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Comparing Body Weight, Body Biometrical Parameters, Blood Metabolites, and Progesterone Concentration of Ewe Lambs and Yearling Ewes

Research Article

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ABSTRACT

Regardless of reasonable reproductive performance of ewe lambs of many breeds, Ghezel ewe lambs have a very poor fertility rate, but Ghezel yearling ewes have a high fertility rate. So, comparing ewe lambs with yearling ewes can help us to understand the reason of this difference. Accordingly, this study was designed to evaluate body weight, body biometrical parameters, serum metabolites, progesterone concentration, and trait correlations of Ghezel ewe lambs and yearling ewes. During the breeding season, Ghezel ewe lambs (n=36, 7 months old) and yearling ewes (n=39, 18 months old) were weighed, their body biometrical parameters were measured, blood samples were collected, and serum metabolites and progesterone concentrations were measured. Then, all data were analyzed by the general linear model procedure of SAS software. The results of this study indicated higher relative body weight, all body biometrical parameters (except head length), and progesterone concentration in yearling ewes in comparison with ewe lambs ($P<0.01$). However, serum urea and glucose concentrations were lower in yearling ewes in comparison with ewe lambs ($P<0.05$). Also, results indicated a positive correlation of relative body weight and age with progesterone concentration of yearling ewes ($P<0.01$). On the other hand, results indicated a negative correlation of serum progesterone, relative body weight and age with urea concentration of yearling ewes ($P<0.05$). The overall results of this study indicated that Ghezel ewe lambs had lower relative body weight, body parameters, and progesterone concentration, but higher blood glucose and urea concentrations in comparison with yearling ewes.

KEY WORDS body weight, blood metabolites, ewe lamb, progesterone.

INTRODUCTION

Although ewe lambs successfully bred at 7 to 9 months of age in some countries (Kenyon *et al.* 2014), mating Ghezel ewe lambs (a fat-tailed sheep breed inhabited in the East and West Azerbaijan provinces, Iran) usually postpone until the second year, when yearling ewes have higher fertility rate (Saadat-Noori and Siah-Mansoor, 1987; Baneh *et al.* 2010). As reproductive performance directly influences farmer's income (Hasani *et al.* 2018), understanding the reason of low reproductive performance of ewe lambs can lead to a solution for improving fertility rate of sheep flocks.

Previous studies indicated the importance of body condition score (BCS) and body weight on reproductive efficiency and lamb survival during the breeding season (Madani *et al.* 2009; Cam *et al.* 2010; Aliyari *et al.* 2012; Aktaş *et al.* 2015). These results proved the impact of nutritional status and body condition on reproductive efficiency (Koycegiz *et al.* 2009). It was indicated that improving nutritional status before or around mating increased reproductive performance and ovulation rate (Lassoued *et al.* 2004; Petrović *et al.* 2012; Ghasemi-Panahi *et al.* 2016). On the other hand, underfeeding, inadequate dietary protein, or low body weight postponed the onset of puberty (Mukasa-Mugerwa and Mutiga, 1993; Kaur and Arora 1995; Garcia *et al.* 2002). Fertility is under the signaling control of sex hormones, gonadotropic hormones, and some metabolic hormones (GH, IGF-I, insulin, leptin), (Chandrashekar and Bartke, 2003; Robinson *et al.* 2006; Abadjieva *et al.* 2011; El-Shahat *et al.* 2014). It was reported that increasing in insulin secretion decreased the prevalence of short luteal phases in ewes (Mitchell *et al.* 2003). Also, the impact of IGF-I, growth hormone, and leptin on oestrous cyclicity was proved (Armstrong *et al.* 2003). Furthermore, some blood metabolites influence fertility rate either in the positive (glucose) or negative way (urea, ammonia, and triglyceride), (Miyoshi *et al.* 2001; Robinson *et al.* 2006).

Ghezel yearling ewes usually have a reasonably good reproductive performance; so, ewe lambs and yearling ewes were compared to understand the ideal situation for improving fertility rate of Ghezel ewe lambs. Accordingly, this study was designed to evaluate body weight, body biometrical parameters, serum metabolites, progesterone concentration, and trait correlations of Ghezel ewe lambs and yearling ewes during the breeding season.

