Iranian Journal of Applied Animal Science

Measuring of Udder Morphological Characteristics among Crossbred and Pure Sheep Breeds

Research Article

S. Sadeghi[1*], S.A. Rafat[2], G. Moghadam[2] and H. Janmohammadi[2]

[1] Young Researchers and Elite Club, Tabriz Branch, Islamic Azad University, Tabriz, Iran
[2] Department of Animal Science, Faculty of Agriculture, University of Tabriz, Tabriz, Iran

Received on: 27 Jan 2015
Revised on: 14 Apr 2015
Accepted on: 31 May 2015
Online Published on: Jun 2016

*Correspondence E-mail: saadat.sadeghi@tabrizu.ac.ir

Online version is available on: www.ijas.ir

ABSTRACT

Image processing technique was used to compare udder morphological characteristics in two Iranian crossbred sheep populations including Ghezel-Arkhamerino, Moghani-Arkharmerino and a pure one that was Ghezel ewes. In addition, the resulted measurements were applied as independent variables for estimation of daily milk yield by regression models. Udder height of Ghezel was higher than Ghezel-Arkhamerino and Moghani-Arkharmerino. The udder left and right cistern height were imbalanced for Moghani-Arkharmerino crossbreds than for other populations. The teat opening, attachment width, direction of the right teat and teat-udder back distance for Ghezel ewes appeared to be the most useful traits among the udder traits taken in this study for predicting daily milk yield. The results reveals that digital image processing may be used as an alternative biometric characterization tool that would provide more accurate observation and measurements on domestic animals than current ones.

KEY WORDS animal characterization, crossbred, image processing, pure sheep, udder.

INTRODUCTION

Sheep rearing is one of the most important means of livelihood and food security for majority of the rural populace, especially in developing countries (Birteeb *et al.* 2012). The anatomy and morphology of the sheep udder has been well known for many years and some examples of curious selection on udder morphology have been assayed, i.e. increasing prolificacy and number of teats (Altincekic and Koyuncu, 2011). The udder is a very important gland in reproducing animals and for milk production and milking rate and time. Several studies have confirmed that udder and teat characteristics are important determinants of milk yield and milking ability in dairy animals (Abu *et al.* 2013). Better knowledge of morphological udder trait variability should allow the identification of mammary traits most suitable for incorporation into selectional programs for dairy sheep breeds (Makovicky *et al.* 2014). Phenotypic characteristics are important in breed identification and the first step of the characterization of local genetic resources is to assess variation of morphological traits (Yakubu *et al.* 2010). Inter-relationships among udder measurements and milk yield within sheep breeds have been demonstrated, yet not fully elucidated. In dairy sheep, the most important functional traits are those related to udder morphology, thus, there is a need to introduce improved udder traits into sheep breeding schemes. Evaluation of udder morphology can be performed by direct measurements of the udder or by image processing. Direct measurements provide objective information, but they are time consuming and laborious for applying on a large scale (Sadeghi *et al.* 2013). Image analysis and belonging biometric techniques have been rapidly increased in the last decade (Onder *et al.* 2011). Therefore, image processing has been an accurate and reliable technique for biometric measurement of morphologic traits. This method allows the extraction of indirect measures of an object provided the presence in the digital picture of a metric indication (Marie-Etancelin *et al.* 2002). The aim of this study was to apply image processing for measuring and comparing udder morphologies in two crossbred sheep Ghezel-Arkharmerino (GH-MR) and Moghani-Arkharmerino (MG-MR) and an Iranian pure bred sheep population (Ghezel; GH), during the lactation period.

