International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:4, No:5, 2010

The Relationship between Sheep Management and Lamb Mortality

T. M. Mousa-Balabel

***Abstract*—**This study was carried out to investigate lamb mortalities relating to ewes' breed and some managemental factors on 250 pregnant ewes (190-Rahmani, 30-Ossimi and 30-Romanov) at Mehallet Mousa, Animal Production Research Station, Kafr El-Sheikh Province, Egypt. These animals divided into five groups according to the managemental factors used. The results revealed that the lamb mortality was higher in Ossimi breed and lower in Romanov one. In addition, the highest lamb mortality occurred among lambs for unsupplemented ewes, for those had body condition score two and for lambs which born outdoor. Moreover, the lamb survivability was increased by the parity of ewes. From this study it can be concluded that the lamb mortality depends on ewes' body condition score, parity, lambing system (indoor or outdoor), nutrition during pregnancy period and selected breed. In addition, the most important period for lamb survival is the first week of age.

***Keywords*—** lamb mortality, sheep breeds, sheep management, sheep parity.

I. INTRODUCTION

INCREASED lambing percentage is the biggest contributor to get higher profits from sheep farms. Lambs survivability is an important issue in highly fecund sheep flocks. Lamb mortality rate averages 9 to 20% in the most sheep producing countries [2], representing an important economic loss for farmers. The decline in single-bearing ewes is compensated by an increase in triplet-bearing ewes. The increased proportion of ewes having triplets is of concern to farmers and to industry because lamb mortality reaches to the greatest in triplets [11, 18] and twin- and triplet-born lambs have greater mortality rates than singles [14].

Lamb mortality is influenced by lamb factors (breed and sex), prenatal influences (prenatal nutrition, litter size), ewe factors (condition score and parity), and the birth process [4]. The main causes of lamb mortality varied according to the farms' location and managemental system. However, the single greatest predictor of lamb mortality is the birth weight [13]. Heavy lambs may experience difficult deliveries and die during birth [3], whereas low birth weight lambs are more likely to experience starvation and hypothermia [33]. Lamb birth weight had the greatest predictive power for survival during the neonatal period as; survivability dramatically decreased with extreme birth weights, although it reached a survival probability greater than 93.5% within the 3.3 to 5.4 kg range. Lamb behavioral progress is retarded in males in comparison with ewe lambs, in larger litter sizes compared with smaller sizes, in lambs that have experienced a difficult delivery, and in low birth weight lambs in comparison with larger lambs [4]. Undernourished pregnancy ewes give birth to lightweight lambs [29] and consequently have impact on either lamb behavior, as same as placental insufficiency [5] or increased mortality rates [16]. Additionally, undernourished ewes were less attached to their lambs than adequately fed ewes [6]. However, in studies in which maternal nutrition was manipulated by altering pasture allowance in late gestation, the effect of nutritional treatment on maternal responses to the ewe's handling of her lambs within 12 hours of birth was small [11], although the ewes with the greatest pasture allowance tended to stay closer to their lambs compared with the ewes with the least allowance. Inadequate maternal nutrition during pregnancy can therefore compromise lamb survival through its impact on lamb prenatal development, maternal lactation and by reducing both the quality of maternal behavior and the strength of the ewe-lamb interaction.

Breed differences in lamb vigor at birth have been reported in pure and crossbred breeds [9]. Romanov ewes show better maternal care (more licking, grooming, and lamb acceptance, and less aggression) than the other breeds [27, 20]. Thus, it is clear that considerable breed differences exist in the quality of expressed maternal behavior. As, the maternal behavior of ewes has been assessed by using a composite measure of ewes' reactions; when their lambs are handled by a shepherd; called the Maternal Behavior Score (MBS) [26]. This score shows variation within and between breeds and is related to both lamb survival and weaning weight. In general, ewes with a low MBS have higher lamb mortality, although survival does not increase with an increase in MBS above the average [12, 31]. Worldwide, lamb mortality ranged between 10 and 30% from birth to weaning age [35, 31]. The vast majority of these mortalities occur within the first 3 days of postnatal life [25].

