Influences of Maternal Undernutrition on Placental Development and Birth Weight in Sheep

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SUMMARY

The aim of this study was to determine the effects of maternal feeding status on placental characteristics and lamb birth weight in mid-gestational period in sheep. The study was carried out in a private sheep farm in Erzincan during the lambing period of 2018 (39°80' N, 40°03' E and 1617 m above sea level). In our study, Morkaraman ewes with 50 heads in 3rd lactation was used. Sheep were divided into two groups. The first group was fed only on pasture until the 80th day of pregnancy; the second group is feed 100% of the daily energy needs of ration between 30-80. days. Although live weight differences between groups were statistically insignificant in mating and 80th days. On the 30th day and at birth there was a statistically significant difference. In our study, significant differences were found between the groups in terms of BW (p <0.01), PE and ACSA (p <0.05). In our study, lamb birth weight was 11.3% higher in the treatment group. The highest BW, PE and ACSA were observed in the treatment group. The results obtained from this study showed that maternal nutrition level between 30th and 80th day was effective on birth weight (P <0.01), placental weight, placental activity and average cotyledon surface area (P <0.01). While there was no significant correlation between birth weight and placental and cotyledon characteristics in the control group, a positive correlation (r =, 829, P <0.01) was found between birth weight and placental weight (r =, 465, P <0.05) and cotyledon number in the treatment group. These data show that in the livestock industry, the manipulation of the mother in terms of nutrition in the prenatal period or the prevention of restricted feeding based only on pasture will affect birth weight, newborn losses, average daily live weight gain, market weight, healthy meat production economy and profitability.

KEY WORDS

Placenta, cotyledon, sheep, nutrition, ACSA.

INTRODUCTION

Feeding in sheep during pregnancy has a significant effect on fetal and placental development. According to fetal programming theory, the fetus gains protective adaptation for the postnatal period in the uterus during pregnancy. Therefore, the failure of nutrition in the prenatal period may harm the developmental adaptation of the lamb. This is called intrauterine growth restriction (IUGR). IUGR is the deterioration in the growth and development of the fetus and hence organs of the animal during pregnancy. In addition, IUGR may cause negative consequences that permanently alter the offspring's structure, physiology, metabolism and postnatal growth[1].
Placenta growth in sheep starts approximately on the 30th day of pregnancy (Symonds et al., 2007) and it is completed by 100 days[2]. Therefore, it has been reported that 30-80 days are sensitive for placental development in the feeding of pregnant sheep[3]. In general, restricted nutrition during pregnancy leads to significant reductions in placental growth[4]. It has also been reported that poor nutrition from 28 days to 78-80 days, when maximum placental growth occurs, reduces placental mass[5] and placenta size[6]. Changes in placental growth may cause low birth weight at the end of pregnancy due to the high correlation between placental weight and fetal weight[7].
When feeding is considered to have an important effect on placental development and to have considerable effect placental characteristics on lamb birth weight, it is concluded that feeding during the period of placental development is important. In many parts of the world, the normal mating period in sheep coincides with autumn and early winter, when pasture quality declines and nutrient intake is poor. Therefore, it is thought that sheep in Turkey are faced with malnutrition during pregnancy and this situation results in poor placental and fetal development. Recently, interest in "fetal programming" has increased, and study of effect of prenatal maternal nutrition on postpartum have become widespread. The aim of this study was to determine the effects of maternal nutrition during mid-gestation on placental characteristics and lamb birth weight in sheep.

MATERIALS AND METHODS

The study was conducted in a private sheep farm in Erzincan during the lambing period of 2018 (39°80' N, 40°03' E and 1617 m above sea level). In this study, 50 Morkaraman ewes in 3rd lactation was used. Starting 15 days before the mating until the

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30th day of pregnancy, all sheep were given 650 gr/day of barley addition to the pasture. The hand mating method was applied in the mating. At 08:00 am and 16:00 pm, 5 rams that have mating ram mark participated in the herd and the sheep have ovulating were hand-mated and recorded. Then, starting from the 30th day of pregnancy, sheep was divided into two groups with 25 sheep in each group considering sheep live weight. The first group (control group; C) was grazed on pasture for 10 hours a day and no additional feeding was done (extensively).

