The relationship between placental characteristics and lamb birth weight in Akkaraman Turkish native sheep breed

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SUMMARY

Introduction - The size and nutrient transfer capacity of the placenta plays a central role in determining the prenatal growth trajectory fetus, resulting in alteration birth weight.
Aim - The aim of this study was to determine the relationship between placental characteristics and lamb birth weight in Akkaraman sheep breed.
Materials and methods - The 63 single born Akkaraman male lambs with low (n= 18), moderate (n= 26) and high (n= 19) birth weight (BW) and their placentas were used as experimental materials. Placental weight (PW), the numbers (TCN) and weights (TCW) of cotyledon were determined. Length (CL), depth (CDe), diameter (CDia) and volume (CV) of cotyledons were also measured with an electronic digital compass. The total cotyledon surface area (TCSA), placental efficiency (PE), cotyledon efficiency (CE), volumetric cotyledon efficiency (VCE) and cotyledon density (CD) were calculated for each ewe.
Results - Placental weight (PW), cotyledon weight, total and small cotyledon number (SCN), total weight, and the number of large cotyledon in lambs with low BW were lower than moderate and high BW ($p < 0.05$). High BW lambs had higher PE, CE, and VCE values than moderate and low BW ($p < 0.05$). Additionally, positive correlations were observed between BW, CE, and VCE ($p < 0.05$). A significant relation was calculated between BW and LCN ($p < 0.05$). The mortality rate of high lambs BW was lower ($p < 0.05$) than moderate and low BW until weaning.
Discussion - Lamb BW changed with placental characteristics, and lambs with higher BW were found to have better placental components.
Conclusions - The results of the present study revealed that placental components affect BW in Akkaraman lambs and poor placental characteristics may have a significant impact on survival until weaning.

KEY WORDS

Placenta, fetal development, birth weight, mortality, Akkaraman sheep.

INTRODUCTION

It is known that the deficiencies in sheep production and management systems increase mortality rates in newborns and also cause serious economic losses [1]. In this respect, it is important to define physiological characteristics of offspring at birth and the postpartum period, to examine the adaptation the adaptability of the offspring and to better address current breeding or management problems as well as to develop the new sheep production strategies [2,3,4,5].
The placenta is an organ that provides the passage of nutrients, respiratory gases such as oxygen and carbon dioxide, and waste materials between maternal and fetal systems through blood circulation [6]. Sheep placenta has multiple cotyledonary structures and the placenta, where the fetus is located, is connected to the uterus wall by the embryo originated cotyledons, which combine with the protrusions on the uterus endometrium called the caruncle [2]. Placentomes is consisted by the combination of cotyledon and caruncle, on the placenta ensure the blood circulation between dam and offspring, transferring nutrients to the fetus and removing the metabolic wastes produced by the fetus through the bloodstream [7]. Therefore, the functional ability of the placenta is directly related to the number and size of the placentomes, which can be affected by both maternal and fetal factors [7,8].
Previous studies in farm animals showed that placental growth occurs before fetal growth, and there is a positive relationship between placental mass and offspring weight at birth [8,9,10,11]. The majority of the placental growth and development occur in the first trimester part of gestation and there is no change in dry matter content of the placenta following the first period in sheep [7,10]. The placenta reaches its maximum size during the first trimester part of gestation, but the fetus gained only 10% of its birth weight [8,10]. Therefore, abnormalities or insufficient in placental development can directly affect fetal growth and development, or even the survival of the fetus. Moreover, the size and nutrient delivery capacity of the placenta play a critical role on the birth weight, growth, postnatal viability, adult productivity and health of newborn [8].
Fetal growth in the last quarter of pregnancy in sheep is influenced by maternal nutrition level [12], nutrient transfer capacity