Primiparous ewes show impairments in the expression of maternal behavior if compared with multiparous ewes. A comparison of the behavior of the same ewes in successive pregnancies revealed that ewes were consistent in their behavior across parity for care giving behaviors (maternal grooming) and for rejection or lamb avoidance behavior, although aggressive behaviors were not repeatable [7]. Primiparous ewes tend to have a longer labor than experienced ewes and are slower to begin grooming their lambs after birth

Tarek Mahmoud Mousa-Balabel (corresponding author) is with Department of Hygiene and Preventive Medicine, Faculty of Veterinary Medicine, Kafr EL-Sheikh, University, Egypt. Current address: Tottori-shi, Mihagino 1chome 55-3 Ken Ju 51 Gou. Postal code. 689-0202. Tel. +81-80-6302-4217, Fax. +81-857-59-1775. (e-mail: balabel_2006@yahoo.com)

[10]. However, on average, when compared with multiparous ewes, primiparous ewes show equivalent amounts of grooming behavior over the first 2 hours after delivery and make a similar number of low-pitched bleats [7]. Experience of being a mother, gained during the initial contacts of the ewe with her lamb, allows her to learn to respond appropriately, and she becomes less likely to prevent subsequent sucking attempts [8]. Higher prenatal [36], neonatal mortality [24] and lower lamb survival [19] was reported in ewes with low body condition score.

The aim of this study was to determine the effect of different sheep breeds (two Egyptian sheep breeds; Ossimi and Rahmani; and Romanov as a foreign breed) on lamb survivability and to investigate the relationship between some sheep managemental practices and lamb mortality.

II. MATERIALS AND METHODS

In this study, 250 pregnant ewes (190-Rahmani, 30-Ossimi and 30-Romanov ewes; their age ranged from 1.5 to 4 years and their body weight ranged from 40 to 62 kg) were selected to study the effect of some sheep managemental practices on their lamb mortalities up to weaning age. These animals were raised at Mehallet Mousa, Animal Production Research Station, Kafr El-Sheikh Province, Egypt. The animals were treated as following; Group I (different breed group), in which 90 pregnant ewes (30-Ossimi, 30-Rahmani and 30-Romanov ewes) were used to study the effect of different breeds on lamb mortality. Group II (lambing system group), in which 20 pregnant Rahmani ewes were used and divided into two subgroups (10 each). The animals in the first subgroup were lambed indoor while, the animals in the second one were lambed outdoor to study the effect of lambing system on lamb mortality. Group III (feed supplementation group), in which 60 pregnant Rahmani ewes were used and divided into two subgroups (30 each). The animals in first subgroup were supplemented at late stage of pregnancy (each ewe was supplemented by 400gm/head/day from the following ration; 65% Cotton seed cake, 9% Wheat bran, 21% Rice polish, 1% Calcium carbonate, 1% Sodium chloride and 3% Molass), meanwhile, the animals in the second subgroup were not supplemented and kept as a control group to study the effect of feed supplementation during late pregnancy on lamb mortality. Group IV (body condition score group), in which 40 pregnant Rahmani ewes were used and divided into four subgroups (10 each) according to their body condition score (the body condition score was based on a 5-point scale with half point gradations, where 1 is very thin and 5 is obese). The animals in the first subgroup had body condition score 2, the animals in the second subgroup had body condition score 2.5, the animals in the third subgroup had body condition score 3 and those in the fourth subgroup had body condition score 3.5 to study the effect of body condition scores of dam on lamb mortality. Group V (parity group), in which 40 pregnant Rahmani ewes were used and divided into four subgroups (10 each) according to their parity (number of giving births before). The animals in the first subgroup had no birth before, the animals in the second subgroup had one birth before, the animals in the third subgroup had two births before and those in the fourth subgroup had three births before to study the effect of parity of dams on lamb mortality. The animals during the course of the present experiment were fed green fodders, concentrates and rice hay in rates of 7, 0.5 and 2 Kg with water adlibitum. The lamb mortalities relating to lambs' birth body weight, sex and single or twin, dam parity and nutrition during late pregnancy were recorded. Statistical analysis was done using a linear model (SAS/STAT, [32], procedure GLM). Non-parametric tests were done on mortality rate with proc CATMOD and significance was evaluated by X^2 values.