MATERIALS AND METHODS

The experiment was carried out at the animal research station, College of Agriculture, University of Tabriz, Iran. The udder of total 96 crossbred and pure ewes with same number including half-breds of Ghezel × Arkharmerino (GH-MR), Moghani × Arkharmerino (MG-MR) crosses and pure Ghezel sheep was photographed. The ewes were in their first or second lactation and belonged to the same experimental flock. The lambs were separated from their mothers at 22:00 and returned to their mothers 04:00 a.m. Ewes were suckled by their lambs until 06:00 (for 2 hours) and then were milked manually for complete evacuation of the udder (until 08:00). The lambs were separated from their mothers and ewes were milked by the machine (14:00). The records were 6 hours milk yield for every ewe and estimated 24 hours (4×6 hours milk yield) daily milk (Hernandez and William, 1979). The milking machine was set up into two groups: a single bucket and vacuum pump, 120 pulse/min and a 50:50 pulsator ratio. The first milk yield was recorded 1 week after postpartum; thereafter milk recordings were conducted approximately every two week for a 23-week period. The ewes were suckled by their lambs freely all over the day except recording days. The ration was based on mixed grass-legume natural prairies throughout the study. The ewes had access to supplemental feed including 0.5 kg barley and 1 kg alfalfa at nights. A 25 mL sample was collected for analysis of milk compositionin 2^{nd}, 11^{th} and 23^{rd} weeks. Milking time (total time of the machine milked in 6 × 4 h) and milking rate (6 h milk/6 h milking time) for statistical analysiswere recorded in 2^{nd}, 11^{th} and 19^{th} weeks. The methodology used for measuring udder traits (Figure 1) was that described by Marie-Etacelin *et al.* (2002). Udder measurements were included: maximum width udder (MWU), udder width–cleft distance (UWC), attachment width (AW), attachment height (AH), AW:AH ratio, point under the tail-cleft distance or udder height (TCD), udder circumference (UC), height of left cistern (HLC), height of right cistern (HRC), cleft height (CH), left udder balance (UBL), right udder balance (UBR), udder balance (UB), cleft surface (CS), maximum lateral depth (MLD), lateral depth of teat level (LDT), lateral cistern height (LCH), distance teat-groin (DTG), lateral teat position (LTP), left rear udder depth (UDL) and right rear udder depth (UDR). Teat characteristics were included width at the base of the left teat (WBLT), length of the left teat (LLT), the average length of teats (ALTS), width at the medium point of the left teat (WMLT), width at the base of the right teat (WBRT), length of the right teat (LRT), width at the medium point of the right teat (WMRT), teat opening (TO), angle of left teat (ALT), angle of right teat (ART), the average angle of teats (AATS) teat distance (TD), direction of the left teat (DLT), direction of the right teat (DRT), teat-udder front distance (TUF) and teat-udder back distance (TUB) (Figure 1).

All the above morphological characteristics were measured before milking and at three different lactation stages that were early (week 2), middle (week 11) and in the end of lactation (week 23) using digital picture analysis by the Digimizer 3.6 software.

Statistical analysis

Statistical analysis was done using the restricted maximum likelihood (REML) methodology (MIXED) procedure as implemented in SAS/STAT v.9.2, (SAS, 2002). The following statistical model with fixed and random effects was applied:

$$Y_{ijklm} = \mu + GEN_i + LS_j + P_k + An_l + (GEN \times LS)_{ij} + (GEN \times P)_{ik} + e_{ijklm}$$

Where:

Y_{ijklm}: dependent variables studied, such as (all udder measurements).

μ:mean.

GEN_i: genotype (breed group; fixed effect with three levels; GH-MR, MG-MR and Ghezel).

LS_j: lactation stage (fixed effect-12 levels 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21 and 23 week postpartum).

P_k: parity (fixed effect with two levels; first and second lactations).

An_l: animal (random effect).

GEN × LS: interaction of genotype with stage of lactation (fixed effect).

GEN × P: interaction of genotype with parity (fixed effect).

e_{ijklm}: random error.

Variable structure

In the present study, daily milk yield was considered as a dependent (target=response) variable. In addition, all udder measurements were considered independent variables. In order to predict daily milk yield (for each genetic group) from udder measurements, multiple linear regression analysis model were used.