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of the placenta to the fetus [7] and blood flow from the uterus to the placenta [13]. Placental development is one of the most important prenatal factors affecting the birth weight of lambs [2,6,11]. Placental weight is becoming more important for explaining the fetal weight variation that occurs when late and middle pregnancy periods are compared [14]. Low birth weight increases postpartum mortality, while high birth weight causes dystocia resulting in decrease maternal care and increasing maternal mortality [15]. Previous studies have reported that postnatal survival rate of lambs with low birth weight were lower than lambs with normal birth weight and slower to stand up and try to suck on their dam after birth [16,17]. Moreover, placental features can be used as an important indicator in the assessment of postpartum infant mortality and survival in small ruminants [6,18]. Additionally, it is known that insufficient placental development negatively affects fetal brain development and nervous system development. Placental insufficiency causes decrease development and number of nerve cells of the fetus and negatively affects the signaling mechanism of nerve cells with other cells [19,20]. These effects can lead to impaired neuromotor development of the offspring after birth and may increase the offspring's time to stand up, but also reduce the willingness to try to suck on their dam. These situations show that the placenta not only plays an important role in adequate fetal development but also significantly affect fetal brain development, which will have possible effects on postpartum behavior, such as stand up and suckling of offspring [2].

Akkaraman sheep breed is commonly raised indigenous sheep breed in Turkey and they constitute approximately 45% of the total sheep population [21]. Akkaraman has high survival capacity and resistant to malnutrition due to a fat-tailed sheep breed [22]. This breed has a high adaptability to the harsh climate, disease resistance, poor pasture and severe conditions [23]. Male lambs of this breed are used as fattening material for meat production, and they makes up an important source of red meat production under harsh climate conditions [24]. As a result, placental features may affect birth weight, survival rate until weaning, daily weight gain, live weight at the end of fattening, which affects the profitability of meat sector. Therefore, the aim of this study was to determine the relationship between placental characteristics, lamb birth weight and postnatal survival until weaning in Akkaraman Turkish native sheep breed.

MATERIAL AND METHODS

The experimental procedures were approved by the Local Animal Care and Ethics Committee of Kirsehir Ahi Evran University, Kirsehir, Turkey, ensuring compliance with EC Directive 86/609/EEC for animal experiments. The study was done during the breeding season (September to March) in Turkey. A total of 63 male singleton lambs with low (n= 18), moderate (n= 26) and high (n= 19) birth weight (BW) from Akkaraman ewes, which at least in second parturition and ranging from 2 - 3 years of age, and their placenta were used as experimental materials. Low and high BW lambs were determined as lambs with one standard deviation difference of the average considering the average BW of all lambs born in the same flock and period. BW of singleton born male Akkaraman lambs (low; 3.88 ± 0.20, moderate; 4.88 ± 0.19 and high; 5.72 ± 0.16) are presented in Figure 1.

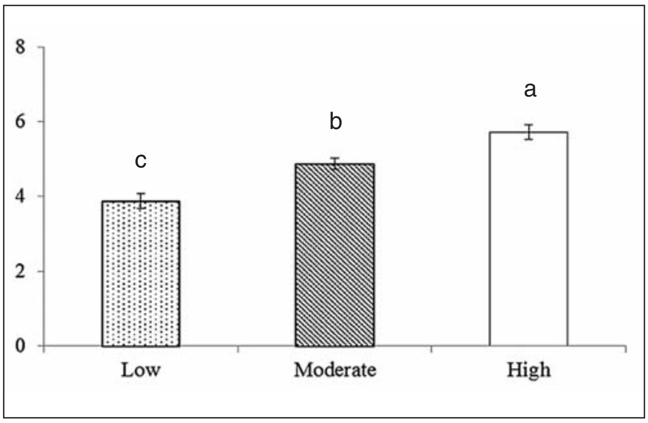

Figure 1 - Birth weights of singleton born male Akkaraman lambs. [a-b] Different letters in the same color bars indicate significant difference ($p<0.05$).

