrum feeding. Serum was separated from the samples and stored at –20 °C. Colostrum samples (about 25 mL) were obtained within 0–8 hours after parturition from the respective ewes and were stored at –20 °C till analysis.

2.3. Serological studies

Serum immunoglobulin (Ig) concentration in samples collected from dams and lambs was determined using the zinc-sulphate turbidity (ZST) method [33]. The absorbance of samples and standards was recorded at 450 nm using a spectrophotometer (Spectronic-21, Bouch and Lomb, Germany) and a standard curve was plotted. As mentioned by Findlay [14] and Logan and Irwin [30], <10 ZST units were considered as hypogammaglobulinemia in lambs.

2.3.1. Colostral immunoglobulin purification

Colostral samples were centrifuged at 3000 rpm for 25 minutes at 4 °C and the fat layer was removed. For each mL of the fat-free colostrum, 0.01 mL of 2% rennin solution was added and incubated at 37 °C till curdling. Whey was separated from colostrum samples by breaking the curd and centrifuging at 2000 rpm at 4 °C for 20 minutes. The quantity of whey was measured. The gammaglobulins in whey were separated with an ammonium sulphate saturated solution. For the precipitation of Ig, the saturated solution of ammonium sulphate was added to whey samples at the rate of 45% (to each 55 mL of whey, 45 mL of saturated ammonium-sulphate solution). After stirring for 10 minutes at 4 °C, it was centrifuged at 4 °C for 30 minutes and the sediment was dissolved in phosphate buffered saline (PBS) to the original volume of whey (already measured). The dissolved Ig were precipitated with saturated ammonium sulphate solution with a final concentration of salt up to 40%. It was stirred and centrifuged at 3000 rpm for 30 minutes at 4 °C. The sediment was dissolved in PBS. Ammonium sulphate was removed by dialysis against 6 changes of PBS at 4 °C. The concentration of Ig was determined using a spectrophotometer at 450 nm.

2.3.2. Serum total proteins and fractions

Serum total proteins were measured with the biuret method and albumin was measured with the bromocresol green binding method [3]. Globulin concentration was determined by subtracting albumin concentration from serum total protein concentration.

2.4. Data analysis

Data collected were subjected to the Chi-square test, analysis of variance (ANOVA) or Pearson correlation and means were compared by the Duncan's multiple range (DMR) test on a personal computer using the MSTAT-C statistical software package [4]. The significance level was $P < 0.05$.

3. RESULTS

The 525 Pak-Karakul ewes gave birth to 528 lambs including three sets of twins. The 412 Thalli ewes gave birth to 423 lambs including 11 sets of twins. The twin lambs survived during the entire study period.

Table I. Mortality/survival in relation to sex for Pak-Karakul and Thalli lambs.

Breed/Survival Status	Sex				χ^2 value	*P* value
	Female		Male			
	No.	%	No.	%		
Pak-Karakul (*n* = 528)	*n* = 281		*n* = 247			
Survived	256	91.0	223	90.0	0.005	0.943
Died	25	9.0	24	10.0	0.087	0.768
Thalli (*n* = 423)	*n* = 218		*n* = 205			
Survived	192	88.0	180	88.0	0.000	0.983
Died	26	12.0	25	12.0	0.006	0.940

Table II. Relationship of birth weight (Mean ± SE) to sex and survival/mortality for Pak-Karakul and Thalli lambs.

Parameters	Sex/Status	Birth weight (kg)			
		Pak-Karakul		Thalli	
		n	Mean ± SE	*n*	Mean ± SE
Sex	Male	223	3.84 ± 0.71	180	3.58 ± 0.59
	Female	256	3.51 ± 0.58	192	2.93 ± 0.37
Survival Status	Survived	479	3.77 ± 0.63a	372	3.36 ± 0.32a
	Died	49	2.59 ± 0.49b	51	2.33 ± 0.26b

Values with different letters in a column differ ($P < 0.05$).