III. RESULTS

Concerning the breed of ewes, the lamb mortality percentage for the different three breeds; Ossimi, Rahmani and Romanov are given in table 1. There was a significant difference ($P<0.05$) in the total lamb mortality between foreign breed (Romanov) and Egyptian breeds (Ossimi and Rahmani); Romanov breed had the lowest overall mortality 7.1%, and Ossimi breed had the highest mortality 21.4% while, Rahmani breed had 16.6%. The mortality percent for ram lambs was higher for the three breeds; Ossimi, Rahmani and Romanov (28.6, 20.1 and 10%; $P<0.05$, respectively) than that for ewe lambs (14.3, 11.8 and 3.8%, respectively) as shown in table 1. The percent of lamb mortality was higher in twin lamb births than in single lamb births among all lambs for the three breeds; Ossimi, Rahmani and Romanov, the former being was 50, 41.7 and 7.6%; $P<0.05$, respectively and the later was 10.7, 4.2 and 0%, respectively as shown in table 1. Moreover, it was observed that most of all dead lambs died shortly after birth or within one week of age in lambs for the three breeds; Ossimi, Rahmani and Romanov as; the record was 17.8, 13.9 and 7.1%; $P<0.05$, respectively. Another 3.6, 2.7 and 0%, respectively died during the period from one week of age till weaning age (Table 1). There was a relationship between the birth weight and the lamb mortality. It was observed that within the three breeds; Ossimi, Rahmani and Romanov the highest mortality occurred in lambs which had birth body weight less than 3 kg (16, 12, and 5.3%; $P<0.05$, respectively) if compared with those had birth body weight over 3 kg (5.4, 4.6, and 1.7%, respectively) as shown in table 1.

The nutrition of ewes at the end of gestation period affected the number of lambs died per ewe as; the total mortality percent among lambs for undernourished ewes was higher 21.7%; $P<0.05$ than that for supplemented ewes 16% as shown in table 2. A relationship has been observed between the lambing system (Indoor or outdoor) and the neonatal lamb mortalities; it was observed that the total mortality percent among lambs born outdoor was higher 20%; $P<0.05$ than those born indoor 14.3% (table 2). There was an effect of parity of the dam on overall mortality of lambs. Unexpectedly, total lamb mortalities was the highest for the first parity dams (Table 3) and the lowest for the second, the third and the fourth parity; lamb mortalities tended to be higher in the first

parity group 33.3%; *P<0.05* and declined until the fourth parity (16.6% for second, 6.6% for third and 7.1%. for the fourth parity). On the other hand, it was observed that the highest total mortalities occurred among the lambs for ewes which had the body condition score two (22.2%) and three and half (18.5%; *P<0.05*) if compared with those for ewes which had body condition score two and half and three (15.4 and 7.1%, respectively) as shown in table 4.

TABLE I
EFFECT OF DIFFERENT BREEDS OF EWES ON LAMB MORTALITY %.

Variables	Breed			X^2
	OS*	RA	RO	
No. of ewes	30	30	30	
Total born lambs	28^{a}	36^{b}	56^{c}	3.7
Mean birth weight (g)	3100^{a}	3300^{b}	3600^{c}	2.8
Ram lambs %	50^{a}	52.7^{a}	53.6^{a}	1.4
Ewe lambs %	50^{a}	47.3^{a}	46.4^{a}	2.4
Single lambs %	92.9^{a}	80^{b}	13.4^{c}	3.0
Twin lambs %	7.1^{a}	20^{b}	86.6^{c}	1.6
Dead ram lambs %	28.6^{aA}	20.1^{bA}	10^{c}	2.6
Dead ewe lambs %	14.3^{aB}	11.8^{bB}	3.8^{a}	2.0
Dead single lambs %	10.7^{aA}	4.2^{bA}	0^{c}	3.2
Dead twin lambs %	50^{aB}	41.7^{bB}	7.6^{c}	3.7
Dead lambs less than 3kg %	16^{aA}	12^{bA}	5.3^{cA}	1.4
Dead lambs over 3kg %	5.4^{aB}	4.6^{aB}	1.7^{bB}	2.7
Deaths from birth to one week age %	17.8^{aA}	13.9^{bA}	7.1^{cA}	2.4
Deaths from week to weaning age %	3.6^{aB}	2.7^{bB}	0^{cB}	3.0
Total dead lambs	6	7	4	
Total lamb mortalities %	21.4^{a}	16.6^{b}	7.1^{c}	8.7

[a. b. c] Superscript in the same row differ significantly (*P<0.05*).
[A, B, C] Superscript in the same column relating to sex, single or twin, birth weight and lamb age within the same subgroup differ significantly (*P<0.05*).
OS= Ossimi RA= Rahmani RO= Romanov * Two Ossimi ewes in this group had prenatal lamb losses.

TABLE II
EFFECT OF LAMBING SYSTEM AND FEED SUPPLEMENTATION OF EWES DURING PREGNANCY ON LAMB MORTALITY %.