All ewes were raised at a private farm in Kirsehir, Turkey (38° 55' 56.8" N, 34° 10' 45.6" E and 985 m above sea level) and they were allowed to graze daily 5 h during gestation. Additionally, the ewes were offered average concentrate at 100 g and wheat straw of 1 kg per day during the last third of gestation. The BW of singleton male lambs was determined within 5 hours following birth and the placentas, which were drop as naturally, were collected as a whole after delivery. Placental weight (PW) was determined with discharged placental fluid before weighing. The numbers (TCN) and weights (TCW) of cotyledons, which were dissected from the chorioallantois were also determined. Length (CL), depth (CDe), diameter (CDia) and volume (CV) of cotyledons were measured with an electronic digital compass. Cotyledons were then classified as small (<10 mm diameter), medium (10-30 mm diameter) and large (>30 mm diameter). The total cotyledon surface area (TCSA) was calculated after the measurements of all the cotyledons in individual placenta as cm^2 with following formulae; radius squared of cotyledon $[((\text{cotyledon width} + \text{cotyledon length}) / 4)^2] \times 3.14\ (\pi) \times \text{TCN}$. Additionally, placental efficiency (PE; lamb BW / PW), cotyledon efficiency (CE; lamb BW / TCSA), volumetric cotyledon efficiency (VCE; CV / PW) and cotyledon density (CD; TCN / per gram PW) were calculated for each ewe.

Following lambing, lambs were kept in the pen with their dam for 15 days in order to suck enough colostrum. After this period, lambs were treated with protection against internal and external parasites, and they were allowed to go to the pasture with their dam until 90 days of weaning age. In addition to pasture, the ewes were fed average concentrate at 50 g and wheat straw of 1 kg per day during the lactation period. Mortality rates of lambs in the BW groups up to weaning was calculated by ratio the number of lambs died until weaning to the number of lambs born.

Placental characteristics and postnatal survival rate of lambs with different BW were analyzed using a completely randomized design by the General Linear Model procedure of the SPSS package program. Significant differences between means were tested using Duncan's test and results were computed as mean ± SE. Statistical significance was considered at $p < 0.05$ and $p < 0.01$. Kruskall-Wallis H test was performed to analyze the effect of lamb birth weight on vital status until weaning survival. Relationships between variable traits for discrete data were determined with Pearson correlation analysis at the 95% confidence interval.

RESULTS

Placental components of Akkaraman male lambs with low, moderate and high BW are presented in Table 1. The significant differences in terms of placental weight, total and average cotyledon weights were found and lambs with low BW had lower placental weight, total and average cotyledon weight than those of moderate and high BW ($p < 0.05$). There were no significant differences between lamb BW groups in terms of medium and small cotyledon weights, but large cotyledon weight of lambs with low BW were lower than high BW lambs ($p < 0.05$).

Cotyledon characteristics of Akkaraman male lambs with low, moderate and high BW are presented in Table 2. Low BW lambs had higher ($p < 0.05$) total cotyledon and small cotyledon numbers compared to lambs with moderate and high BW, but they had lower ($p < 0.05$) large cotyledon numbers. There were no significant differences between lamb BW groups in terms of size measurements of placental cotyledons except for small cotyledon length. Low BW lambs had lower ($p < 0.05$) small cotyledon length than those of moderate BW.

Various efficiency features of placenta and cotyledon of Akkaraman male lambs with low, moderate and high BW are presented in Table 3. Placental efficiency of high BW lambs was higher ($p < 0.05$) than lambs with low and moderate BW. Similarly, high BW lambs had higher ($p < 0.05$) cotyledon, volumetric cotyledon and average volumetric cotyledon efficiency values than those of low BW. There were no significant differences between lamb BW groups in terms of cotyledon volume and cotyledon surface area features.

Pearson correlation coefficients of placental characteristics and birth related factors in Akkaraman male lambs are presented

Table 1 - Placental components of Akkaraman male lambs with low, moderate and high birth weight.