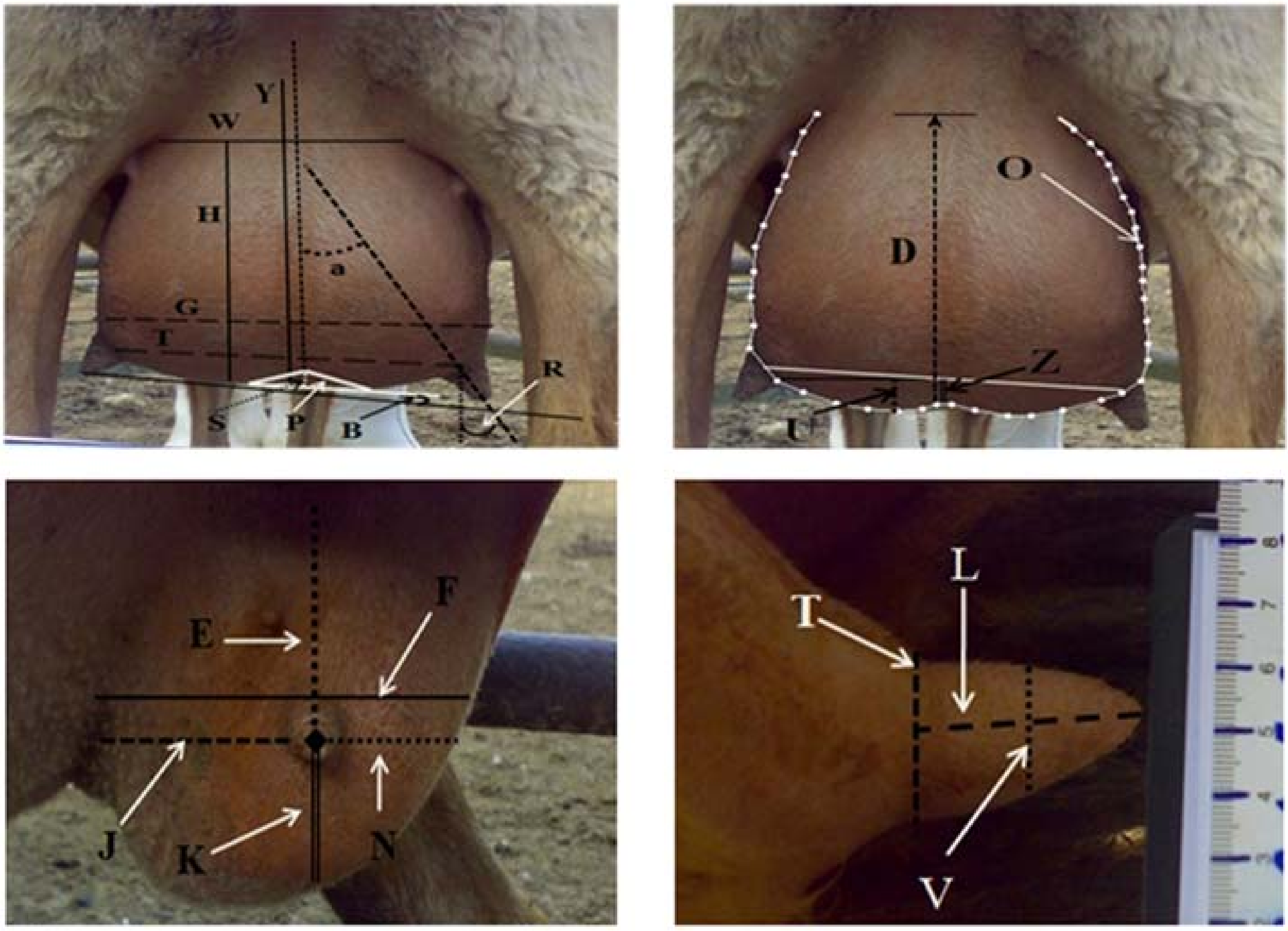

Figure 1 Udder digitally taken measurements Y: point under the tail-cleft distance or udder height (TCD); W: attachment width (AW); D: attachment height (AH); W/D: AW/AH ratio; H: rear udder depth of left (UDL), rear udder depth of right (UDR); G: maximum width udder (MWU); T: teat distance (TD); a: angle of right teat (ART), angle of left teat (ALT); ART + ALT: teat opening (TO); R: direction of right teat (DRT), direction of the left teat (DLT); U: height of left cistern (HLC), height of right cistern (HRC); Z: udder width-cleft distance (UWC); B: udder balance of right (UBR), udder balance of left (UBL), (UBL+UBR) / 2: udder balance (UB); P: cleft surface (CS); S: cleft height (CH); O: udder circumference (UC); T: width at the base of the left teat (WBLT), width at the base of the right teat (WBRT); L: length of left teat (LLT), length of right teat (LRT); V: width at the medium point of the left teat (WMLT), width at the medium point of the right teat (WMRT); E: distance teat-groin (DTG); K: lateral cistern height (LCH); J: teat-udder front distance (TUF); N: teat-udder back distance (TUB); J + N: lateral depth of teat level (LDT); (TUF/TUB): lateral teat position (LTP) and F: maximum lateral depth (MLD).