MATERIALS AND METHODS

Animals and housing

All procedures of the present experiment were proved by Animal Care and Use Committee (887/17, University of Tabriz, Iran). In this experiment, Ghezel ewe lambs and yearling ewes were evaluated during the breeding season. Animals were kept in Khalat-Pushan Agricultural Research Station (38˚ 01'54"N 46˚ 23'41"E), University of Tabriz, Tabriz, Iran. The feeding system of ewe lambs and yearlings was as follows: Lambs were received milk from birth to three months of age. During this time, lambs were also fed a starter diet as the mixture of alfalfa hay (40%) and concentrate (60%). The concentrate (CP=15.93%, ME= 2.36 Mcal) was composed of grounded barley (40%), wheat bran (16.67%), beet pulp (21.67%), cottonseed (8.33%), soybean meal (6.67%), salt (0.33%), calcium carbonate (0.5%), and mineral and vitamin premix (0.83%). After three months, lambs were grazed on intermediate pasture along with their mothers. During the late days of autumn and entire winter, lambs were housed in a pen and had *ad libitum* access to alfalfa hay and corn silage. Then, they were grazed on intermediate pastures in the spring, summer, and early autumn. Feeding on intermediate pastures could not comply with animal’s requirement. Breeding season in this breed is between July and August. During the breeding season, 36 ewe lambs with the average age of 7.03 ± 0.98 months and 39 yearling ewes with the average age of 18.32 ± 0.67 months were used for evaluations. All selected ewe lambs showed estrous signs during the breeding season (detected by daily using of ram teasers for 40 days).

Data collection

For this reason, Ghezel ewe lambs and yearling ewes were weighed and their relative body weight was calculated as percentage of body weight to the mature body weight in this breed (59.1 kg; Farid and Mokarechian, 1977). Also, an animal’s body condition score (BCS) was determined. Then, body biometrical parameters were measured (based on centimeters), which are presented in Figure 1. Body biometrical parameters included: head length: a distance between the rostral tip of the nose and the caudal base line of the forehead; head width: a distance between the two ears; body length: a distance between shoulders and hip; withers height: a distance between the base of the front hooves and the tip of two shoulders; croup height: a distance between the base of the hind limb hooves and the tip of the croup; thigh-pelvic junction width (hip to hip): a distance between left and right thigh-pelvic junction; pelvic length: a distance between coxal tuber and ischiatic tuber (between the iliac wing and ischiatic tuber); shoulder width: a distance between right and left shoulders; pelvic width: a distance between left and right coxal tubers; ischium width (pin to pin): a distance between left and right ischiatic tubers; body barrel: the circumference of abdomen around umbilical region; heart girth: the circumference of chest right behind the elbows (olecranon); body depth: a vertical distance between the ventral base of abdomen (around an umbilical region) and backbones; metacarpus circumference: the circumference of metacarpal bone; tarsus height (ankle height): a distance between the base of the hind limb hooves and tarsus (calcaneal tuber); elbow height: a distance between the base of the front limb hooves and the point of elbow (olecranon), (Getty, 1975; Ommer and Harshan, 1995; Frandson *et al.* 2009; Ferra *et al.* 2010; Haldar *et al.* 2014; Soltani *et al.* 2017).

Blood evaluations

During the breeding season, blood samples of ewe lambs and yearling ewes were collected from the jugular vein using non-heparinized tubes. Then, the sample tubes were remained for one hour at room temperature to clot. Next, blood samples were centrifuged (3000×g for 15 min at 4 ˚C) and serum was separated and kept at -20 ˚C until analysis of serum metabolites and progesterone.

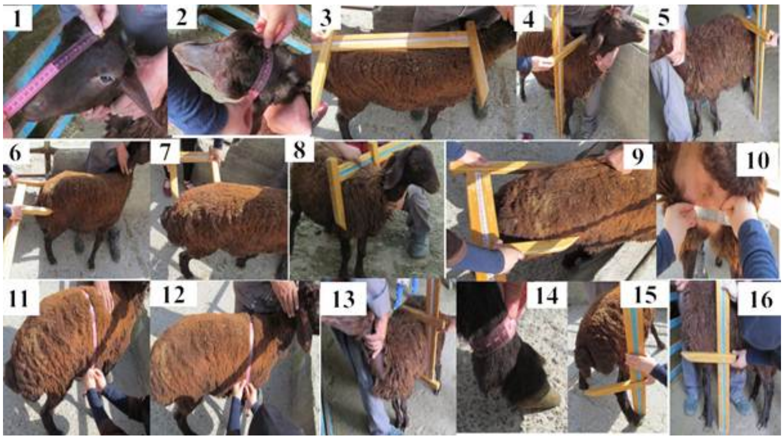

Figure 1 Body biometrical parameters of one- and two- year-old Ghezel ewe lambs, included: 1: head length; 2: head width; 3: body length; 4: withers height; 5: croup height; 6: thigh-pelvic junction width (hip to hip); 7: pelvic length; 8: shoulder width; 9: pelvic width; 10: ischium width (pin to pin); 11: body barrel; 12: heart girth; 13: body depth; 14: metacarpus circumference; 15: tarsus height (ankle height) and 16: elbow height