Traits (g)	Birth weights: Low	Moderate	High
PW	326.3 ± 30.1^{b}	370.8 ± 38.5^{a}	392.4 ± 16.9^{a}
TCW	77.50 ± 4.12^{b}	93.20 ± 6.19^{a}	93.56 ± 10.70^{a}
ACW	1.10 ± 0.07^{b}	1.632 ± 0.12^{a}	1.514 ± 0.15^{a}
SCW	14.50 ± 1.18	13.20 ± 1.75	16.68 ± 3.64
MCW	37.80 ± 2.88	35.38 ± 3.21	42.06 ± 2.88
LCW	25.20 ± 3.41^{b}	38.31 ± 5.08^{a}	41.2 ± 10.7^{a}

^{a,b} Different superscript letters in the same line indicate a significant difference ($p < 0.05$)
PW = placental weight, TCW = total cotyledon weight, ACW = average cotyledon weight, SCW = small cotyledon weight, MCW = medium cotyledon weight, LCW = large cotyledon weight

Table 2 - Cotyledon characteristics of Akkaraman male lambs with low, moderate and high birth weight.

Traits (mm)		Birth weights: Low	Moderate	High
TCN		71.00 ± 1.68^{a}	58.59 ± 2.89^{b}	61.33 ± 4.20^{b}
SCN		32.00 ± 1.50^{a}	18.71 ± 2.25^{b}	20.00 ± 5.06^{b}
MCN		29.18 ±2.66	26.24 ±2.11	26.83 ± 1.70
LCN		9.82 ±0.980^{b}	13.65 ±1.60^{a}	14.50 ±3.01^{a}
CD		0.26 ± 0.02	0.19 ± 0.02	0.28 ± 0.1
ACDia		19.95 ± 0.45	22.72 ± 0.67	21.09 ± 0.53
ACL		24.92 ± 0.58	28.59 ± 0.72	26.69 ± 0.69
ACDe		3.62 ± 0.11	4.11 ± 0.10	3.87 ± 0.122
	SC	9.11 ± 0.30	11.75 ± 1.03	10.13 ± 0.41
CDia	MC	20.09 ± 0.36	23.06± 0.10	20.99 ± 0.51
	LC	30.76 ± 0.35	33.45 ± 0.10	32.26 ± 0.838
	SC	16.65^{b} ± 0.35	20.55 ± 0.98^{a}	17.66 ± 0.39^{ab}
CL	MC	25.24 ± 0.47	28.12 ± 0.99	26.58 ± 0.61
	LC	32.88 ± 0.57	37.08 ± 1.05	35.82 ± 1.04
	SC	2.97 ± 0.17	3.28 ± 0.15	2.76 ± 0.12
CDe	MC	3.60 ± 0.16	4.03 ± 0.15	4.19 ± 0.16
	LC	4.28 ± 0.19	5.01 ± 0.16	4.65 ± 0.25

^{a,b} Different superscript letters in the same line indicate a significant difference ($p < 0.05$)
TCN = total cotyledon number, SCN = small cotyledon number, MCN = medium cotyledon number, LCN = large cotyledon number, CD = cotyledon density, ACDia = average cotyledon diameter, ACL = average cotyledon length, ACDe = average cotyledon depth, SC = small cotyledon, MC = medium cotyledon, LC = large cotyledon

Table 3 - Various efficiency features of placenta and cotyledon of Akkaraman male lambs with low, moderate and high birth weight.

	Birth weights		
Traits (g)	Low	Moderate	High
PE	14.25 ± 0.98^b	16.27 ± 2.15^b	24.14 ± 5.63^a
CE	14.39 ± 0.64^b	20.32 ± 1.40^{ab}	23.58 ± 3.39^a
VCE	44.32 ± 2.88^b	50.89 ± 4.34^{ab}	64.6 ± 10.33^a
AVCE	0.62 ± 0.04^b	0.86 ± 0.07^{ab}	1.04 ± 0.17^a
TCV	90.05 ± 6.6	108.53 ± 10.69	112.29 ± 16.16
ACV	1.29 ± 0.10	1.88 ± 0.17	1.76 ± 0.22
TCSA	270.28 ± 10.32	255.49 ± 15.86	285.58 ± 28.53
ACSA	3.86 ± 0.16	4.38 ± 0.20	4.51 ± 0.34