Variables	Feed		X^2	Lambing system		X^2
	S	US		Indoor	Outdoor	
No. of ewes	30	30		10	10	
Total born lambs	50^{a}	46^{b}	3.8	14^{a}	15^{a}	2.8
Mean birth weight (g)	3390^{a}	3290^{a}	2.6	3350^{a}	3250^{a}	1.6
Ram lambs %	52^{a}	56.5^{a}	1.6	57.2^{a}	46.7^{b}	2.2
Ewe lambs %	48^{a}	43.5^{a}	2.8	42.8^{a}	53.3^{b}	3.8
Single lambs %	75^{a}	85^{b}	3.2	60^{a}	50^{b}	1.4
Twin lambs %	25^{a}	15^{b}	1.8	40^{a}	50^{b}	2.8
Dead ram lambs %	19.2^{aA}	23.1^{aA}	2.4	12.5^{aA}	14.3^{aA}	3.4
Dead ewe lambs %	12.5^{aB}	20^{bA}	2.2	16.7^{aB}	25^{bB}	2.6
Dead single lambs %	6.7^{aA}	7.9^{aA}	3.6	10^{aA}	0^{bA}	1.8
Dead twin lambs %	30^{aB}	87.5^{bB}	3.2	25^{B}	50^{bB}	2.2
Deaths from birth to one week age %	12^{aA}	17.3^{bA}	1.8	14.3^{aA}	20^{bA}	3.2
Deaths from week to weaning age %	4^{aB}	4.4^{aB}	2.4	0^{aB}	0^{aB}	1.4
Total dead lambs	8	10		2	3	
Total lamb mortalities %	16^{a}	21.7^{b}	3.4	14.3^{a}	20^{b}	6.6

[a. b. c] Superscript in the same row differ significantly (*P<0.05*). S= Supplemented by feed. US= Unsupplemented by feed.
[A, B, C] Superscript in the same column relating to sex, single or twin, birth weight and lamb age within the same subgroup differ significantly (*P<0.05*).

TABLE III
EFFECT OF PARITY FOR RAHMANI EWES ON LAMB MORTALITY %.

Variables	Parity				X^2
	1	2	3	4	
No. of ewes	10	10	10	10	
Total born lambs	10^{a}	12^{c}	15^{b}	14^{b}	2.2
Mean birth weight (g)	3100^{a}	3150^{a}	3300^{b}	3350^{b}	1.8
Ram lambs %	70^{a}	41.6^{b}	46.6^{b}	57.1^{c}	2.4
Ewe lambs %	30^{a}	58.4^{b}	53.4^{b}	42.9^{c}	3.2
Single lambs %	90^{a}	80^{b}	50^{c}	60^{d}	1.6
Twin lambs %	10^{a}	20b	50^{c}	40^{d}	3.0
Dead ram lambs %	28.5^{aA}	20^{bA}	0^{cA}	12.5^{dA}	3.4
Dead ewe lambs %	33.3^{aB}	14.2^{B}	12.5^{cB}	0^{dB}	2.6
Dead single lambs %	12.5^{aA}	12.5^{A}	20^{bA}	0^{cA}	1.6
Dead twin lambs %	100^{aB}	25^{bB}	0^{cB}	12.5^{dB}	2.6
Deaths from birth to one week age %	20^{aA}	16.6^{bA}	6.6^{cA}	7.1^{cA}	4.2
Deaths from week to weaning age %	13.3^{aB}	0^{bB}	0^{b}B	0^{b}B	1.4
Total dead lambs	3	2	1	1	
Total lamb mortalities %	33.3^{a}	16.6^{b}	6.6^{c}	7.1^{c}	6.8

[a. b. c] Superscript in the same row differ significantly ($P<0.05$).
[A, B, C] Superscript in the same column relating to sex, single or twin, birth weight and lamb age within the same subgroup differ significantly ($P<0.05$).

TABLE IV
EFFECT OF BODY CONDITION SCORE FOR RAHMANI EWES ON LAMB MORTALITY %.