An automatic analyzer instrument (Alyson 300, England) was applied to determine serum high-density lipoproteins (HDL), low-density lipoproteins (LDL), cholesterol, triglyceride, glucose, total protein, and urea concentrations using Sigma Diagnostics reagents (Zist Shimi Co, Iran).

Serum progesterone concentrations of ewe lambs and yearling ewes were determined using progesterone enzyme-linked immunosorbent assay (ELISA) kit (Product No. 4825-300, Monobind, USA) and ELISA reader instrument (Awareness Technology STAT-FAX 3200, Microplate Reader, USA).

Statistical analyses

All data were analyzed using the GLM procedure of SAS software (SAS, 2008). Results are presented as mean ± SE and Duncan's multiple range test was used for treatment comparisons ($P<0.05$).

Also, CORR procedure of SAS software (SAS, 2008) was used to examine the Pearson correlation between traits. For this analysis, separate data related to yearling ewes and ewe lambs were considered for correlation analysis. In the results section, correlations of relative body weight and age with all body biometrical parameters were reported. Furthermore, correlation results of serum metabolites with relative body weight, age, and progesterone concentration were reported.

RESULTS AND DISCUSSION

The results of the present study indicated that body weight, relative body weight (%), BCS, and all body biometrical parameters (except head length) were significantly higher in yearling ewes in comparison with ewe lambs ($P<0.01$), (Table 1).

However, head length was not significantly different between yearling ewes and ewe lambs, but head length tended to be higher in yearling ewes ($P=0.09$), (Table 1).

Based on the present results, there was a positive correlation between relative body weight of ewe lambs and their BCS, head length, croup height, pelvic length, body barrel, heart girth, body depth, and metacarpus circumference ($P<0.01$), (Table 2). Also, the highest positive correlation was observed between relative body weight of ewe lambs and body barrel ($r=0.79$; $P<0.01$), (Table 2). Meanwhile, relative body weight of ewe lambs tended to have a positive correlation with withers height, pin to pin, and tarsus height ($P<0.10$), (Table 2). On the other hand, no significant correlation was observed between relative body weight and ewe lamb's head width, body length, hip to hip, shoulder width, pelvic width, and elbow height ($P>0.05$), (Table 2).

Results related to yearling ewes indicated a positive correlation between relative body weight and animal's BCS, head length, head width, withers height, pelvic width, pin to pin, body barrel, heart girth, body depth, and elbow height ($P<0.05$), (Table 2). The highest positive correlation was observed between relative body weight and BCS of yearling ewes ($r=0.61$; $P<0.01$), (Table 2). Also, relative body weight tended to have a positive correlation with the metacarpus circumference of yearling ewes ($P=0.08$), (Table 2).

Nevertheless, no significant correlation was observed between relative body weight and yearling ewe's body length, croup height, hip to hip, pelvic length, shoulder width, and tarsus height ($P>0.05$), (Table 2).

Results also indicated a positive correlation between age and ewe lamb's relative body weight, BCS, head length, and body barrel ($P<0.01$), (Table 2). The highest positive correlation was observed between age and head length of ewe lambs ($r=0.67$; $P<0.01$), (Table 2).

Table 1 Body weight and body biometrical parameters of Ghezel ewe lambs and yearling ewes