[a,b] Different superscript letters in the same line indicate a significant difference ($p < 0.05$).
PE = placental efficiency, CE = cotyledon efficiency, VCE = volumetric cotyledon efficiency, AVCE = average volumetric cotyledon efficiency, TCV = total cotyledon volume, ACV = average cotyledon volume, TCSA = total cotyledon surface area, ACSA = average cotyledon surface area.

in Table 4. The correlation coefficients of BW groups for placental characteristics and birth-related factors were pooled and presented in the table. There were positive correlation between BW and CE (r = .420; $p < 0.05$) and BW and VCE (r = .422; $p < 0.05$). Positive correlations were calculated between PW and LCN (r = .488; $p < 0.05$) and PW and ACDia (r = .356; $p < 0.05$), while negative correlations were found between PW and SCN (r = -.405; $p < 0.05$), PW and CD (r = -.641; $p < 0.01$) and PW and PE (r = -.694; $p < 0.01$). Negative correlations were obtained between the LCN and SCN (r = -.495; $p < 0.05$) and MCN and CE (r = -.342; $p < 0.05$). Positive correlations were calculated between SCN and TCSA (r = .385; $p < 0.05$), SCN and CD (r = .701; $p < 0.01$) and SCN and PE (r = .471; $p < 0.05$), while negative correlations were found between SCN and CE (r = -.475; $p < 0.05$), and SCN and VCE (r = -.451; $p < 0.05$). Positive correlations were obtained between ACDia and ACL (r = .636; $p < 0.01$), ACDia and ACSA (r = .879; $p < 0.01$), ACDia and TCSA (r = .737; $p < 0.01$) and ACDia and TCV (r = .587; $p < 0.05$), while negative correlations were calculated between ACDia and CE (r = -.559; $p < 0.05$), and ACDia and VCE (r = -.534; $p < 0.05$). Positive correlations were calculated between ACL and ACSA (r = .923; $p < 0.01$), ACL and TCSA (r = .536; $p < 0.05$) and ACL and TCV (r = .542; $p < 0.05$), while negative correlations were found between ACL and CE (r = -.349; $p < 0.05$) and ACL and VCE (r = -.404; $p < 0.01$). A positive correlations was obtained between ACDe and TCV (r = .751; $p < 0.01$), but a negative correlations was calculated between ACDe and VCE (r = -.421; $p < 0.05$). A positive correlation was calculated between ACSA and TCV (r = .618; $p < 0.01$), while negative correlations were found between ACSA and CE (r = -.455; $p < 0.05$) and ACSA and VCE (r = -.477; $p < 0.01$). There was positive correlation between CE and VCE (r = .889; $p < 0.01$), but a negative correlations was calculated between CE and TCV (r = -.506; $p < 0.05$). There were positive correlation between CD and PE (r = .918; $p < 0.01$) and TCV and CE (r = .889; $p < 0.01$).

The vital status of male Akkaraman lambs (death or alive) with low, moderate and high birth weight until weaning age are presented in Figure 2. The significant differences in terms of survival rates until weaning were found between the lamb BW groups ($p < 0.05$). As expected, lambs with high BW had lower death rate (5.26%) and higher alive rate (94.74%) compare to lambs with moderate (15.4% and 84.6%) and low BW (16.7% and 83.3%) until 90 days of weaning age.

