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RESEARCH ARTICLE

Risk Factors Associated with Passive Immunity, Health, Birth Weight and Growth Performance in Lambs: I. Effect of Parity, Dam's Health, Birth Weight, Gender, Type of Birth and Lambing Season on Morbidity and Mortality [1]

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Summary

This study was designed to examine the effect of birth weight, gender, birth type, lambing season, and dam parity and health status on lamb morbidity and mortality during the neonatal (first four weeks of life) and post-neonatal (first 5-12 weeks of life) periods in lambs born in two flocks in the 2009 lambing season in Kars, Turkey. EPI INFO 6 was used to determine differences in morbidity or mortality rates and risk according to risk factors including birth weights, genders, type of birth, lambing seasons, and parity and health of dams. The significance level was set at P<0.05 for all comparisons. The neonatal morbidity and mortality rates (48% and 33.3%, respectively) and risk of the lambs in the low birth weight group were significantly higher than those of the lambs in the medium birth weight (18.9%, χ^2=10.4, OR=3.9 for morbidity and 1.6%, χ^2=32.5, OR=30, for mortality) and high birth weight (9.8%, χ^2=26.9, OR=8.5 for morbidity and 1.2%, χ^2=46.5, OR=42.7 for mortality) groups (P<0.01 and P<0.001, respectively). The neonatal mortality rate and risk of lambs born in the winter season (9.2%) were significantly (P<0.01) higher than those of lambs born in the spring season (1.8%, χ^2=9.6 and OR=5.5). Lambs born to primiparous ewes had a neonatal morbidity rate (29.6%) and risk significantly higher than those of ewes at second parity (13.9%, χ^2=6.4, OR=2.6) and third parity (11.1%, χ^2=7.8, OR=3.3) (P<0.05 and P<0.01, respectively). Similarly, lambs born to primiparous ewes had a neonatal mortality rate (14.8%) and risk significantly higher than those of ewes at second parity (2.9%, χ^2=9.3, O=5.7), third parity (0%, χ^2=14.1) and ≥4 parity (2.4%, χ^2=4.2, OR=6.9) (P<0.001, P<0.001 and P<0.05, respectively). Lambs born to ill ewes had a neonatal morbidity rate (64.7%) and risk significantly higher (P<0.001) than those of lambs born to healthy ewes (13.8%, χ^2=30.38, OR=11.4). In the present study, it was concluded that the most significant risk factors for lamb morbidity and mortality were season of birth, parity, birth weight and health status of dams. Therefore, timely implemented health and management measures targeting these factors are required to reduce disease and death.

Keywords: *Lamb, Morbidity, Mortality, Risk factors*

Kuzularda Pasif İmmünite, Sağlık, Doğum Ağırlığı ve Büyüme Performansı ile İlişkili Risk Faktörleri: I. Anne Doğum Sayısı ve Sağlığı, Doğum Ağırlığı, Cinsiyet, Doğum Tipi ve Kuzulama Sezonunun Hastalık ve Ölümler Üzerine Etkisi