Body parameters[1]	Ewe lambs	Yearling ewes	P-value
Body weight (kg)	30.17±0.82[b]	52.80±0.79[a]	< 0.01
Relative body weight (%)[2]	51.05±1.39[b]	89.35±1.33[a]	< 0.01
BCS	2.21±0.06[b]	2.74±0.06[a]	< 0.01
Head length (cm)	20.92±0.64	22.44±0.61	0.09
Head width (cm)	11.38±0.32[b]	13.41±0.31[a]	< 0.01
Body length (cm)	67.93±2.69[b]	86.54±2.59[a]	< 0.01
Withers height (cm)	61.82±0.58[b]	71.56±0.56[a]	< 0.01
Croup height (cm)	63.40±0.69[b]	69.97±0.67[a]	< 0.01
Hip to hip (cm)	17.13±0.38[b]	23.79±0.36[a]	< 0.01
Pelvic length (cm)	19.81±0.45[b]	27.95±0.44[a]	< 0.01
Shoulder width (cm)	15.94±0.41[b]	21.89±0.39[a]	< 0.01
Pelvic width (cm)	18.53±1.11[b]	29.41±1.07[a]	< 0.01
Pin to pin (cm)	6.42±0.24[b]	8.28±0.23[a]	< 0.01
Body barrel (cm)	87.97±1.16[b]	105.97±1.12[a]	< 0.01
Heart girth (cm)	76.47±0.96[b]	95.31±0.93[a]	< 0.01
Body depth (cm)	30.49±0.38[b]	36.28±0.36[a]	< 0.01
Metacarpus circumference (cm)	9.92±0.12[b]	10.87±0.12[a]	< 0.01
Tarsus height (cm)	27.00±0.24[b]	28.62±0.23[a]	< 0.01
Elbow height (cm)	39.42±0.38[b]	43.85±0.36[a]	< 0.01

[1] Data are means ± standard error.
[2] As percentage of body weight to the mature body weight.
BCS: body condition score.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Table 2 Correlation of relative body weight and age with body biometrical parameters of Ghezel ewe lambs and yearling ewes

Body parameters	Ewe lambs				Yearling ewes			
	Correlation with relative body weight[1]		Correlation with age		Correlation with relative body weight[1]		Correlation with age	
	Correlation	P-value	Correlation	P-value	Correlation	P-value	Correlation	P-value
Relative body weight (%)[2]	1	-	0.43	< 0.01	1	-	-0.02	0.89
BCS	0.56	< 0.01	0.57	< 0.01	0.61	< 0.01	0.12	0.48
Head length (cm)	0.37	0.03	0.67	< 0.01	0.47	< 0.01	0.18	0.27
Head width (cm)	0.05	0.79	0.18	0.30	0.54	< 0.01	0.07	0.65
Body length (cm)	-0.23	0.17	-0.61	< 0.01	0.25	0.12	0.15	0.35
Withers height (cm)	0.30	0.07	-0.17	0.31	0.44	< 0.01	-0.01	0.99
Croup height (cm)	0.41	0.01	0.02	0.90	0.22	0.18	-0.06	0.72
Hip to hip (cm)	-0.16	0.34	-0.57	< 0.01	-0.02	0.92	0.39	0.01
Pelvic length (cm)	0.34	0.04	0.30	0.07	-0.17	0.31	-0.14	0.39
Shoulder width (cm)	-0.07	0.70	-0.57	< 0.01	0.25	0.12	0.29	0.08
Pelvic width (cm)	-0.26	0.13	-0.62	< 0.01	0.57	< 0.01	0.03	0.86
Pin to pin (cm)	0.29	0.09	0.13	0.46	0.51	< 0.01	0.13	0.42
Body barrel (cm)	0.79	< 0.01	0.52	< 0.01	0.59	< 0.01	0.37	0.02
Heart girth (cm)	0.71	< 0.01	0.12	0.48	0.49	< 0.01	0.12	0.47
Body depth (cm)	0.61	< 0.01	0.22	0.19	0.55	< 0.01	0.19	0.23
Metacarpus circumference (cm)	0.37	0.02	0.03	0.86	0.28	0.08	-0.22	0.18
Tarsus height (cm)	0.32	0.06	-0.33	0.05	0.07	0.67	-0.07	0.68
Elbow height (cm)	0.19	0.26	-0.22	0.21	0.33	0.04	-0.06	0.71

[1] As percentage of body weight to the mature body weight.
BCS: body condition score.

Meanwhile, age of ewe lambs tended to have a positive correlation with pelvic length (P=0.07), (Table 2). On the opposite, a negative correlation was observed between age and ewe lamb's body length, hip to hip, shoulder width, pelvic width, and tarsus height (P<0.05), (Table 2). Also, the highest negative correlation was observed between age and pelvic width of ewe lambs (r=-0.62; P<0.01), (Table 2).

Nevertheless, no significant correlation was observed between age and ewe lamb's head width, withers height, croup height, pin to pin, heart girth, body depth, metacarpus circumference, and elbow height (P>0.05), (Table 2).

Results indicated a positive correlation between age and yearling ewe's hip to hip and body barrel (P<0.05), (Table 2). In addition, age tended to have a positive correlation with the shoulder width of yearling ewes (P=0.08), (Table 2). However, no significant correlation was observed between age of yearling ewes and their relative body weight, BCS, head length, head width, body length, withers height, croup height, pelvic length, pelvic width, pin to pin, heart girth, body depth, metacarpus circumference, tarsus height, and elbow height (P>0.05), (Table 2).