Variables	Body condition score				X^2
	2*	2.5	3	3.5	
No. of ewes	10	10	10	10	
Total born lambs	9^{a}	13^{b}	14^{b}	11^{c}	3.4
Mean birth weight (g)	3000^{a}	3300^{c}	3350^{ac}	3250^{ab}	2.8
Ram lambs %	55.6^{a}	46.2^{b}	57.1^{a}	81.8^{c}	1.8
Ewe lambs %	44.4^{a}	53.8^{b}	42.9^{a}	18.2^{c}	2.2
Single lambs %	100^{a}	70^{b}	60^{c}	90^{d}	1.4
Twin lambs %	0^{a}	30^{b}	40^{c}	10^{d}	2.8
Dead ram lambs %	40^{aA}	16.6^{bA}	12.5^{cA}	11.1^{cA}	3.4
Dead ewe lambs %	0^{aB}	14.3^{bA}	0^{aB}	50^{cB}	2.6
Dead single lambs %	22^{aA}	0^{bA}	0^{bA}	0^{bA}	3.4
Dead twin lambs %	0^{aB}	33.3^{bB}	12.5^{cB}	100^{dB}	6.4
Deaths from birth to one week age %	22.2^{aA}	15.4^{bA}	7.1^{cA}	9.1^{cA}	2.2
Deaths from week to weaning age %	0^{aB}	0^{aB}	0^{aB}	9.1^{bA}	1.2
Total dead lambs	2	2	1	2	
Total lamb mortalities %	22.2^{a}	15.4^{b}	7.1^{c}	18.2^{b}	8.6

[a. b. c] Superscript in the same row differ significantly ($P<0.05$).
[A, B, C] Superscript in the same column relating to sex, single or twin, birth weight and lamb age within the same subgroup differ significantly ($P<0.05$).
* One ewe in this group had prenatal lamb loss.

IV. DISCUSSION

The number of born lambs per ewe is certainly an economical important trait in a commercial sheep enterprise. However, the profitability is largely determined by the number of lambs sold per ewe. Therefore, much attention should be paid to the care of pregnant ewes and their lambs before, during, and after birth. The neonatal period is very decisive for lambs rearing. During this period, mortality is a major factor limiting the profitability in sheep farming. The total lamb mortality percentage for the different three breeds; Ossimi, Rahmani and Romanov are 21.4, 16.6 and 7.1%, respectively. This may be due to ewes may differ in the maternal care they express, e.g. the amount of grooming behavior, responses to the lamb's suckling attempts, likelihood of desertion. These differences usually persist over successive births [7] suggesting that they are intrinsic to the individual. One of the most frequently explored sources of maternal behavior variation is breed differences. As well as, foreign breed (Romanov) ewes showed better maternal care; more licking, grooming, and lamb acceptance, and less aggression [27, 20] than Egyptian breeds (Ossimi and Rahmani). Lamb mortalities were affected by Litter size; twin-born lambs died overall more than singles did; suggesting that this may be attributing to their lower birth weight relative to single-born lambs. The majority of all dead lambs died from birth till one week of age in lambs for the three breeds; Ossimi, Rahmani and Romanov; 17.8, 13.9 and 7.1%, respectively if compared with 3.6, 2.7 and 0%, respectively died from one week of age till weaning age. These results are in concert with those obtained by Hight [15] who mentioned that most deaths of lambs are invariably concentrated in the first days after birth. In addition, the attention of the shepherd should then focus on this period. The weight of lamb at birth has a tremendous impact on the ability of the lamb to survive. The mortality of lambs is extremely high in low birth weight lambs within the three breeds; Ossimi, Rahmani and Romanov, but improves steadily for any increase in the lamb birth weight. In addition, lambs with low birth weight are subject to death from starvation due to their lower energy reserves and weakness. Ram lambs have a slightly higher mortality percent for the three breeds; Ossimi, Rahmani and Romanov (28.6, 20.1 and 10%, respectively) if compared with that for ewe lambs (14.3, 11.8 and 3.8%, respectively). This difference in death percent resulted in tendency to balance the sex ratio as the lambs got older. Finally, under Egyptian environmental conditions, the productivity and survivability of lambs were higher in Romanov breed than that for Ossimi and Rahmani breeds as well as the maternal care of ewes.