Özet

Bu çalışma Kars'ta iki sürüde 2009 kuzulama sezonunda doğan kuzularda doğum ağırlığı, cinsiyet, doğum tipi, kuzulama sezonu, anne doğum sayısı ve sağlığının neonatal (yaşamın ilk 4 haftası) ve sonraki (yaşamın ilk 5-12 haftalık kısmı) dönemlerde hastalık ve ölümler üzerine etkisinin incelenmesi amacıyla tasarlandı. Doğum ağırlığı, cinsiyet, doğum tipi ve kuzulama sezonu ve anne doğum sayısı ve sağlık durumu içeren risk faktörlerinin göre hastalık veya ölüm oran ve risk farklılıklarını belirlemek için EPI INFO 6 kullanıldı. Tüm karşılaştırmalarda önemlilik seviyesi P<0.05 olarak kabul edildi. Düşük doğum ağırlığı grubunda olan kuzuların hem neonatal hastalık ve ölüm oranları (sırasıyla %33.3 ve %48) hem de riskleri orta doğum ağırlığı (hastalık için %18.9, χ^2=10.4, OR=3.9 ve ölümler için %1.6, χ^2=32.5, OR=30) ve yüksek doğum ağırlığı (hastalıklar için %9.8, χ^2=26.9, OR=8.5 ve ölümler için %1.2, χ^2=46.5, OR=42.7) gruplarına göre önemli seviyede (sırasıyla P<0.01 ve P<0.001) yüksek bulundu. Kış sezonunda doğan kuzuların neonatal ölüm oran (%9.2) ve riski ilkbahar sezonunda doğanlara göre (%1.8, χ^2=9.6, ve OR=5.5) önemli seviyede (P<0.01) yüksek bulundu. İlk doğumunu yapan annelerden doğan kuzuların neonatal hastalık oran (%29.6) ve riski 2. (%13.9, χ^2=6.4, OR=2.6) ve 3. doğumunu (%11.1, χ^2=7.8, OR=3.3) yapan annelerden doğan kuzulara göre önemli seviyede (sırasıyla P<0.05 ve P<0.01) yüksek bulundu. Benzer şekilde, ilk doğumunu yapan annelerden doğan kuzularının neonatal ölme oranı (%14.8) ve riski 2. (%2.9, χ^2=9.3, O=5.7), 3. (0%, χ^2=14.1) ve 4. (%2.4, χ^2=4.2, OR=6.9) doğumunu yapan annelerden doğan kuzulara göre önemli seviyede (sırasıyla P<0.001, P<0.001 ve P<0.05) yüksek bulundu. Herhangi bir hastalığa maruz kalan annelerden doğan kuzuların neonatal hastalanma oranı (%64.7) ve riski sağlıklı olan annelerden doğan kuzulara göre (%13.8, χ^2=30.38, OR=11.4) önemli seviyede (P<0.001) yüksek bulundu. Bu çalışmada kuzu hastalık ve ölümleri için en önemli risk faktörlerinin doğum sezonu, anne doğum sayısı, doğum ağırlığı ve annenin sağlık durumunun olduğu sonucuna varılmıştır. Bu nedenle, bu faktörler üzerine odaklanarak zamanında sağlık ve sevk-idare önlemlerinin sağlanması kuzu hastalık ve ölüm oranlarını azaltmak için gereklidir.

Anahtar sözcükler: *Kuzu, Hastalık, Ölüm, Risk faktörleri*

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INTRODUCTION

High lamb morbidity and mortality during the first 12 weeks of life or the pre-weaning period cause the considerable economic loss, and greatly reduce the efficiency and profitability of lamb production. In many flocks worldwide, 6.9 to 37.5% of lambs die by three months of age [1-8] with neonatal lambs being at greater risk particularly during the first week of life [9-11]. In a study conducted in Kars region [6], the neonatal morbidity and mortality rates of lambs were determined as 48.6% and 20.8%, respectively, which is above economically acceptable rates. Some flocks experience severe losses, which may reduce the farmers' motivation for keeping sheep [1].

Although the majority of producers are aware that an efficient and profitable system would minimise lamb morbidity and mortality, currently applied management programmes may overlook the underlying factor, which would in return increase the risk of morbidity and mortality [2,4]. In a previous study [6] conducted on neonatal morbidity and mortality in this region, the majority of mortalities and morbidities in lambs were reported to have arisen from noninfectious causes such as birth stress, trauma, starvation due to hypothermia and mismothering, abdominal mass caused by trichobezoar, lameness, and congenital abnormality. It was indicated that the primary causes of neonatal diseases vary with environmental conditions and flock management. It has been suggested that lamb mortality could be reduced only if the specific causes of mortality on a given farm are identified and eliminated [2,12,13]. Nevertheless, as the main causes of lamb mortality in different production systems and countries display similarity, it would be more appropriate to identify all underlying factors associated with mortality and adapt farm and lambing management practices accordingly in predefined region or farms [2,13-16]. The main problems encountered in sheep production are diseases, malnutrition and poor management, which often result in reduced productivity and increased mortality. Management factors that have significant effect on lamb survival include the nutrition and immune status of the ewe, good hygiene practices and the colostrum intake of the lamb [2,15,17,18].

In order to prevent mortality, losses in production and profitability and high treatment costs, the adaptation and implementation of management practices could prove to be a useful alternative for the reduction and elimination of risk factors involved in disease development. Firstly, risk factors that predispose lambs to the development of disease must be identified [2]. In this respect, investigations are recommended to focus on the effect of multiple factors, including breed, age of dam, parity, gender, type of birth, birth weight, behaviour of the lamb and dam (ewe/lamb interaction) after birth, environmental factors such as lambing season, farm management (the feeding of dams particularly during gestation, good hygiene practices and colostrum intake), on mortalities [2,9,13,17,18]. However, to date, only a very limited number of studies have been conducted on the effect of environmental or flock management factors on morbidity. The impact of predisposition factors on morbidity and mortality varies from country to country in relation to varying conditions, such as the environment and the breeds raised. Nonetheless, it is interesting that very little research has been carried out in Turkey to determine the overall level of lamb mortality and morbidity, and to identify the underlying causes and other management factors that may have effect.