The second group was housed in a closed barn (treatment group; T) and ration that corresponding to 100% of daily energy requirement according to live weight was given (89% DM, 23.4% crude protein and 10.7 MJ ME / kg DM). In addition, *ad libitum* good quality alfalfa (86.1% DM, 15.4% crude protein and 8.1 MJ ME / kg DM) were given. Live weights were determined at the beginning of the mating, 30th, 80th day and before birthing. The ration amount to be given in each weighing period was recalculated according to live weight. From the 80th day onwards, both groups were combined and fed with a ration that corresponded to 100% of the daily energy requirement until birth in a closed barn.

After birthing, the placentas were collected and they were weighed after removal of the liquid. In addition, birth weight and gender of the lambs were recorded. Although the Morkaraman breed was usually single birthing, two sheep with twin births were not included in the study. The distribution of lambs by sex was 13 males and 10 females in the control group and 11 males and 12 females in the treatment group.

Width, length and depth measurements were taken on 30 samples representing small and large cotyledons taking into account the vascularity in each placenta. In the observations of placentas, cotyledon number (CN), cotyledon density (CD), placental weight (PW), placental efficiency (PE) and total cotyledon surface area (TCSA) were determined. PE refers to the ratio of birth weight to placental weight (PE = BW / PW). CD is the ratio of cotyledon number to placental weight (CD = CN / PW). TCSA was calculated according to the following formula: [((CWi + CL) / 4) ×2] × 3.14 (π) × TCN. Average cotyledon surface area (ACSA) was obtained by dividing TCSA by cotyledon number[8].

The effect of the groups on placenta and cotyledon characteristics was analyzed using a general linear model (GLM) procedure in SPSS using a completely randomized design. In addition, gender was added as cofactor in the model to adjust placental and cotyledon characteristics between groups. Pearson correlation was used in 95% confidence interval to determine the relationships between placenta and cotyledon characteristics.

Table 1 - Effect of groups on placental traits (X ± SD)

	BW (kg)	PW (g)	CN	PE	CD	CE	ACSA (cm²)
Mean	4,67±0,85	437,1±6,3	56,20±2,8	11,44±0,4	0,13±0,0	10,93±0,4	7,76±0,1
Group	**	*	ns	*	ns	ns	*
Control	4,42±0,35	425,0±27,6	55,4±4,3	10,40±0,5	0,13±0,0	11,06±1,3	7,25±0,2
Treatment	4,92±0,24	449,2±16,4	57,0±12	12,48±1,8	0,14±0,0	10,80±1,4	8,27±0,8

Means with different superscript in each column (a, b) differ significantly; ns=not significant, *: P<0.05, **:P<0.01

Table 2 - Effect of groups on cotyledon traits (X ± SD)

	CNs	CNm	CNl	CL (cm)	CWi (cm)	CDe (cm)
Mean	3,18±0,5	45,4±3,9	7,20±1,5	2,71±0,0	2,22±0,0	0,99±0,0
Group	ns	ns	*	*	*	ns
Control	3,80±2,0	46,20±6,1	5,40±3,0	2,53±0,1	2,08±0,0	0,99±0,1
Treatment	2,57±1,9	44,71±8,5	9,00±6,2	2,89±0,3	2,37±0,2	0,98±0,1

Means with different superscript in each column (a, b) differ significantly; ns=not significant, *: P<0.05

Table 3 - Pearson correlation coefficient of placental and cotyledon traits in control group

	BW	PW	CN	CL	CWi	CDe	PE	CD	CE
PW	,299								
CN	,189	-,259							
CL	,106	,771**	-,291						
CWi	-,163	,761*	-,396	,869**					
CDe	-,075	,661*	-,325	,802**	,883**				
PE	,228	-,849**	,408	-,688*	-,831**	-,695*			
CD	-,011	-,648*	,888**	-,536	-,624	-,533	,704*		
CE	,055	-,049	-,826**	-,181	-,105	-,147	,026	-,624	
ACSA	,002	,791**	-,345	,980**	,951**	,862**	-,768**	-,591	-,153

*: P<0.05, **:P<0.01

Table 4 - Pearson correlation coefficient of placental and cotyledon traits in treatment group