The mortality percent of lambs was affected by the nutrition of the ewe at the end of gestation; undernourished ewes give birth to smaller lamb prone to an early death, whereas, the lamb of supplemented ewe may be too big for a chance of survival. Moreover, undernourished ewes produced less colostrum and less milk during lactation and lambs will have a lower intake of colostrum, reduced immunoglobulins and hence greater mortality from infectious disease may occur. Additional adverse effects of maternal under-nutrition include reduced udder development as well as less colostrum production and quality. Nutritional supplementation during late pregnancy can be used to reduce lamb mortality by increasing the birth weight of the lamb [21, 17], increasing colostrum and milk production [22, 1]. Indeed, ewes that are underfed during pregnancy have differing physiological profiles during gestation period compared to well-fed ewes. Low nutrition is associated with higher plasma progesterone in late gestation period [10] and a lower ratio of oestradiol to progesterone at birth [6]. High plasma progesterone is negatively related to colostrum and milk yield and therefore may threaten the survival of newborn lambs. In addition, progesterone and oestradiol are involved in the onset of maternal behavior, and high ratios of oestradiol to progesterone are correlated with maternal grooming behavior [34]. Therefore, nutrition of the ewes during gestation period and at parturition can also influence ewes' maternal behavior. Elevated progesterone in underfed ewes might contribute to poor maternal behavior. Underfed ewes actually take longer time to interact with their lambs, display more aggression, spend less time grooming and more time eating after birth [6], and are more likely to desert their lambs [28].

The lamb mortalities were affected by the lambing system (Indoor or outdoor); the total mortality percent of outdoor born lambs was higher 20% than those born indoor 14.3%. This may be attributed to outdoor lambing sheep (and the newly born) are exposed to different environmental circumstances specially humidity and temperature. Housing ewes at lambing time was associated with a decreased risk of stillbirth; suggesting that this may be because of better supervision, or decreased losses due to starvation (which can be confused with stillbirths if lambing is not monitored closely) [30]. However, hygienic precautions in lambing pens are important; the risk of prenatal mortality increased when mothering pens were less bedded down as; poor hygiene allows lambs to have increased contact with pathogenic agents [30, 23]. For proper lambing management, the lambing place should be taken into consideration since it has great impact on neonatal lamb mortality. Regarding the parity of ewes; total lamb mortality tended to be higher in the first parity and declined until the fourth parity as; the record in the first parity was 33.3%, for the second was 16.6%, for the third was 6.6% and 7.1% for the fourth parity). This was partly accounted by birth weight which was significantly lower for born lambs to the first parity dams. In addition, the parity had an influence on lamb mortality due to the incidence of negative maternal behavior, such as rejection (butting and abandoning the lamb) and fear-like behavior (withdrawing from the lamb, moving as the lamb attempts to suck) [9]. Concerning the body condition of ewes; it was observed that there was a relationship between ewes' body condition score and lamb mortality. The higher total lamb mortality was recorded among those for ewes had the body condition score two and three and half. This may be attributed to low birth weight lamb getting from this ewes, low

milk production, low colostrum and low maternal care of dam. These results are in agreement with that recorded by West [36] who mentioned that ewes with low body condition score have been associated with higher prenatal and neonatal mortality [24] and lower lamb survival [19].

V. CONCLUSION

This study has raised the hypotheses for managemental factors associated with lamb mortality particularly under intensive rearing systems. Romanov breed has better maternal care than Ossimi and Rahmani breeds resulting in lower lamb mortality and higher lamb survivability for Romanov breed. Supplementation of ewes during pregnancy and evaluating body condition of the ewe flock may help to reduce lamb mortality. The attention of the shepherd should be focus on the first week after lambing. The major managemental factors affecting lamb survival include lamb birth weight and age, litter size, nutrition and parity of the ewe and selected breed.

ACKNOWLEDGMENT

The author would like to express his appreciation to Mrs. Eman Moustafa Moustafa Assistant lecturer of Fish Disease and Management, Fac. of Vet. Med. Kafr El-sheikh University for her help of English revising the manuscript.

REFERENCES

[1]. G. E. Banchero, G. Quinans, G. B. Martin, D. R. Lindsay, and J. T. B. Milton, ‘‘Nutrition and colostrum production in sheep.1. Metabolic and hormonal responses to high-energy supplement in the final stages of pregnancy,’’ *Reprod. Fertil. Dev.*, vol. 16, 2004, pp. 633-643.

[2]. S. H. Binns, I. J. Cox, S. Rizvi, and L. E. Green, ‘‘Risk factors of lamb mortality of UK sheep farms, ’’*Prev. Vet. Med.*, vol. 52, 2002, pp. 287-303.

[3]. D. C. Dalton, T. W. Knight, and D. L. Johnson, ‘‘Lamb survival in sheep breeds on New Zealand hill country,’’ *N. Z. J. Agri. Res.*, vol. 23, 1980, pp. 167-173.

[4]. C. M. Dwyer, ‘‘Behavioral development in the neonatal lamb: effect of maternal and birth-related factors,’’ *Theriogen.*, vol. 59, 2003, pp. 1027-1050.