Despite the already significant contribution of sheep breeding to the national economy, it is imperative that the productive performance of the ovine population meets the increasing domestic demand for animal proteins. This can be achieved by increasing the number of lambs born per ewe in a given season. This target bears great significance as sheep breeding is a major economic activity in Anatolia, including Kars province. It plays a unique role in the utilisation of vast areas of natural grazing throughout Turkey [19,20]. The fat-tailed Akkaraman sheep, reared in Central and Eastern Anatolia, have adapted well to harsh environmental conditions and are resistant to unfavourable management conditions, poor feeding, and diseases. Approximately 87% of the sheep population in Turkey consist of the fat-tailed breeds mainly Akkaraman, which is considered valuable owing to its productivity [20,21]. In order to meet the increased domestic demand for this breed, it is important that its productive performance is increased and the spread of diseases is prevented. Although lamb morbidity and mortality rates have been reported to be high in this region [6], the risk factors predisposing lambs to morbidity or mortality have not been studied systematically. Therefore, the primary objective of this study was to determine the effect of certain risk factors such as lambing season, birth type, birth weight, gender of lamb, and parity and health status of dam on neonatal (birth to 28 days) and post-neonatal (from 28th day to 84th day) lamb mortality and morbidity in two crossbreed Akkaraman sheep flocks in Kars province, located in north-eastern Turkey. The study also identified the causes of lamb morbidity and mortality in the neonatal and post-neonatal periods. By the quantification of the risk factors, which affected mortality or morbidity, it was possible to identify the points at which changes in management might have decreased the morbidity and mortality rates of the lambs.

MATERIAL and METHODS

Animals, Data Collection and Farm Management

This study was carried out in two sheep farms located in the centre of Kars province in north-eastern Anatolia, Turkey, in 2009. All ewes and lambs were kept under identical feeding and management conditions. Management was typical of North-eastern Anatolian flocks with lambs being

born in winter (December to February) or spring (March to May), and being raised intensively. At birth, the lambs were ear-tagged and registered with an individual identification number, and gender, date of birth, parity of dam, and ear tag number and type of birth were recorded for each lamb. The lambs were weighed at birth (before colostrum intake) using a scale [CASIA DB2-150 kg (±30 g)]. After this procedure, lambs were allowed to naturally suckle their dams. The newborn lambs were kept with their dams during their first week of life. After this period, the lambs were transferred to a separate pen and allowed to suckle twice a day (in the morning and evening) for 3 months. Lambs had access to hay after the first week of neonatal life, and to straw and commercial growth feed (Bayramoglu AS, Turkey) as from the third week of life. This feeding regime lasted for three months. Subsequently, lambs were grazed on pasture and supplemented with hay and commercial feed when they were brought in for the night.

Clinical Examination

Clinical examination and case definition were performed as previously defined by the authors [6]. The health status of the lambs was monitored on farms by visits made on a daily basis during the neonatal period (first 4 weeks of life) and every two days in the post-neonatal period until the 12th week of life. Throughout the study period, ewes were determined to have disease (mastitis, pneumonia, enteritis, pregnancy toxaemia etc.) were categorized as ill and recorded with their ear tag number.

Statistical Analysis

The present study was conducted on 301 Akkaraman crossbreeds and 347 lambs born to these ewes. However, lambs, for which no data was able to be collected related to health status and the parameters investigated for their effects on morbidity and mortality, namely, birth weight, gender, birth type, lambing season, dam health status and parity, were not included in the study. Therefore, only 322 lambs, for which data on all the variables investigated in the study was obtained, were used. Data collected by a longitudinal survey were numerically coded and entered into a database (Microsoft Access) and analysed using EPI INFO 6. The lambs were categorized, based on their clinical examination results as healthy or ill. Clinical examination results were categorized for the neonatal (first four weeks of life) and post-neonatal (first 5 to 12 weeks of life) periods with a view to compare morbidity and mortality rates and their relations with variables. Birth weights were categorized as low (≤3 kg), medium (>3 to ≤4 kg) and high (>4 kg). Dam parity was categorized as 1, 2, 3 and ≥4. EPI INFO 6 [chi-squared (χ^2), odds ratios (OR) and relative risk (RR)] was used to determine the differences in morbidity and mortality rates and risk according to categorical risk factors [birth weight (low, medium, high), parity (1 2, 3, ≥4), gender (male versus female), type of birth (twin versus single), lambing season (winter versus spring), health status of dams (ill versus healthy)]. The significance level was set at $P<0.05$.