A forward selection method was used to select the most relevant variables.

RESULTS AND DISCUSSION

Daily milk yield of Ghezel ewes was 43% and 58% more than GH-MR and MG-MR, respectively (Table 1). This indicates dairy potential of Ghezel breed. The means of genetic groups and stages of lactation for teat traits are summarized in Table 2. Results showed that stage of lactation had significant effect on teat traits. Increased teat length during lactation was due to sucking by lamb and milking machine. In the present study, a decrement of the udder volume with decreased teat angle, teat opening and direction of the teat were observed.

Izadifard and Zamiri (1997) reported that mean teats length, right teat length, left teat length, at two weeks post-partum and two weeks post-weaning in Ghezel ewes were 3.3 and 3.6, 3.4 and 3.7, 3.3 and 3.5 cm, respectively. Marie-Etancelin *et al.* (2002) reported that a symmetric udder with similar angles for right and left teats in Chilota (48.2˚ and 47.8˚) and Suffolk Down (46.3˚ and 46.8˚). Fernandez *et al.* (1995) observed that teat size (length and width) tended to decrease and it was significantly different for width teat size between the 1st and 4th month of lactation. The same study showed that horizontal teat position reduced suitability of the udder for milking machine (Dzidic *et al.* 2004). The means of udder characteristics except for teat traits are summarized in Table 3. It seems that reduced daily milk during lactation were main reason for differences between udder measurements. Means of rear udder depth for Ghezel was more than crossbreeds. Marie-Etancelin *et al.* (2002) reported cistern height (7.7 and 9.0 mm) imbalance in Suffolk Down breed.

Table 1 Means of milk compositions for breeds and stages of lactation

Factors		Milk yield (gram/day)	Milking rate (gram/sec)	Milking time (sec)	Fat %	Protein %	SNF %	Dry matter %
Breed	Ghezel	674±35^{a}	5.33±0.38^{a}	131±8	6.14±0.24	5.73±0.05^{a}	11.06±0.82	17.21±0.81^{a}
	GH × MR	427±30^{b}	3.21±0.33^{b}	134±7	6.33±0.20	6±0.05^{b}	13.14±0.71	19.49±0.71^{b}
	MG × MR	470±31^{b}	3.85±0.34^{b}	123±7	6.22±0.21	5.95±0.04^{b}	12.09±0.74	18.33±0.73^{ab}
P-value		0.001	0.0007	0.546	0.822	0.0028	0.176	0.122
Stage of lactation	Early	765±39^{a}	5.17±0.25^{a}	153±4^{a}	6.07±0.24	5.88±0.07	12.35±0.52	18.43±0.05
	Middle	574±37^{b}	4.65±0.34^{a}	135±8^{b}	6.15±0.21	5.87±0.04	11.7±0.56	17.85±0.49
	End	262±31^{c}	2.55±0.31^{b}	100±6^{c}	6.48±0.14	5.93±0.04	12.25±0.51	18.74±0.47
P-value		0.001	0.001	0.001	0.378	0.585	0.381	0.0427

GH × MR: Ghezel × Arkharmerino and MG × MR: Moghani × Arkharmerino.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).