3.1. Factors affecting lamb mortality

The mortality of Pak-Karakul and Thalli lambs was 9 and 12%, respectively ($P > 0.05$) and there was no difference between sex within each breed (Tab. I). Parity did not affect birth-weights, however, lamb mortality tended to be higher in first parity and declined until 4th parity, after which it increased. The birth-weights were similar for male and female lambs from both breeds, averaging 3.66 kg for Pak-Karakul and 3.42 kg for Thalli lambs (Tab. II). All lambs weighing more than 3.0 kg at birth, survived during the period of study i.e. 60 days. Lamb mortality was the greatest in the first week after birth. All deaths of Pak-Karakul lambs occurred in the first week; while 82 and 18% of Thalli lambs died during the first and 2nd weeks respectively. No lamb death was recorded in the following six weeks.

3.2. Serological studies in lambs

The Pak-Karakul and Thalli lambs that survived had significantly ($P < 0.001$) higher immunoglobulin (Ig) concentration than those that died (Tab. III). Birth weight had a significant ($P < 0.05$) effect on Ig concentration. At <3 kg birth-weight, significantly ($P < 0.05$) low Ig concentration as compared to Ig concentration at 3–4 and >4 kg birth weights in the lambs of both the breeds was recorded (Tab. IV).

There were no effects of breed or sex of lambs on Ig concentration (27.14 ZST units), serum total proteins (70.63 $g\cdot L^{-1}$), albumin (35.76 $g\cdot L^{-1}$) and globulin (35.36 $g\cdot L^{-1}$) in the lambs of both breeds (Data not presented in the table). The Pak-Karakul and Thalli lambs that survived had significantly ($P < 0.01$) higher concentration of serum total proteins and globulins than those that died (Tab. III). Significantly

Table III. Serum immunoglobulin (Ig) and total protein concentrations (Mean ± SE) in Pak-Karakul and Thalli lambs in relation to survival and mortality during the neonatal period.

Parameters	Pak-Karakul		Thalli	
	Survived (*n* = 91)	Died (*n* = 9)	Survived (*n* = 89)	Died (*n* = 11)
Ig (ZST Units)	31.56 ± 1.20a	4.78 ± 1.43b	25.20 ± 1.28a	10.14 ± 3.93b
Serum Total Protein ($g \cdot L^{-1}$)	80.32 ± 8.68a	44.50 ± 4.35b	76.41 ± 2.45a	50.76 ± 10.73b
Albumin ($g \cdot L^{-1}$)	39.40 ± 1.04	38.05 ± 3.75	38.90 ± 1.03	34.00 ± 1.15
Globulins ($g \cdot L^{-1}$)	40.82 ± 2.18a	16.30 ± 1.96b	38.30 ± 2.23a	15.60 ± 4.39b

Values with different letters in a row differ ($P < 0.001$).

Table IV. Serum immunoglobulin (Ig) and total serum proteins (Mean ± SE) in relation to birth weights of Pak-Karakul and Thalli lambs.

Parameters	≤ 3 kg	3–4 kg	> 4 kg
Pak-Karakul lambs	*n* = 38	*n* = 40	*n* = 13
Ig (ZST units)	23.29 ± 2.31a	31.55 ± 1.28b	30.39 ± 1.91b
Serum Total Proteins ($g \cdot L^{-1}$)	68.72 ± 3.61a	79.33 ± 2.66b	80.15 ± 4.23b
Albumin ($g \cdot L^{-1}$)	38.60 ± 1.45	39.15 ± 0.89	39.83 ± 2.23
Globulins ($g \cdot L^{-1}$)	30.01 ± 3.17a	40.10 ± 2.27b	40.41 ± 3.83b
Thalli lambs	*n* = 32	*n* = 49	*n* = 8
Ig (ZST units)	23.99 ± 2.77a	30.43 ± 2.71b	26.40 ± 2.51b
Serum Total Proteins ($g \cdot L^{-1}$)	66.30 ± 3.40	71.50 ± 3.06	73.21 ± 3.74
Albumin ($g \cdot L^{-1}$)	34.71 ± 2.52	33.62 ± 1.36	34.30 ± 1.19
Globulins ($g \cdot L^{-1}$)	31.52 ± 2.88a	37.20 ± 2.76b	38.81 ± 3.56b

Values with different letters in a row differ ($P < 0.05$).