RESULTS

Health Status

The morbidity and mortality rates in the neonatal period were determined as 17.3% (60/347) and 3.8% (13/347), respectively. The majority of neonatal deaths occurred (84.6%, 11/13) in the first week of life. Diseases determined in the neonatal period were diarrhoea (n=32), suspected septicaemia (n=11), Fatigue-Anorexia Syndrome-FAS (n=11) and pneumonia (n=6). Twenty-five of the diseased lambs re-contracted disease in the period of 5-12 weeks, and 7 of these animals dead. The proportions of lambs that were ill and dead during the period of 5-12 weeks were 32.6% (109/225) and 4.8% (16/334), respectively. Lamb diseases encountered in this period were diarrhoea (n=62), pneumonia (n=25), pneumo-enteritis (n=12), and suspected septicaemia (n=4), while in some other animals the disease remained unclassified (n=6). *Table 1* presents the morbidities and mortalities during the neonatal and post-neonatal periods on the basis of gender, type of birth, birth weight, lambing season, dam health status and parity.

The strength of statistical associations (χ^2) and some epidemiological parameters (OR and RR) and their 95% confidence intervals for morbidities *(Table 2)* and mortalities *(Table 3)* according to gender, type of birth, birth weight, lambing season, dam health status and parity are presented.

Effect of Gender, Type of birth, Birth Weight, Lambing Season, Maternal Health Status and Parity on Morbidity and Mortality in the Neonatal and Post-neonatal Periods

With regard to birth weight, the neonatal morbidity and mortality rates of lambs in the low weight category were significantly ($P<0.001$) higher than those of medium ($\chi^2=10.4$ and $\chi^2=32.5$, respectively) and high ($\chi^2=26.9$ and $\chi^2=46.5$, respectively) birth weight. The neonatal morbidity rate of lambs with medium birth weight was significantly ($\chi^2=4.97$, $P<0.05$) higher than that of lambs with high birth weight. However, there was no significant difference between the neonatal mortality rates of lambs with medium and high birth weight ($\chi^2=0.1$ $P=0.7$). Additionally, there were no significant differences between the post-neonatal morbidity and mortality rates of lambs with different birth weights. With regard to lambing season, the neonatal mortality rate of lambs born in the winter season (9.2%) was significantly higher than those born in the spring season (1.8%, $\chi^2=9.6$ $P<0.01$). However, no significant difference was determined between lambs born in the winter and spring seasons for neonatal morbidity and post-neonatal morbidity and mortality rates Twin-born lambs displayed higher morbidity rates during both periods

(22.6% and 35.4%, respectively) compared to single-born lambs (14.3% and 31.3%, respectively), but the differences were statistically insignificant (χ^2=3.1 P=0.07 and χ^2=0.4, P=0.4 respectively). Furthermore, there were no significant differences in the neonatal or post-neonatal mortality rates between single- and twin-born lambs *(Table 2* and *Table 3)*.

Neonatal lamb morbidity and mortality rates were higher for the first parity. The neonatal morbidity rate of lambs born to primiparous ewes was significantly higher than that of lambs born to ewes at their second and third parity (χ^2=6.4 P<0.05 and χ^2=7.8 P<0.01, respectively), however, no significant difference was observed in comparison to lambs born to ewes with ≥4 parity (χ^2=1.26 P=0.2). Furthermore, the neonatal mortality rate of lambs born to primiparous ewes was significantly higher than that of lambs born to ewes at their second, third and ≥4 parity (χ^2=9.3 P<0.001, χ^2=14.1 P<0.001 and χ^2=4.2 P<0.05, respectively). However, no significant difference existed between the lambs included in the different parity groups for post-neonatal morbidity and mortality rates. Compared to lambs born to healthy dams, the neonatal morbidity rate of lambs born to ill dams was significantly higher (χ^2=30.38 P<0.001). However, the lambs born to ill and healthy dams did not significantly differ from each other for neonatal mortality and post-neonatal morbidity or mortality rates *(Table 2* and *Table 3)*.