Blood evaluations indicated a higher progesterone concentration in yearling ewes compared with ewe lambs (P<0.01), (Table 3). Also, lower serum urea and glucose concentrations was observed in yearling ewes in comparison with ewe lambs (P<0.05), (Table 3). Moreover, total protein concentration tended to be higher in yearling ewes than ewe lambs (P=0.09). Results indicated no differences in blood lipid contents (cholesterol, LDL, HDL, and triglyceride) between yearling ewes and ewe lambs (P>0.05), (Table 3).

Based on the results, a positive correlation was observed between relative body weight of ewe lambs and their blood LDL and total protein concentrations (P<0.05), (Table 4). Also, relative body weight tended to have a positive correlation with cholesterol concentration of ewe lambs (P=0.08), (Table 4). Nonetheless, results indicated no significant correlation between relative body weight of ewe lambs and their blood HDL, triglyceride, glucose, urea, and progesterone concentrations (P>0.05), (Table 4).

Results indicated a positive correlation between relative body weight of yearling ewes and their serum LDL, total protein, and progesterone concentrations (P<0.05), (Table 4). Also, relative body weight of yearling ewes tended to have a positive correlation with cholesterol concentration (P=0.09), (Table 4). On the other hand, a negative correlation was observed between relative body weight of yearling ewes and serum glucose and urea concentrations (P<0.05), (Table 4). Results indicated no significant correlation between relative body weight of yearling ewes and serum HDL and triglyceride concentrations (P>0.05), (Table 4).

Results indicated a positive correlation between age and serum total protein concentration of ewe lambs (P<0.01), (Table 4). Although age tended to have a positive correlation with the progesterone concentration of ewe lambs (P=0.09), age tended to have a negative correlation with HDL of ewe lambs (P=0.07), (Table 4). However, age had no significant correlation with serum cholesterol, LDL, triglyceride, glucose, and urea concentrations of ewe lambs (P>0.05), (Table 4).

Results indicated a positive correlation between age of yearling ewes and their blood progesterone concentration (P<0.01), but there was a negative correlation between age and serum urea concentration (P<0.05), (Table 4). Meanwhile, age tended to have a positive correlation with serum cholesterol concentration of yearling ewes (P=0.09), though age tended to have a negative correlation with glucose concentration (P=0.06), (Table 4). Nevertheless, no significant correlation was observed between age of yearling ewes and serum LDL, HDL, triglyceride, and total protein concentrations (P>0.05), (Table 4).

Results indicated a negative correlation between progesterone concentration and serum triglyceride concentration of ewe lambs (P<0.05), (Table 4). Also, blood progesterone concentration tended to have a negative correlation with serum cholesterol and HDL concentrations of ewe lambs (P<0.10), (Table 4).

There was no significant correlation between blood progesterone concentration of ewe lambs and serum LDL, glucose, total protein, and urea concentrations (P>0.05), (Table 4).

Results of the present study indicated a negative correlation between progesterone concentration and serum urea concentration of yearling ewes (P<0.01), (Table 4). Also, blood progesterone concentration of yearling ewes tended to have a negative correlation with the serum glucose concentration (P=0.06), (Table 4). Though, results indicated no significant correlation between blood progesterone concentration of yearling ewes and serum cholesterol, LDL, HDL, triglyceride, and total protein concentrations (P>0.05), (Table 4).

Results of the present study indicated that body weight, relative body weight, BCS, and all body biometrical parameters (except head length) were higher in yearling ewes in comparison with ewe lambs. Results of the present study also indicated a positive correlation between relative body weight and animal's BCS, head length, withers height, pin to pin, body barrel, heart girth, and body depth of ewe lambs and yearling ewes. Resemble to the present results, other studies reported the same positive correlations between body weight and body biometrical parameters (Fakhrayi *et al.* 2008; Ferra *et al.* 2010; Musa *et al.* 2012; Yilmaz *et al.* 2013). Also, Ferra *et al.* (2010) reported higher body biometrical parameters of ewe lambs whom reached puberty than those did not reach puberty. Also, most of the studies indicated a positive correlation between body weight and BCS with fertility traits (Montgomery *et al.* 1988; Bathaei, 1996; Ferra *et al.* 2010; Aliyari *et al.* 2012; Aktaş, *et al.* 2015). Then, the onset of puberty related to the attainment of critical body mass (Rosales Nieto *et al.* 2013).