	BW	PW	CN	CL	CWi	CDe	PE	CD	CE
PW	,465*								
CN	,829**	,021							
CL	-,458*	-,084	-,755*						
CWi	-,202	,022	-,440	,692					
CDe	-,412	-,134	-,548	,702	,073				
PE	-,195	-,049	,060	-,397	,074	-,619			
CD	,371	-,165	,750	-,825*	-,381	-,706	,672		
CE	-,801*	,048	-,923**	,534	,071	,565	-,108	-,690	
ACSA	-,383	-,041	-,679*	,947**	,887**	,482	-,221	-,698	,374

*: P<0.05, **:P<0.01

RESULTS

The live weight change graphic of sheep during pregnancy is given in Figure 1. The live weights of both groups (control and treatment) were found to be similar during the the mating and 30th day. However, there was a difference in favor of treatment group at 80th day (p<0,05). The control and treatment groups had a live weight of 59.14 ± 1.61 and 57.88 ± 1.77 kg respectively in mating. Until 30 days of pregnancy from mating, control group and treatment group provided 5.8% (3,42 kg) and 7.2% (4,18 kg) live weight gain, respectively. In the following period, the treatment group gained 6.3% live weight and reached 65.96 ± 1.85 kg on the 80th day, whereas the control group lost 6.2% live weight and decreased to 58.92 ± 1.94 kg. From day 80, both groups were taken into the same feed and the control group and the treatment group showed a live weight gain to 63.41 ± 2.23 kg and 71,06 ± 2.41 kg, respectively.
The effect of the groups on birth weight and placental characteristics is given in Table 1. As can be seen in Table 2, significant differences were found between the groups in terms of BW (p <0.01), PE and ACSA (p <0.05) (Table 2.). In our study, lamb birth weight was 11.3% higher in the treatment group. The highest BW, PE and ACSA were observed in the treatment group. PW and CN were not different between the groups.
In terms of CNl, CL and CWi in favor of the treatment group, the differences were determined (p <0.05) (Table 2). The CL and CWi were higher 14.2% and 13.9%, respectively, in treatment groups. There was no difference between the groups in terms of CNs, CNm and CN1. Although CNs and CNm were higher in the control group, CN1 was 66.7% higher in the treatment group.
The results of Pearson correlation analysis showing the relationship between birth weight, placenta and cotyledon characteristics for both control and treatment groups were given in Tables 3 and 4, respectively. While there was no significant correlation between birth weight and placental and cotyledon characteristics in the control group, a positive correlation was found between birth weight and placental weight (r =,465, P<0.05) and number of cotyledons (r =,829, P<0.01) in the treatment group. There was no relationship between BW and ACSA in both groups. Positive correlation was determined between PW and CL (r=,771, p<0.01), CWi (r=,761, p<0.05), CDe