Epidemiological Parameters for Lamb Morbidity and Mortality with Regard to Various Variables

Birth weight was a major risk factor for neonatal morbidity and mortality. In the neonatal period, lambs born with low birth weight when compared to those with medium and high birth weight had significantly (P<0.01 to P<0.001) higher risk of morbidity (OR=3.9 RR=2.5 and OR=8.5 RR=4.9, respectively) and mortality (OR=30 RR= 20.3 and OR=42.7 RR=28.8, respectively). Additionally, in comparison to high birth weight lambs, lambs born at medium birth weight had a higher risk of neonatal morbidity (OR=2.1 and RR=1.9) and mortality (OR/RR=1.4), the statistical difference was only evident for morbidity (P<0.05).) However, no significant differences were detected for mortality risk between lambs with medium and high birth weights in the neonatal period (OR/RR=1.4). Although, in general, it was ascertained that the post-neonatal morbidity and mortality risks of low birth weight lambs were higher than those with medium and high birth weights, and those of medium birth weight lambs were higher than those with high birth weight (generally OR>1), these results did not bear any statistical significance. Lambs born in the winter season had a significantly (P<0.01) higher risk of mortality than lambs born in the spring season (OR=5.5 and RR=5.1). However, there were no significant differences in the risk of neonatal morbidity or post-neonatal morbidity and mortality between lambs that were born in the winter and

Table 1. *Neonatal and post-neonatal morbidity and mortality rates in lambs according to birth weight, type of birth, gender, parity, lambing season, and dam health status*

Table 1. *Kuzularda cinsiyet, doğum ağırlığı, kuzulama sezonu, doğum tipi, annenin doğum sayısı ve sağlık durumuna göre neonatal ve post-neonatal morbidite ve mortalite oranları*

Factor	Group	N	Clinical Examination (%)								
			Period								
			Neonatal					Post-Neonatal			
			N1	Morbidity	N2	Mortality	N	N1	Morbidity	N2	Mortality
BW (kg)	Low	27	13	48.1	9	33.3	18	7	38.9	2	11.1
	Medium	122	23	18.9	2	1.6	120	42	35	5	4.2
	High	173	17	9.8	2	1.2	171	51	29.8	7	4.1
Type of Birth	Twin	84	19	22.6	2	2.4	82	29	35.4	5	6
	Single	238	34	14.3	11	4.6	227	71	31.3	9	4
Gender	Male	173	32	18.5	8	4.6	165	52	31.5	7	4.2
	Female	149	21	14.1	5	3.4	144	48	33.5	7	4.9
Parity	1	54	16	29.6	8	14.8	46	13	28.2	3	6.5
	2	137	19	13.9	4	2.9	133	52	39.1	6	4.5
	3	90	10	11.1	0	0	90	26	28.9	3	3.3
	≥4	41	8	19.5	1	2.4	40	9	22.5	2	5
Lambing Season	Winter	98	17	17.3	9	9.2	89	30	33.7	4	4
	Spring	224	36	16.1	4	1.8	220	70	31.8	10	4.5
Dam's Health	Healthy	17	11	64.7	2	11.8	15	5	33.3	0	0
	Ill	305	42	13.8	11	3.6	294	95	32.3	14	4.8

N: *Total number of animals,* ***N1:*** *Number of ill animals,* ***N2:*** *Number of animals that dead*

Table 2. *The effect of birth weight, type of birth, gender, parity, lambing season and dam health status on lamb morbidity*
Tablo 2. *Kuzu hastalıkları üzerine, cinsiyet, doğum ağırlığı, kuzulama sezonu, doğum tipi, annenin doğum sayısı ve sağlığının etkisi*

Factors	Comparisons	Period	χ^2	OR	95% CI	RR	95% CI
Birth Weight	Low vs. Medium	1	10.35**	3.99**	1.52-10.56	2.55**	1.35-4.32
		2	0.10	1.18	0.37-3.61	1.11	0.49-1.98
	Low vs High	1	26.90***	8.52***	3.12-23.28	4.90***	2.48-8.89
		2	0.63	1.49	0.49-4.48	1.30	0.58-2.29
	Medium vs. High	1	4.97*	2.13*	1.03-4.42	1.91*	1.02-3.61
		2	0.86	1.26	0.74-2.14	1.17	0.81-1.66
Type of Birth	Twin vs. Single	1	3.14	1.75	0.89-3.43	1.58	0.91-2.68
		2	0.46	1.20	0.68-2.12	1.13	0.76-1.62
Gender	Male vs. Female	1	1.13	1.38	0.73-2.63	1.31	0.76-2.27
		2	0.12	0.92	0.55-1.53	0.94	0.67-1.33
Parity	1 vs. 2 lambing	1	6.43*	2.62*	1.14-5.96	2.14*	1.12-3.99
		2	1.74	0.61	0.27-1.35	0.72	0.40-1.20
	1 vs. 3 lambing	1	7.82**	3.34**	1.29-8.91	2.67*	1.23-5.93
		2	0.006	0.97	0.41-2.28	0.97	0.51-1.76
	1 vs. ≥4 lambing	1	1.26	1.74	0.60-5.12	1.52	0.68-3.61
		2	0.37	1.36	0.46-4.05	1.26	0.56-2.93
	2 vs. 3 lambing	1	0.37	1.28	0.53-3.15	1.25	0.58-2.78
		2	2.46	1.58	0.86-2.92	1.35	0.90-2.07
	2 vs. ≥4 lambing	1	0.78	0.66	0.25-1.83	0.71	0.32-1.68
		2	3.71	2.21	0.91-5.46	1.74	0.94-3.57
	3 vs. ≥4 lambing	1	1.67	0.52	0.17-1.59	0.57	0.22-1.50
		2	0.57	1.39	0.54-3.67	1.28	0.65-2.77
Lambing Season	Winter vs. Spring	1	0.08	1.09	0.55-2.15	1.07	0.61-1.87
		2	0.10	1.09	0.62-1.89	1.05	0.72-1.51
Dam's Health	Ill vs. Healthy	1	30.38***	11.48***	3.67-37.17	4.69***	2.61-6.65
		2	0.007	1.04	0.31-3.45	1.03	0.39-1.96