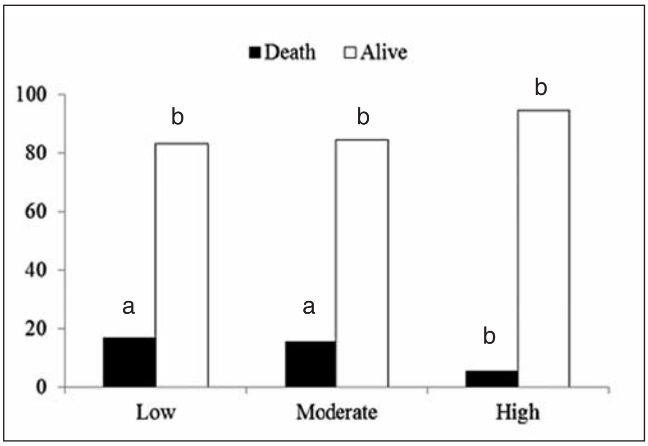

Figure 2 - The vital status of male Akkaraman lambs (death or alive) with low, moderate and high birth weight until weaning age. [a-b] Different letters in the same color bars indicate significant difference ($p<0.05$).

Regression of placental characteristics on birth weight was performed by linear regression, and although the regression model was found statistically significant, the coefficient of expression (R^2) was determined as 0.139. SCN and TCW were excluded from regression model because of null coefficient and the resulting regression model; $BW= 4.355 + 0.001 \times PW + 0.005 \times LCW + 0.003 \times MCW + 0.045 \times SCW + 0.037 \times LCN + 0.019 \times MCN - 0.023 \times TCN$. To determine the effective variables stepwise variable selection procedure was applied. A significant relation was calculated between BW and LCN and this model found as statistically significant with determination coefficient of $p < 0.05$. After elimination of the variables obtained regression model was; $BW= 4.251 + 0.05 \times LCN$ (Figure 3).

DISCUSSION

Previous studies show that the nutrient intake during gestation especially the second trimester, in which term placental growth occur in sheep, affects the placental development and resulting in alteration lamb BW [8,11,14]. Additionally, past studies indicated that the lambs with low BW had a higher mortality rate until weaning [16,25] and it was taken long to try to stand up and suck on the dam [17]. Ocak et al. [4] reported that the par-

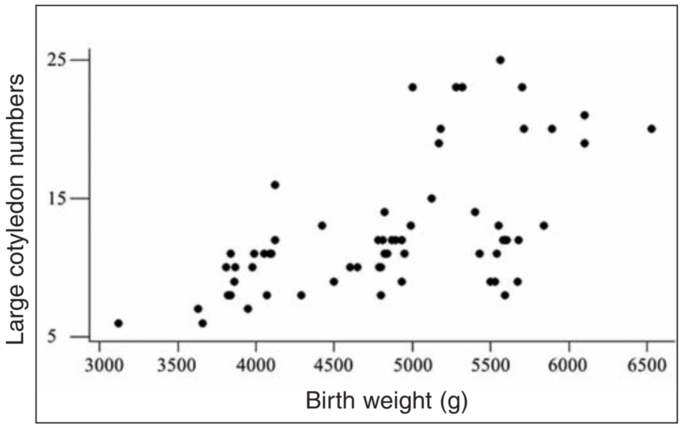

Figure 3 - Correlation between birth weight and large cotyledon numbers for 63 lambs born to Akkaraman Turkish native sheep breed.

ity did not affect the BW of lamb, but Dwyer et al. [2] reported that lamb BW increased as the number of parity increased, and younger ewes had lower BW lambs than mature. Similarly, Sen and Onder [6] reported that the yearling goats in the first party had a lower kid BW than those of adults. Although breeding conditions and parity number of the Akkaraman sheep breed, which are used as experimental animal, were nearly similar, there were differences in terms of lamb BW and placental characteristics. Therefore, the current study was based on these basic differences, and it is thought that the differences in placental characteristics may cause differences in lamb BW.

Previous studies have reported that placental weight, which is one of the indicators of growth deficiency of the fetus, can be associated with cotyledon weight and number [6]. Dwyer et al.[2] observed a difference in the placental characteristics of lambs with relatively different BW obtained from sheep with different parity numbers. Same authors reported that lambs with higher BW from sheep with more parity numbers had the heavier placenta and average cotyledon weights. Similarly, Konyali et al. [26] reported that BW and placental weight increased or decreased together in goats. On the contrary, Ocak et al. [4] did not observe a relationship between placental weight and BW of lambs obtained from sheep with different number of parity. In the present study, it has been determined that Akkaraman lambs with low BW have lower PW, TCW and ACW than those of lambs with moderate and high BW. Additionally, it was determined that the lambs with high BW had higher weight of large, medium and small and total cotyledons than low BW lambs. These results might suggest that differences in BW of lambs with same parity of ewes maybe due to variations of the placental development. Differences in BW of Akkaraman lambs with same parity cannot be explained by only the variation of placental development. Therefore, future researches on histological components are necessary to define the variations of placentas.