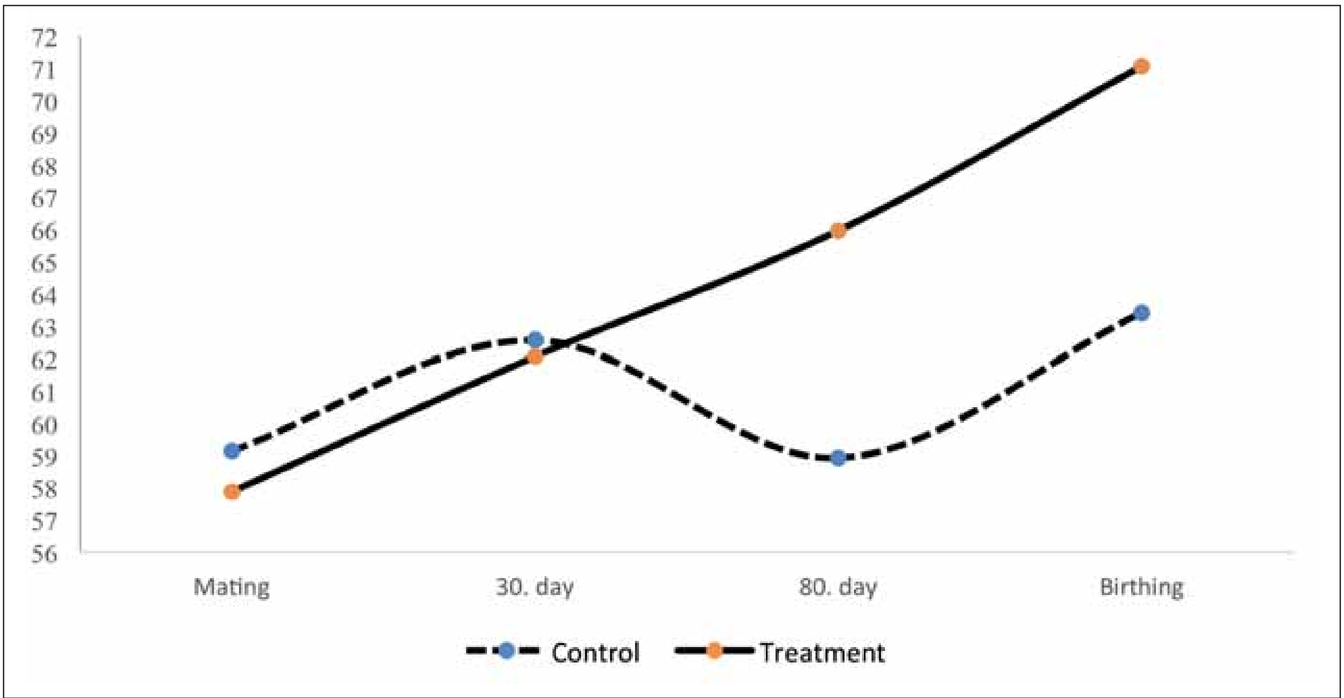

Figure 1 - Live weight change during pregnancy (kg)

(r=,661, p<0.05) and ACSA (r=,791, p<0.01) and negative correlation was determined between PE (r=-,849, p<0.01) and CD (r=,th 648, p<0.05). In the treatment group, there was no correlation between PW and other factors (Table 4).

DISCUSSION

In both groups, it is thought that the increase in live weight from the mating period until the 30th day of pregnancy is based on the flushing. For control group the loss of 6,2% live weight in the pasture was result of that the pasture was insufficient to meet the daily energy needs of the sheep. Thomas et al.[9] reported that in West America, ewes grazing on pasture without additional feeding, the pasture supplies 50% less nutrient requirements than the National Research Council's (NRC) recommended consumption. In both groups, the increase in live weight from the 80th day of pregnancy to birthing is due to the growth of the fetus. The results are consistent with a research study on Angora goats[10].

The results of this study show that maternal nutrition level between 30-80 days is effective on birth weight (P <0.01), PW, PE and ACSA (P <0.01). These observations are consistent with the view that maternal dietary restriction during pregnancy may affect placental development and thereby reduce placental weight and size[2;6;11;12]. Also, Muñoz et al.[13] reported that sheep that received 200% of their daily energy requirement during mid-pregnancy had heavier lambs than received 100% and 60%. In addition, McGregor[10] reported that the birth weight increased by 0.3 kg for each 10 kg increase in doe live weight on the 137th day of pregnancy. But contrary to the results found, Fahey et al.[14], Daniel et al.[15] and Sen and Onder[16] found that the mother's nutritional level during mid-pregnancy did not have an effect on the lamb's birth weight.

Ocak et al.[17] on sheep, Konyali et al.[8] on goats reported a positive correlation between PW with CN and CD in their studies. However, in this study, no correlation was found between PW with CN and CD in both groups. When the correlations between placental characteristics in the treatment group were analyzed, it supports the opinion that nutrition in middle pregnancy bring on an increase in birth weight. As a result of the nutritional amount, the number of cotyledons increased in the treatment group and the increase in placental weight lead to an increase in birth weight. Also, the negative correlation between PW and PE observed in this study supports the findings of Ocak and Onder[18] for goats. In the control group, there was no correlation between birth weight and placental weight similar to Ocak et al.[19], whereas in the treatment group, positive correlation was determined similar to Sen and Onder[16]. Also, relationship between birth weight and placental weight is similar to the findings of Sen et al.[20]. In treatment group, the positive correlation between BW and CN obtained in this study are in agreement with past studies in beef cattle and sheep[19;21;22].

CONCLUSION

This study showed that only pasture-based feeding between 30-80 days of pregnancy reduced the mother's live weight during mid-gestation and resulted in lower lamb birth weights (11% lighter). These data show that in the livestock industry, the manipulation of the mother in terms of nutrition in the prenatal period or the prevention of restricted feeding based only on pasture will affect birth weight, newborn losses, average daily live weight gain, market weight, healthy meat production economy and profitability.

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