Periods; 1: *Neonatal (First 4 weeks of life)* ***2:*** *Post-Neonatal (Period from the first 5th to 12th weeks of life), * P<0.05 ** P<0.01 *** P<0.001*

spring seasons. Twin-born lambs had a higher risk of morbidity in both periods (OR=1.8 RR=1.6 and OR=1.2 RR=1.1, respectively) than single-born lambs, but the differences were not significant (P=0.08 and P=0.4, respectively). Furthermore, there were no significant differences between twin- and single-born lambs for the risk of neonatal or post-neonatal mortality. The risk of neonatal and post-neonatal morbidity and morbidity did not differ between males and females *(Table 2* and *Table 3)*.

First parity was found to be an important risk factor for increased neonatal lamb morbidity and mortality. The risk of neonatal lamb morbidity for the first parity, compared to the second and third parity (OR=2.6 RR=2.1 and OR=3.3 RR=2.6, respectively), was significantly higher (P<0.05 and P<0.01). Similarly compared to lambs born to ewes with 2, 3, ≥4 parity (OR=5.7 RR=5.1, uncalculated and OR=6.9 RR=6.1, respectively), it was ascertained that the neonatal mortality risk of the first parity lambs was significantly higher (P<0.01, P<0.001 and P<0.05, respectively). It was observed that the neonatal and post-neonatal morbidity and mortality risks were higher for lambs born to ewes at their first parity compared to those born to ewes with 2, 3 and ≥4 parity, and it was also ascertained that the risks for the second parity were higher than those for 3 and ≥4 parity, while the risks for the third parity were greater than those for ≥4 parity (generally OR>1), yet, no statistical significance apart from that mentioned above was detected (P>0.05). Furthermore, it was determined that the risks neonatal morbidity and mortality for lambs born to ill ewes were greater than those born to healthy ewes (OR=11.4 RR=4.6 and OR=3.5 RR=3.2, respectively), but only the risk for morbidity was statistically significant (P<0.001) *(Table 2* and *Table 3)*.

Table 3. *The effect of birth weight, type of birth, gender, parity, lambing season and dam's health status on lamb mortality*
Tablo 3. *Kuzu ölümleri üzerine, cinsiyet, doğum ağırlığı, kuzulama sezonu, doğum tipi, anne doğum sayısı ve sağlığının etkisi*