The newborn mortality and survival rate until weaning age are important indicators of sustainability in livestock farming. Postnatal lamb mortality, which is an important factor for profitability in sheep production, varies between 7-51% around the world [3]. Importance factors for the postnatal mortality rate are multiple births, dystocia, BW, ambient temperature, maternal care, placental insufficiency, breed and flock management [6,27,28,29]. Ocak et al. [4,30] determined that there is a relationship between placental characteristics and postnatal mortality, and also they reported that the postnatal survival rate of lambs born to different sheep breeds were between 5-6% until weaning. Additionally, Mellor and Stafford [27] indicated that postnatal mortality of the offspring in livestock is associated with the growth and development of the placenta during pregnancy. In the present study, postnatal mortality rate of lambs was between 5-16% until weaning. However, it was observed that the survival rates of lambs with high BW were found higher than that of low and moderate BW lambs from birth to weaning. These results indicated that the Akkaraman lambs, which have heavier various cotyledons, with higher birth weight than flock

Table 4 - Pearson correlation coefficients of placental characteristics and birth related factors in Akkaraman male lambs.

	PW	TCN	LCN	MCN	SCN	ACDia	ACL	ACDe	ACSA	TCSA	CE	CD	PE	TCV	VCE
BW	.108	-.202	.232	-.215	-.262	.200	.240	.185	.265	.091	.420*	.050	.301	.188	.422*
PW		.054	.488*	.196	-.405*	.356*	.184	-.050	.285	.290	-.187	-.641**	-.694**	.119	-.155
LCN				-.268	-.495*	.032	.052	-.247	.042	.080	.022	-.248	-.245	-.129	.149
MCN					-.003	.212	-.040	-.036	.082	.310	-.342*	-.187	-.309	.182	-.310
SCN						-.017	-.172	.043	-.136	.385*	-.475*	.701**	.471*	.281	-.451*
ACDia							.636**	.156	.879**	.737**	-.559*	-.100	-.107	.587*	-.534*
ACL								.304	.923**	.536*	-.349*	-.089	.032	.542*	-.404*
ACDe									.266	.091	.000	.130	.231	.751**	-.421*
ACSA										.675**	-.455*	-.115	-.033	.618**	-.477*
TCSA											-.796**	.197	.034	.707**	-.712**
CE												-.171	.109	-.506*	.889**
CD													.918**	.235	-.207
PE														.197	.005
TCV															-.729**

BW= birth weight, PW = placental weight, TCN = total cotyledon number, SCN = small cotyledon number, MCN = medium cotyledon number, LCN = large cotyledon number, ACDia = average cotyledon diameter, ACL = average cotyledon length, ACDe = average cotyledon depth, ACSA = average cotyledon surface area, TCSA = total cotyledon surface area, CE = cotyledon efficiency, CD = cotyledon density, PE = placental efficiency, TCV = total cotyledon volume, VCE = volumetric cotyledon efficiency. * $p < 0.05$, ** $p < 0.01$.

average have a higher survival rate until weaning.