[5]. C. M. Dwyer, S. K. Calvert, M. Farish, J. Donbavand, and H. E. Pickup, ‘‘Breed, litter and parity effects on placental weight and placentome number, and consequences for neonatal behavior of the lamb,’’ *Theriogen.*, vol. 63, 2005, pp. 1092-1110.

[6]. C. M. Dwyer, A. B. Lawrence, S. C. Bishop, and M. ewis, ‘‘Ewe-lamb bonding behaviors at birth are affected by maternal under nutrition in pregnancy,’’ *Br. J. Nutr.*, vol. 89, 2003, pp. 123-136.

[7]. C. M. Dwyer, and A. B. Lawrence, ‘‘Maternal behavior in domestic sheep (*Ovis aries*): constancy and change with maternal experience,’’ *Behav.*, vol. 137, 2000, pp. 1391-1413.

[8]. C. M. Dwyer, and A. B. Lawrence, ‘‘Variability in the expression of maternal behavior in primiparous sheep: Effects of genotype and litter size,’’ *Appl. Anim. Behav. Sci.*, vol. 58, 1998, pp. 311-330.

[9]. C. M. Dwyer, and A. B. Lawrence, ‘‘Does the behavior of the neonate influence the expression of maternal behavior in sheep? ,’’ *Behav.*, vol.136, 1999, pp. 367-389.

[10]. C. M. Dwyer, and A. B. Lawrence, ‘‘A review of the behavioral and physiological adaptations of extensively managed breeds of sheep that favour lamb survival,’’ *Appl. Anim. Behav. Sci.*, vol. 92, 2005, pp. 235-260.

[11]. J. M. Everett-Hincks, H. T. Blair, K. J. Stafford, N. Lopez-Villalobos, P. R. Kenyon, and S. T. Morris, ‘‘The effect of pasture allowance during pregnancy on maternal behavior and lamb rearing performance in highly fecund ewes,’’ *Livest. Prod. Sci.*, vol. 97, 2005, pp. 253-266.

[12]. J. M. Everett-Hincks, N. Lopez-Villalobos, H. T. Blair, and K. J. Stafford, ‘‘The effect of ewe maternal behavior score on lamb and litter survival,’’ *Livest. Prod. Sci.*, vol. 93, 2004, pp. 51-61.

[13]. N. M. Fogarty, D. L. Hopkins, and R. van de Ven, ‘‘Lamb production from diverse genotypes 1. Lamb growth and survival and ewe performance,’’ *Anim. Sci.*, vol. 70, 2000, pp. 135-145.

[14]. D. G. Hall, L. R. Piper, A. R. Egan, and B. M. Bindon, ‘‘Lamb and milk production from Booroola ewes supplemented in late pregnancy,’’ *Aust. J. Exp. Agr.*, vol. 32, 1992, pp. 587-593.

[15]. G. K. Hight, and K. E. Jury, ‘‘Hill country sheep production. II. Lamb mortality and birth weights in Romney and Border Leicester × Romney flocks,’’ *N. Z. J. Agri. Res.*, vol. 13, 1970, pp. 735-752.

[16]. G. N. Hinch, J. J. Lynch, J. V. Nolan, R. A. Leng, B. M. Bindon, and L. R. Piper, ‘‘Supplementation of high fecundity Border Leicester x Merino ewes with a high protein feed: Its effect on lamb survival,’’ *Aust. J. Exp. Agric.*, vol. 36, 1996, pp.129-136.

[17]. R. W. Kelly, E. J. Speijer, I. G. Ralph, and J. P. Newnham, ‘‘Lambing performances and wool production in maiden adult Merino ewes fed different amount of lupin seed in mid-pregnancy,’’ *Aust. J. Agri. Res.*, vol. 43, 1992, pp. 339-354.

[18]. J. I. Kerslake, J. M. Everett-Hincks, and A. W. Campbell, ‘‘Lamb survival: A new examination of an old problem,’’ *Proc. N. Z. Soc. Anim. Prod.*, vol. 65, 2005, pp.13-18.

[19]. K. Khan, ‘‘Effects of body condition and pre-lambing supplementation on ewe productivity,’’ *Masters Thesis*, 1994, Oregon State University, Corvallis.