Factors	Comparisons	Period	χ^2	OR	95% CI	RR	95% CI
Birth Weight	Low vs. Medium	1	32.47***	30.00***	5.35-220.9	20.33***	4.47-133.9
		2	1.57	2.88	0.35-19.09	2.67	0.37-14.29
	Low vs. High	1	46.52***	42.75***	7.66-313.1	28.83***	6.31-190.1
		2	1.77	2.93	0.38-17.59	2.71	0.39-12.83
	Medium vs. High	1	0.13	1.43	0.14-14.36	1.42	0.14-13.96
		2	0.001	1.01	0.27-3.68	1.01	0.28-3.49
Type of Birth	Twin vs. Single	1	0.81	0.51	0.08-2.48	0.52	0.08-2.37
		2	0.63	1.57	0.44-5.34	1.54	0.45-4.87
Gender	Male vs. Female	1	0.33	1.39	0.41-5.03	1.38	0.42-4.77
		2	0.07	0.87	0.26-2.83	0.87	0.28-2.71
Parity	1 vs. 2 lambing	1	9.31**	5.78**	1.48-24.14	5.07*	1.44-19.59
		2	0.28	1.47	0.27-7.05	1.45	0.29-6.24
	1 vs. 3 lambing	1	14.11***	NC***	2.76-NC	NC**	2.59-NC
		2	0.73	2.02	0.31-13.25	1.96	0.32-11.88
	1 vs. ≥4 lambing	1	4.16*	6.96*	0.82-154.7	6.07*	0.83-129.3
		2	0.09	1.33	0.16-12.01	1.30	0.18-10.98
	2 vs. 3 lambing	1	2.66	NC	0.43-NC	NC	0.44-NC
		2	0.19	1.37	0.29-7.12	1.35	0.31-6.75
	2 vs. ≥4 lambing	1	0.03	1.20	0.12-29.09	1.19	0.13-28.8
		2	0.02	0.89	0.15-6.73	0.90	0.17-6.40
	3 vs. ≥4 lambing	1	2.21	0.00	0.00-7.94	0.00	0.00-7.87
		2	0.21	0.65	0.08-5.88	0.66	0.09-5.63
Lambing Season	Winter vs. Spring	1	9.6 **	5.56**	1.51-22.08	5.14**	1.48-19.58
		2	0.00	0.98	0.25-3.55	0.99	0.26-3.32
Dam's Health	Ill vs. Healthy	1	2.76	3.56	0.49-19.59	3.26	0.51-13.49
		2	0.74	0.00	0.00-7.53	0.00	0.00-6.08

Periods; 1: *Neonatal (First 4 weeks of life)* ***2:*** *Post-Neonatal (First 5- 12 weeks of life)* ***NC:*** *Not calculated * P<0.05 ** P<0.01 ** P<0.001*

DISCUSSION

This study was carried out examine the effect of birth weight, gender, birth type, lambing season, and dam parity and health status on lamb morbidity and mortality during the first 12 weeks of life. This was the first detailed study for the determination of neonatal lamb morbidity and mortality and associated risk factors in a large number of lambs [6]. The mean morbidity and mortality rates ascertained in this study (7% and 10%, respectively) were lower than those reported by Gokce and Erdogan [6]. This difference might be attributed to different farm management programs. Farm management and particularly feeding programs, have a major effect on certain parameters including birth weight. The main causes of neonatal morbidity and mortality were found to be similar to those reported by Gokce and Erdogan [6].

In the present study, lamb birth weight was a significant risk factor, as lambs with low birth weight had a greater risk of mortality and morbidity, compared to those with medium or high birth weights. This, in general, is in agreement with previous reports [8,9,18,22-25]. It has previously been reported that lambs with a birth weight ≤3 kg have a significantly greater risk of mortality [16,26]. Khan et al.[16], hypothesized that lambs with low birth weight, being physically weak, were unable to suckle sufficient amounts of colostrum as a result the IgG concentration in their serum remained low, which might have led to an increased mortality and hypothermia in these lambs. Similarly, other researchers also argued that, lamb survival depends on good preferable weight and an adequate colostrum intake [2,27]. This was confirmed in the present study, in where the mortality rate of lambs, with birth weights less than 3 kg, was higher than those having birth weights greater than 3 kg. The authors of the present study also found that, the serum IgG level of lambs with low birth weights (≤3 kg) was lower than the lambs born at medium (>3 to ≤4 kg) or high (>4 kg) birth weights [28]. Apart from being a source of immunoglobulins, colostrum is also a major source of

energy. Lambs born at a low birth weight rapidly consume their body energy reserves and eventually, may die due to hypothermia if not able to suckle enough colostrum [18,29]. In this respect, the implementation of management programmes targeted at increasing lamb birth weight (i.e. sufficient concentrate feed intake by ewes in the last trimester of pregnancy), as well as the observation of animals during the lambing season so that the timely contact of lambs born at low birth weight is ensured with their dams (the housing of the lamb and dam in the same paddock, etc.) as strong lamb-dam interaction results in both colostrums production and colotrum intake in lambs and the control of body temperature with an aim to prevent hypothermia (adequate and early intake of colostrum by the lamb, treatment with glucose, enabling of drying of the animal etc.) are considered as important factors in the survival of lambs [18,22,26,29-31]. Factors that have effect on birth weight include birth type and gender of lambs, prenatal nutrition, health status, parity and placental size of dam as well as foetal genotype [18,26,28,30] therefore, measures aimed at increasing birth weight should address these factors especially at last trimester of gestation.