Growth rate and the amount of body fat are also important factors influencing reproductive performance (Aktaş *et al.* 2015; Rosales Nieto *et al.* 2018; Zarkawi and Al-Daker, 2018).

Table 3 Serum metabolites and progesterone concentrations of Ghezel ewe lambs and yearling ewes

Parameters[1]	Ewe lambs	Yearling ewes	P-value
Cholesterol (mg/dL)	66.11±4.05	72.71±4.17	0.27
LDL (mg/dL)	32.38±3.25	38.31±3.34	0.21
HDL (mg/dL)	29.93±1.89	30.74±1.94	0.77
Triglyceride (mg/dL)	20.78±1.95	18.29±2.01	0.38
Glucose (mg/dL)	59.56±3.71[a]	46.24±3.82[b]	0.02
Total protein (g/dL)	8.35±0.29	9.06±0.29	0.09
Urea (mg/dL)	42.86±1.63[a]	36.71±1.67[b]	0.01
Progesterone (ng/mL)	1.52±0.63[b]	5.54±0.56[a]	< 0.01

[1] Data are means ± standard error.
LDL: low-density lipoproteins and HDL: high-density lipoproteins.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Table 4 Correlation of relative body weight, age, and progesterone concentration with blood parameters of Ghezel ewe lambs and yearling ewes

Parameters	Ewe lambs						Yearling ewes					
	Correlation with relative body weight[1]		Correlation with age		Correlation with progesterone		Correlation with relative body weight[1]		Correlation with age		Correlation with progesterone	
	Correlation	P-value	Correlation	P-value	Correlation	P-value	Correlation	P-value	Correlation	P-value	Correlation	P-value
Cholesterol (mg/dL)	0.42	0.08	0.12	0.64	-0.59	0.06	0.28	0.09	0.28	0.09	-0.12	0.55
LDL (mg/dL)	0.46	0.05	0.37	0.13	-0.44	0.17	0.33	0.05	0.25	0.14	-0.09	0.67
HDL (mg/dL)	-0.01	0.98	-0.44	0.07	-0.57	0.07	0.04	0.79	0.16	0.37	-0.09	0.65
Triglyceride (mg/dL)	-0.08	0.75	-0.09	0.69	-0.69	0.02	-0.13	0.44	-0.04	0.82	-0.29	0.15
Glucose (mg/dL)	0.11	0.65	0.19	0.44	-0.34	0.33	-0.33	0.05	-0.32	0.06	-0.39	0.06
Total protein (g/dL)	0.54	0.02	0.75	< 0.01	0.37	0.26	0.37	0.03	0.27	0.12	0.07	0.75
Urea (mg/dL)	0.10	0.68	0.09	0.70	-0.35	0.29	-0.43	< 0.01	-0.39	0.02	-0.52	< 0.01
Progesterone (ng/mL)	-0.23	0.50	0.54	0.09	1	-	0.64	< 0.01	0.68	< 0.01	1	-

[1] As percentage of body weight to the mature body weight.
LDL: low-density lipoproteins and HDL: high-density lipoproteins.

So, favorable body weight activates hypothalamo-pituitary-gonadal (HPG) axis, which leads to successful fertilization and reproductive performance (Haldar *et al.* 2014; Zarkawi and Al-Daker, 2018).

Present results related to ewe lambs indicated a positive correlation between the age of animals and their relative body weight, BCS, head length, pelvic length, and body barrel.

However, a negative correlation was observed between age and ewe lamb's body length, hip to hip, shoulder width, pelvic width, and tarsus height. On the other hand, results related to yearling ewes indicated a positive correlation between age and animal's hip to hip, body barrel, and shoulder width. Similarly, previous studies indicated a positive correlation between age and animal's body weight and their body biometrical parameters (Ferra *et al.* 2010; Aktaş *et al.* 2015).

However, observing a negative correlation between age of ewe lambs and some body biometrical parameters may relate to the animal's low body weight or their low nutritional status, which decelerate the growth of ewe lambs (Rosales Nieto *et al.* 2013).

Also, it was indicated that weaning can cause growth retardation (Foster *et al.* 1985; Pluske *et al.* 1997); then, these negative correlations may relate to the prolonged negative effects of weaning on the growth of ewe lambs.