($P < 0.05$) higher concentrations of serum total proteins and globulins were recorded in heavy (>4 kg) birth-weight Pak-Karakul lambs. A similar trend of serum total proteins was observed in Thalli lambs. Lamb status (survival or death) or birth weight had no effect on the concentration of serum albumin (Tab. IV). Similarly, the parity of the dam did not affect the concentrations of serum Ig, total proteins, albumin and globulins in lambs of both breeds. The Pearson correlation revealed a positive and significant relationship between birth weights of Pak-Karakul lambs and serum Ig concentration ($r = 0.847$, $P = 0.000$), serum total proteins ($r = 0.887$, $P = 0.000$) and globulins ($r = 0.834$, $P = 0.000$). Such relationships in Thalli lambs were found in serum Ig concentration ($r = 0.580$, $P = 0.000$) and globulin concentration ($r = 0.765$, $P = 0.000$).

3.3. Lamb diseases

Overall morbidity due to various disease conditions was 15 and 16% in Pak-Karakul and Thalli lambs, respectively (Tab. V). Most of the mortalities were due to infectious conditions like pneumonia, diarrhoea and pneumo-enteritis. Chilling and mismothering were observed in Thalli lambs whereas parrot mouth condition (a lower

Table V. Morbidity and mortality due to various diseases/conditions in Pak-Karakul (n = 528) and Thalli (n = 423) lambs.

Disease/condition	Pak-Karakul		Thalli		χ^2 value	P value
	No.	%	No.	%		
Morbidity	**79a**	**15.0**	**68a**	**16.0**	**0.163**	**0.686**
Pneumonia	37a	47.0	20a	29.4	2.090	0.148
Diarrhoea	20a	25.3	33b	49.0	3.992	0.046
Pneumo-enteritis	21a	27.0	7b	10.3	4.340	0.037
Parrot Mouth	1	1.3	–	–	–	–
Chilling	–	–	5	7.4	–	–
Mis-mothering	–	–	3	4.4	–	–
Mortality	**49a**	**9.3**	**51a**	**12.1**	**1.554**	**0.213**
Pneumonia	27a	55.1	13b	26.0	3.940	0.047
Diarrhoea	13a	27.0	25a	49.0	2.434	0.119
Pneumo-enteritis	8a	16.3	5a	10.0	0.724	0.395
Parrot Mouth	1	2.0	–	–	–	–
Chilling	–	–	5	10.0	–	–
Mis-mothering	–	–	3	6.0	–	–

Values with different letters in a row differ significantly ($P < 0.05$). For each comparison, the χ^2 value and P value are provided in the respective row.

mandible small in size and the upper one resembling a parrot beak) was recorded in one Pak-Karakul lamb. Various clinical signs showed by the lambs suffering from diarrhoea included profuse watery diarrhoea with often loose but scanty faeces which were occasionally blood mixed. These animals showed anorexia, weakness, dullness and depression with subnormal temperature. The other group of lambs that died of pneumonia showed signs of coughing, sneezing, mucus to mucopurulent nasal discharge, sunken eyes, and elevated body temperature.

3.4. Serological studies in ewes

The concentration of serum Ig, albumin and globulins at the pre-lambing stage showed a non-significant difference between the ewes of both the breeds given birth to male or female lambs. The concentration of colostral Ig was significantly ($P < 0.05$) lower in dams than in those that lost their lambs within 15 days of parturition compared with dams having survived lambs (Tab. VI). No relationship was observed in serum Ig and total proteins including albumin and globulins at pre-lambing and post-lambing stages in dams with survival or death of their lambs in both breeds (Tab. VI). The parity of the ewe had no effect on the concentration of colostral Ig, serum total proteins, albumin and globulins at pre-lambing and post-lambing periods. A significant positive correlation existed between serum Ig concentration of survived lambs of Pak-Karakul and Thalli breeds and colostral Ig concentration of respective dams (r = 0.837, P = 0.000 and r = 0.739, P = 0.000).