[20]. P. Le-Neindre, P. M. Murphy, A. Boissy, I. W. Purvis, D. Lindsay, P. Orgeur, J. Bouix, and B. Bibé, ‘‘Genetics of maternal ability in cattle and sheep. Proc. 6th World Congr,’’ *Genet. Livest. Prod.*, vol. 27, 1998, pp. 23-30.

[21]. J. J. Lynch, R. A. Leng, G. N. Hinch, J. Nolan, B. M. Bindon, L. R. Piper, ‘‘Effects of cottonseed supplementation on birth weights and survival of lambs from a range of litter sizes, ’’ *Proc. Aust. Soc. Anim. Prod.*, vol. 18, 1990, pp. 516-521.

[22]. P. M. Murphy, D. McNeill, J. S. Fisher, and D. R. Lindsay, ‘‘Strategic feeding of Merino ewes in late pregnancy to increase colostrum production,’’ Proc. *Aust. Soc. Anim. Prod.*, vol. 21, 1996, pp. 227-230.

[23]. M. L. Nash, L. L. Hungerford, T. G. Nash, and G. M. Zinn, ‘‘Risk factors for prenatal and postnatal mortality in lambs,’’ *Vet. Rec.*, vol. 139, 1996, pp. 64-67.

[24]. D. J. Nordby, R. A. Field, M. L. Riley, C. L. Johnson, and C. J. Kercher, ‘‘Effects of maternal under-nutrition during early pregnancy on postnatal growth in lambs,’’ *Proc. West. Sec. Am.Soc. Anim. Sci.*, vol. 37, 1986, pp. 92.

[25]. R. Nowak, R. H. Porter, F. Lévy, P. Orgeur, and B. Schaal, ‘‘Role of mother-young interactions in the survival of offspring in domestic mammals,’’ *Rev. Reprod.*, vol. 5, 2000, pp.153-163.

[26]. C. E. O’Connor, N. P. Jay, A. M. Nicol, and P. R. Beatson, ‘‘Ewe maternal behavior score and lamb survival,’’ *Proc. N. Z. Soc. Anim. Prod.*, vol. 45, 1985, pp. 159-162.

[27]. P. Poindron, P. Le-Neindre, F. Lévy, and E. B. Keverne, ‘‘The physiological mechanisms of the acceptance of the newborn among sheep,’’ *Biol. Behav.*, vol. 9, 1984, pp. 65-88.

[28]. I. G. Putu, P. Poindron, D. R. Lindsay, ‘‘A high level of nutrition during late pregnancy improves subsequent maternal behavior of Merino ewes,’’ *Proc. Aust. Soc. Anim. Prod.*, vol. 17, 1988, pp. 294-297.

[29]. J. J. Robinson, T. G. McEvoy, and K. D. Sinclair, ‘‘Nutritional effects on foetal growth,’’ *Anim. Sci.*, vol. 68, 1999, pp. 315-331.

[30]. J. P. Rowland, M. D. Salman, C. V. Kimberling, D. J. Schweitzer, and T. J. Keffe, ‘‘Epidemiologic factors involved in perinatal lamb mortality in four range sheep operations,’’ *Am. J. Vet. Res.*, vol. 53, 1992, pp. 262-267.

[31]. R. M. Sawalha, J. Conington, S. Brotherstone, and B. Villaneuva, ‘‘Analyses of lamb survival in Scottish Blackface sheep,’’ *Animal*, vol. 1, 2007, pp. 151-157.

[32]. SAS/STAT, User's Guide, Version 6, Cary NC, 1990.

[33]. G. H. Scales, R. N. Burton, and R. A. Moss, ‘‘Lamb mortality, birth weight and nutrition in late pregnancy,’’ *N. Z. J. Agric. Res.*, vol. 29, 1986 pp. 75-82.

[34]. M. P. Shipka, and S. P. Ford, ‘‘Relationship of circulating oestrogen and progesterone concentrations during late pregnancy and the onset phase of maternal behavior in the ewe,’’ *Appl. Anim. Behav. Sci.*, vol. 31, 1991, pp. 91-99.

[35]. B. B. Southey, S. L. Rodriguez-Zas, and K. A. Leymaster, ‘‘Competing risks analysis of lamb mortality in a terminal sire composite population,’’ *J. Anim. Sci.*, vol. 82, 2004, pp. 2892-2899.

[36]. K. S. West, H. H. Meyer, and R. G. Sasser, ‘‘Ewe body condition and nutrition effects on embryonic loss,’’ *J. Anim. Sci.*, vol. 67(1), 1989, pp. 424.