Results of this experiment indicated higher urea, but lower total protein concentration in ewe lambs in comparison with yearling ewes. Although both animals were under the same nutritional conditions, this result may indicate for higher protein degradation (probably used for gluconeogenesis) in ewe lambs due to the lower body weight of these animals or because of higher need for glucose bioavailability during the onset of puberty (Decombaz *et al.* 1979; Goodman, 2010; El-Shahat *et al.* 2014; Rosales Nieto *et al.* 2018). It was indicated that growth hormone (GH) and insulin-like growth factor-I (IGF-I) affect synthesis of GnRH and pituitary gonadotrophs and advance puberty (Chandrashekar and Bartke, 2003; El-Shahat *et al.* 2014). Then, GH may play a role in increasing glucose concentration of ewe lambs. However, lower body weight of ewe lambs (possibly due to the negative energy balance) may cause an uncoupling of the link between GH and IGF-I (Lawrence and Fowler, 2002; Robinson *et al.* 2006).

This condition causes a decrease in insulin and IGF-I, but an increase in GH concentration, which could not support protein synthesis (Lawrence and Fowler, 2002; Robinson *et al.* 2006). Then, this condition increases serum urea and glucose concentrations, but decreases serum total protein of ewe lambs (Decombaz *et al.* 1979; Goodman, 2010).

Present results showed higher glucose concentration in ewe lambs in comparison with yearling ewes. Since glucose availability considered as one of the metabolic regulators in the onset of puberty; then, increasing in glucose concentration of ewe lambs may relate to the onset of puberty (El-Shahat *et al.* 2014). It was indicated that glucose concentration has beneficial effects on ovarian function (Miyoshi *et al.* 2001). Glucose acts as a nutritional regulator of GnRH and LH secretions (Diskin *et al.* 2003).

Based on the results, serum progesterone concentration was lower in ewe lambs in comparison with yearling ewes. Previous studies indicated shorter estrous cycles, lower progesterone production of corpus luteum, and lower LH and FSH secretion in ewe lambs than ewes (Camp *et al.* 1983; Gonzalez *et al.* 1987; Sasa *et al.* 2002). Another explanation for lower progesterone concentration in ewe lambs may relate to the possible negative energy balance in these animals, which can reduce the concentrations of insulin and IGF-I, but increase GH concentration (Armstrong *et al.* 2003; Robinson *et al.* 2006). Accordingly, this condition causes a reduction in ovarian follicle domination, preovulatory LH surge, oocyte quality, and corpus luteum function (Armstrong *et al.* 2003; Robinson *et al.* 2006). Then, these pathways may be the reason of lower progesterone concentration in ewe lambs.

Results of the present study related to ewe lambs indicated a positive correlation between relative body weight and blood LDL, cholesterol, and total protein concentrations. Results also indicated a positive correlation between relative body weight of yearling ewes and serum LDL, cholesterol, total protein, and progesterone concentrations. However, the results indicated a negative correlation between relative body weight of yearling ewes and serum glucose and urea concentrations. Observing a positive correlation between body weight and LDL, cholesterol, and total protein concentrations confirm higher proteins and lipids synthesis due to the higher body weight of animal (Goodman, 2010). Resemble to the present results related to progesterone, Ferra *et al.* (2010) indicated a positive correlation between body weight and progesterone concentration. The presence of a positive correlation between body weight and progesterone concentration proves that increasing in body weight can improve reproductive performance (Aliyari *et al.* 2012; El-Shahat *et al.* 2014; Aktaş *et al.* 2015). In accordance with these results, Gaskins *et al.* (2005) indicated the positive effect of ewe lamb's body weight on their fertility and prolificacy. On the other hand, observing a negative correlation between body weight and serum urea concentration indicates that animals with lower body weight are under negative energy balance, which causes an increase in protein degradation (Goodman, 2010; Junqueira *et al.* 2019).

Results related to ewe lambs indicated a positive correlation between age and serum total protein and progesterone concentrations, but a negative correlation between age and HDL concentration. On the other hand, results related to yearling ewes indicated a positive correlation between age and blood progesterone and cholesterol concentrations, but a negative correlation between age and serum urea and glucose concentrations. A previous study indicated the same positive correlation between age and progesterone concentration (Ferra *et al.* 2010). Gaskins *et al.* (2005) indicated that increasing the age of animals at breeding increased pregnancy of ewe lambs. Observing a positive correlation between age and serum total protein, cholesterol and progesterone concentrations may relate to the positive correlation between age and body weight of ewe lambs. Then, older animals with higher body weight have higher lipid and protein synthesis (Goodman, 2010; Hafez and Hafez, 2013). Also, this condition advances the growth hormone and insulin like growth factor secretion, which further affects progesterone secretion and fertility rate (Hafez and Hafez, 2013; Rosales Nieto *et al.* 2013; El-Shahat *et al.* 2014; Aktaş *et al.* 2015). Meanwhile, age per se can advance follicular growth and progesterone secretion (Hafez and Hafez, 2013; Rosales Nieto *et al.* 2013). Although Junqueira *et al.* (2019) reported a linear increase in serum HDL with age of ewe lambs, it seems that observing a negative correlation between age and HDL concentration of ewe lambs in the present study caused by possible malnutrition of animals. Observing a negative correlation between age and serum urea and glucose concentrations may relate to higher protein synthesis and glycogenesis, but lower gluconeogenesis and protein degradation in older animals (Goodman, 2010).