4. DISCUSSION

The neonatal period is very decisive in the rearing of lambs. During this period,

Table VI. Colostral Ig and serum proteins (Means ± SE) at the pre and post-lambing stage of Pak-Karakul and Thalli ewes whose lambs died/survived.

Parameters	Stage of lambing	Pak-Karakul lambs		Thalli lambs	
		Died (n = 9)	Survived (n = 91)	Died (n = 11)	Survived (n = 89)
Colostral Ig (g·L^{-1})		12.11 ± 1.97a	17.81 ± 2.72b	13.13 ± 1.55a	18.43 ± 1.14b
Serum Total Protein (g·L^{-1})	1	60.43 ± 4.58	59.30 ± 3.90	60.02 ± 3.40	64.81 ± 4.37
	2	65.62 ± 5.73	63.82 ± 5.75	62.74 ± 5.31	63.60 ± 4.67
Serum Albumin (g·L^{-1})	1	42.61 ± 3.21	40.00 ± 2.48	38.43 ± 4.26	38.73 ± 4.40
	2	43.22 ± 2.39	40.50 ± 2.41	38.72 ± 3.22	38.77 ± 3.36
Serum Globulins (g·L^{-1})	1	17.91 ± 3.68	19.42 ± 4.82	22.36 ± 4.25	26.33 ± 4.86
	2	22.72 ± 4.76	23.33 ± 3.82	24.00 ± 3.45	25.11 ± 3.78
Serum Ig (ZST-units)	1	20.87 ± 2.65	23.25 ± 4.45	21.88 ± 2.56	23.85 ± 3.44
	2	18.75 ± 2.09	23.66 ± 3.89	18.78 ± 2.29	24.56 ± 3.78

Values with different letters in a row differ significantly ($P < 0.05$).
1= Pre-Lambing; 2 = Post-Lambing.

mortality is a major factor limiting profitability in sheep farming. According to Eales et al. [13], lamb mortality represents about 35% of all sheep losses and 15% of all lambs born. In the present study, overall mortality was 9 and 12% in Pak-Karakul and Thalli neonates, respectively. Neonatal lamb mortality was similar to that reported in other studies [8, 17]. However, a much higher mortality (15–51.5%) has also been reported in several instances [7, 17,22,29,37,38,40,41,43]. The differences in mortality could be due to a variation in environmental factors and management conditions prevailing at the respective sites of these studies. Moreover, some studies might have concentrated on farms with high mortality specifically [8].

In the present study, the majority (100 and 82% respectively for Pak-Karakul and Thalli lambs) of lamb mortalities took place during the first week of life. This was in accordance with the findings of earlier reports [10, 31, 47]. According to Rowland et al. [41] and Maru et al. [32], most lamb mortalities occur within the first two days of life, whereas Al-Sabbagh et al. [2] reported that the majority (57%) of lambs died at birth or within 2 to 3 h of birth. Mortality during the first few days of life could be attributed to low temperature, mis-mothering and the primiparous dams, which produced less and low quality colostrum [49].

Lamb survival depends on optimum birth weight and intake of adequate amounts of colostrum with high immunoglobulin (Ig) concentration [6, 36]. The lambs of both the breeds that survived during the experimental period had significantly higher birth weights (Tab. II) and Ig concentration (Tab. III) than the lambs that died. It is hypothesised that lambs with low birth weight, being physically weak, were unable to suckle sufficient amounts of colostrum; as a result the Ig concentration in their serum remained low which might have lead to an increased mortality in these lambs. Survival of lambs is also influenced by birth weight, since lambs with low birth weight showed less survival as compared to those having high birth weights [12, 16, 46]. This was confirmed in the present study in which the survival rate of lambs with birth weights less than 3 kg was lower than those having birth weights greater than 3 kg. The lamb birth weight showed a positive and significant correlation with Ig, total proteins and globulin concentration. Previous studies also support these findings and higher Ig and protein concentrations have been reported to increase the lamb survival rate [1, 10].