In the present study, a significantly higher proportion of lambs dead in the neonatal period during the winter season. Lambs born in the period from December to February were about 5 times more likely to die than were lambs born in the period from March to May. This may be linked to high stocking density or overcrowding, climate and weather conditions, as well as to the high infection potential in the winter season resulting from the accumulation of manure and contaminated bedding. This result is in line with some previous investigations [22,32,33]. Previous studies have pointed out to the fact that environ-mental conditions arising from harsh climate (cold, wind, rain), together with poor management, increase losses [6,22,33]. However, an insignificant effect of birth season on mortality rate was reported by Turkson and Sualisu [8], Mandal et al.[34], and Piwczynski et al.[35]. Severe cold weather can stress lambs, increasing their energy requirements by 500 percent, and the depletion of their energy reserves where in particularly lambs born at low birth weight susceptible to cold stress, starvation and disease exposure [2,4].

The odds of death or disease during the neonatal and post-neonatal periods did not differ significantly between the genders in this study. This finding is in line with previous reports obtained for the first three months of life [7,8,16,22,34,35]. As the birth weight of male lambs is expected higher, males are considered to be born physically stronger and to have greater advantage with regards to protection from diseases and the development of passive immunity. Thus, morbidity and mortality rates of male lambs are expected to be lower than those of female lambs. Aksakal et al.[36], having studied the Awassi breed, observed higher mortality rates in female lambs. However, some studies reported that, male lambs displayed higher mortality than females, particularly after the first three months of life [2,8,9,13,33,34]. This is attributed to dystocia caused by male lambs as they are usually born heavier and the advantage of female lambs to recognize their dams when compared to their male counterparts [15,22,26,30]. Similarly, Nash et al.[15], suggested that the gender variation observed in mortality, with females and castrated males having similar and lower risk, could reflect the effect of male hormones on immune function.

In the present study, an insignificant statistical relationship was observed for mortality rates between single- and twin-born lambs, which is in agreement with the results of Turkson and Sualisu [8], Turkson [37], Mandal et al.[34] and Yapi et al.[7]. However, the twin-born lambs were observed to be confronted with multiple disadvantages, including reduced low birth weight [18,28,35], increased exposure to mismothering, more difficult access to udders, competition for access to feed, inadequate suckling of colostrum or milk [1,2,9,18,29,35,36]. Nevertheless, in the present study, the association of birth type was marginal with only neonatal morbidity ($P = 0.07$). Similarly, mortality in twin-born lambs in the two periods were not significantly different from those in single-born lambs. Twinning slightly increased the risk of mortality in the post-neonatal period, but this difference was statistically insignificant. This result was similar to that reported by Turkson and Saualisu [8] and that reported by Nash et al.[2]. However, some studies [1,2] argued that multiple births increased the risk of neonatal or perinatal (first week of life) mortality.

Parity has a significant effect on neonatal lamb morbidity and mortality and this finding is in agreement with previous literature reports [9,15,16,25,30,34,36]. In the present study, the risk of neonatal mortality and morbidity tended to be higher for the first parity compared to ewes that had given birth before. This was attributed to primiparous dams producing less and low quality colostrum/milk and displaying poor mothering ability (mismothering). Primiparous ewes show impairments in the expression of maternal behaviour when compared to multiparous ewes [31]. Additionally, the first parity is characterized by a lower lamb birth weight and poor postnatal vigour compared to second and further births [15,18,28,30,31,34,38]. Furthermore, lambs born to primiparous ewes display slower neonatal behavioural progress (i.e. standing up and reaching the udder), compared to lambs born to more experienced multiparous ewes [30,31]. These factors increase either the risk of hypothermia and failure of passive immunity transfer or susceptibility to infection in lambs suffering from malnutrition born to primiparous ewes. The present study also observed that the poor health status of ewes increases both the rate and risk of neonatal morbidity and mortality in lambs. This could be explained with the insufficient production of colostrum or milk and the poor mothering ability observed in these ewes [25,29,39]. Consequently, the risk of morbidity and mortality increased in their lambs.

The present investigation revealed some important

environmental and animal-related factors that affect lamb morbidity in the Akkaraman crossbreed. The birth weight of lambs being lower than ≤3 kg and first parity significantly increased neonatal morbidity and mortality, while the poor health status of ewes significantly increased neonatal morbidity, and birth in the winter season increased the rate and risk of neonatal mortality. When developing programmes targeted at the prevention of potential mortality and morbidity, these results should be taken into consideration. However, further research is required to be conducted on a larger number of animals and farms as the number of lambs dead within the first 12 weeks of life was low in our study which may limit the interpretation of our results.

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