Results related to the ewe lambs indicated a negative correlation between progesterone concentration and serum triglyceride, cholesterol, and HDL concentrations. Also, results related to yearling ewes indicated a negative correlation between progesterone concentration and serum urea and glucose concentrations. Observing a negative correlation between progesterone concentration and serum urea concentrations indicate a negative impact of high urea concentration and low body weight on progesterone concentration and reproduction (Mukasa-Mugerwa and Mutiga, 1993; Miyoshi *et al.* 2001; Robinson *et al.* 2006). It was indicated that feed restriction increased triglyceride and glucose concentrations, while non-significantly reduced progesterone concentration (Junqueira *et al.* 2019). This result may explain the observed negative correlation between progesterone concentration and serum lipid (triglyceride, cholesterol, and HDL) concentrations (Miyoshi *et al.* 2001; Robinson *et al.* 2006; Junqueira *et al.* 2019). Observing a negative correlation between progesterone concentration and serum urea and glucose concentrations may relate to higher protein synthesis and glycogenesis, but lower gluconeogenesis and protein degradation in heavier animals with higher progesterone concentration (Miyoshi *et al.* 2001; Gaskins *et al.* 2005; Robinson *et al.* 2006; Goodman, 2010; Aktaş *et al.* 2015).

Reproduction and fertility are energy-demanding functions (Sanchez-Garrido and Tena-Sempere, 2013). It was indicated that critical body weight and body fat require for hypothalamo-pituitary-gonadal (HPG) axis activity (through the leptin signaling pathway) and then, reproductive performance of animals (Hafez and Hafez, 2013; Sanchez-Garrido and Tena-Sempere, 2013; Haldar *et al.* 2014; Aktaş *et al.* 2015; Zarkawi and Al-Daker, 2018). It was indicated that ewe lambs have the potential of being successfully mated in their first year of life and by which, they can have higher profitability and reproductive performance (Kenyon *et al.* 2014). However, heavier ewe lambs with faster growth rates have higher fertility rates (Gaskins *et al.* 2005; El-Shahat *et al.* 2014). It was indicated that underweight ewe lambs did not reach puberty in the first breeding season and have a low reproductive performance (Moreno *et al.* 2000; Hafez and Hafez, 2013; Aktaş *et al.* 2015). Edwards *et al.* (2016) indicated lower mating, ovulation, and pregnancy rates, but higher embryo loss in one year-old ewes in comparison with two year-old ewes. However, they reported that ewe lambs which attained puberty in their first year of life had a higher pregnancy rate and had more multiple births and fewer singleton at 2 years of age (Edwards *et al.* 2015). Regardless of the positive role of body weight on fertility of ewe lambs, the importance of live body weight decreases with increasing in animal's age (Aktaş *et al.* 2015). In order to improve fertility of ewe lambs, flushing and using supplementary diets can be used for ewe lambs to improve their blood progesterone concentration and reproductive organ development (Aliyari *et al.* 2012; Khalifa *et al.* 2013; Kenyon *et al.* 2014; Macias-Cruz *et al.* 2018). Also, genetic and phenotypic selections for higher growth or muscle gain can be used to increase reproductive performance and then, profitability of sheep farm (Gaskins *et al.* 2005; Rosales Nieto *et al.* 2013). Furthermore, it was reported that improving body weight and nutritional status of ewe lambs caused more puberty of ewe lambs at year one, which resulted in improving reproductive performance and economical profitability of the herd, even when animals mated at 18-19 months of age (Wall *et al.* 2018). However, mating of ewe lambs with low body weight should be postponed until the second reproductive season (Bathaei, 1996).

CONCLUSION

The overall results of this study indicated higher serum glucose and urea, while lower progesterone concentration, body weight, BCS, and body biometrical parameters of ewe lambs in comparison with yearling ewes.

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