The birth weight of lambs also has an effect on animal development and growth. The growth rates are shown to be lower in the surviving light weight lambs than in the heavier lambs [23]. Dwyer [11] has reported that low birth weight lambs are slower than heavier lambs to stand and suckle less frequently, which may lead to starvation resulting in a higher mortality [7].

Adequate colostrum with high quality Ig intake is a prerequisite for lamb survival. Ruminants are characterised by the possession of a thick syndesmochorial placentation [45] that prevents in utero transfer of large molecular weight Ig, therefore, lambs are born immunologically naïve [9]. Thus these neonates are essentially agammaglobulinemic at birth and rely on ingestion and subsequent absorption of antibodies from the colostrum [9, 25]. Besides a rich source of Ig, colostrum is also an excellent source of energy, vitamin A and essential minerals [26]. The immune system of the lamb is fully developed well before birth but is in an unprimed state [45]. The maternal Ig acquired through colostrum plays a significant role in the defence mechanism of newborn lambs until their own immune system is primed and produces a protective level of antibodies [45]. The primary Ig in colostrum is IgG [44] which is associated with diarrhoea [15], therefore, Ig deficient lambs are more likely to suffer and die since more mortality (49%) was observed due to diarrhoea in Thalli lambs (Tab. V). According to White and Andrews [48], calves without adequate circulatory IgG are four times more likely to die and twice as likely to become ill as compared to calves with adequate circulatory Ig. This seems to be confirmed for lambs, since in the present study, Ig levels were 7 and 2.5 times lower in lambs that had died than in those that had survived in Pak-Karakul and Thalli lambs, respectively (Tab. III). This trend was not only found for Ig, but was also recorded for serum total proteins and globulins, since these were nearly 2.5 times higher in surviving lambs than in those that had died (Tab. III).

The level of passive immunity acquired from the colostrum by a lamb depends upon the quality of Ig produced by the dams. Colostral Ig measured during the present study was higher ($P < 0.05$) in ewes of both breeds whose lambs survived as compared to the ewes whose lambs had subsequently died (Tab. VI). Healthy dams produce good quality colostrum rich in Ig [24, 34] that also influences the absorption of Ig from the intestines [21] for better lamb survival [18]. During late gestation, proper attention of dam nutrition and in particular supplementation, enhances lamb survival by increasing body weight [42]. According to Reese et al. [39], preweaning mortality rates of lambs (45, 12, 3 and 12% for the control, low, medium and high groups, respectively) were reduced ($P < 0.01$) with the supplementation of ewe (23 kg average body weight) diets that provided 354 (low), 591 (medium) and 826 (high) kcal ME per day. Similar views have been expressed by Hall et al. [19]. In Pakistan at private and public farms, sheep are pastured from the morning to the evening with no concentrate feeding which could be one of the causes of mortality observed in the present study. As discussed earlier [19, 39, 42], concentrate supplementation can reduce lamb mortality.

5. CONCLUSIONS

Lamb mortality rate was similar for Thalli (12%) and Pak-Karakul lambs (9%). Invariably, disease conditions are the same in both breeds and include diarrhoea, pneumonia, pneumo-enteritis etc. The first week of life of lambs is the more critical from the survival point of view. Birth weight of neonates showed a significant ($P < 0.05$) effect on their survival, therefore special care should be paid during the first week of life, especially to lambs with low birth weight. Lambs with Ig levels less than 20 ZST-units need more special attention than those with >20 ZST-units since the former are more prone to death than the latter. Dams that lost their lambs had lower concentrations of colostral Ig than those with live neonates, this can also be used as a tool to foresee subsequent mortalities in lambs and a little attention to such lambs may result in their survival and help to reduce lamb losses.

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