The attachment of cotyledons to the uterus takes place between 25 - 30 days of gestation in sheep, and growth restrictions (insufficient main feeding, abnormal environmental conditions and abnormal endocrinal activity etc.) during this period may affect the number of placental cotyledons [7,11]. Moreover, restrictive factors in the last period of gestation can affect the morphology and size of cotyledons rather than the number [7,31]. Dwyer et al. [2] reported that lambs with higher BW had fewer cotyledons. However, Konyali et al. [26] observed that there was a positive relationship between kid BW and cotyledon number in the goat placenta. Similarly, Sen and Onder [6] show that as the BW increases, the number of cotyledons on the placenta increase as well. We observed that the number of total and small cotyledons was higher in lambs with low BW than lambs with moderate and high BW. On the other hand the number of large cotyledons was higher in lambs with high BW than those with low and moderate BW. In the study, cotyledon number with same parity seems to be the most important indicator for different BW.

Previous studies show that the morphological characteristics of cotyledons on the placenta and the exchange between the maternal and fetal circulation are highly related [7,11]. Ocak et al.[4] indicated that singleton and twin lambs with different BW had similar diameter, length and depth in placental cotyledons. However, Ocak et al. [30] reported that twin kids had higher cotyledon diameter, length, and depth than single born in Damascus goats. Moreover, Ocak and Önder [29] showed that parity did not affect the cotyledon diameter and depth of kids, but it affects cotyledon length. Similarly, it was observed that small cotyledons were longer in lambs with moderate BW than lambs with high BW in the current study. This result may indicate that cotyledonal measurements were related to lamb BW and there were a difference in the length of small cotyledons.

Uterus capacity is defined as the total placental tissue mass and also placenta efficiency has been calculated as an index of uterine capacity [20]. Placenta efficiency is used as an important parameter for the assessment of offspring development during gestation in multiple birth farm animals such as pigs and sheep [2, 32]. However, it has been reported that the determination of the TCSA and the calculation of the CE give more precise and reliable results in determining the differentiation in placental development, its functional ability and its effect on the development of offspring [30]. Although it is difficult to measure the placental surface area in sheep, determining of the cotyledonal surface area and cotyledon density in the placenta is a strong indicator of the link between dam and offspring and it is a useful tool for predicting adequate placental development during gestation [6,7,30]. In the present study placental efficiency of lambs with high BW was higher than lambs with low and moderate BW. Similarly, cotyledon efficiency and volumetric cotyledon efficiency of lambs with high BW were observed to be higher than lambs with low BW. Previous studies reported that parity did not affect PE and CD [4], but twin-born lambs had higher rate of PE and CD than those of singleton [4,30]. Ocak et al. [3] reported that female lambs with low BW had a lower rate of placental efficiency and cotyledon density than male lambs with higher BW. Also, Sen and Onder [6] reported that there was a difference in cotyledon efficiency of kids with different BW. The results of the current study show that PW, PE, CE and CE are directly related to BW of Akkaraman male lambs and these results support the conclusion of previous studies [2,3,4,6,11,30].

Previous studies reported that there was significant relationship between BW and PW in different species [2,6,33]. However, there was no significant correlation between pooled lamb BW and PW in the present study. The results of the present study are consistent with the results of Ocak et al. [4,30]. Pooled data of Akkaraman male lambs with different birth weight showed that there were positive correlations among BW, CE and VCE placental characteristics. These observations are in agreement with the argument of past studies [4,6]. In the current study relationships were determined among PW and some cotyledon type and dimensions as positively, but a negative correlation was observed between PE and CD measuremets. These observations are consistent with the findings reported by Ocak and Onder[29], Ocak et al. [30] and Sen and Onder [6].

In the current study, we observed that lamb BW changed with placental characteristics and lambs with higher BW were found to have better placental components. Although, Akkaraman sheep breed was raised in the same management and feeding procedure, the differences in the BW of lambs might be due to different placental development. Additionally, the results of the current study indicated that the placental characteristics significantly affected the postnatal survival of the lambs in relation to BW in Akkaraman sheep breed, which is an importance native breed of Turkey. All these results suggest that placental development during gestation can affect the future productivity of the lambs in relation considering BW in Akkaraman sheep breed. Future studies may enable the determination of the possible effects of placental characteristics on the subsequent productivity characteristics such as meat, milk and wool yield, and the development of new breeding strategies by looking at the placental characteristics of lambs.

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