Table 2 Means teat traits for breeds and stages of lactation

Factors		AATS	ALTS	WBLT	LLT	WMLT	WBRT	LRT	WMRT	TO	ALT	ART	DLT	DRT
Breed	Ghezel	53.01±1.92	1.8±0.08	2.25±0.09	1.99±0.09	1.25±0.04	2.1±0.07	1.73±0.08	1.21±0.04	106.04±3.83	53.62±2.1	52.38±2.23	53.59±3.48	53.5±3.55
	GH × MR	48.24±1.79	1.98±0.07	2.07±0.07	1.98±0.08	1.22±0.04	2.18±0.07	1.93±0.07	1.27±0.4	96.46±3.57	48.67±1.99	47.67±2.05	50.35±3.09	48.1±3.18
	MG × MR	51.3±1.74	1.91±0.06	2.14±0.07	1.97±0.08	1.21±0.04	2.14±0.06	1.84±0.07	1.17±0.04	102.6±3.48	51.96±1.92	51.38±2.01	54.29±3.12	53.23±3.18
P-value		0.192	0.268	0.355	0.99	0.801	0.779	0.25	0.253	0.19	0.23	0.26	0.64	0.43
Stage of lactation	Early	57.5±1.69^{a}	1.64±0.04^{a}	2.11±0.07	1.8±0.06^{a}	1.159±0.03^{a}	2.02±0.06^{a}	1.5±0.05^{a}	1.06±0.02^{a}	115.02±3.38^{a}	59.0.9±1.7^{a}	55.95±2.37^{a}	59.31±1.76^{a}	56.21±2.36^{a}
	Middle	49.13±1.84^{b}	1.90±0.06^{b}	2.10±0.08	2.03±0.07^{b}	1.157±0.04^{a}	2.05±0.06^{a}	1.86±0.07^{b}	1.13±0.04^{a}	98.27±3.68^{b}	48.84±2.3^{b}	49.24±1.9^{b}	50.28±2.24^{b}	50.8±1.93^{b}
	End	45.92±1.92^{b}	2.14±0.08^{c}	2.25±0.07	2.11±0.09^{b}	1.38±0.05^{b}	2.35±0.06^{b}	2.15±0.08^{c}	1.45±0.03^{b}	91.84±3.83^{b}	46.33±2^{b}	46.23±2.14^{c}	48.64±2.31^{b}	47.82±2.47^{b}
P-value		0.0002	0.0001	0.316	0.0044	0.0004	0.0003	0.0001	0.0001	0.0002	0.0001	0.0163	0.0001	0.0014

AATS: average angle of teats; ALTS: average length of teats; WBLT: width at the base of the left teat; LLT: length of the left teat; WMLT: width at the medium point of the left teat; WBRT: width at the base of the right teat; LRT: length of the right teat; WMRT: width at the medium point of the right teat; TO: teat opening; ALT: angle of left teat; ART: angle of right teat; DLT: direction of the left teat and DRT: direction of the right teat.
GH × MR: Ghezel × Arkharmerino and MG × MR: Moghani × Arkharmerino.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).

Table 3 Means udder traits (except teat traits) for genetic groups and stages of lactation

Factors		TD	TUF	TUB	MWU	UWC	AW	AH	AW/AH	TCD	UC	HLC	HRC
Breed	Ghezel	13.31±0.34	4.13±0.32	5.77±0.24^{a}	15.65±0.35	2.45±0.25ab	11.36±0.36	12.28±0.52	0.97±0.06	17.17±0.57^{a}	39.72±1.2	1.86±0.23	1.84±0.22
	GH × MR	12.41±0.32	3.7±0.29	4.56±0.22^{b}	14.95±0.32	1.89±0.22^{a}	11.02±0.34	11.21±0.47	1.01±0.05	15.5±0.51^{b}	38.24±1.11	1.56±0.2	1.57±0.2
	MG × MR	12.77±0.31	4.3±0.29	4.88±0.22^{b}	14.72±0.3	2.85±0.22^{b}	10.89±0.33	11.70±0.47	0.99±0.05	16.37±0.5^{ab}	36.47±1.07	2.15±0.2	1.88±0.2
P-value		0.184	0.351	0.003	0.143	0.018	0.636	0.331	0.887	0.111	0.146	0.152	0.515
Stage of lactation	Early	13.31±0.22^{a}	4.94±0.22^{a}	5.49±0.21^{a}	16.69±0.22^{a}	3.02±0.18^{a}	12.23±0.29^{a}	12.7±0.41a	1±0.04	18.24±0.4^{a}	40.92±0.91^{a}	2.04±0.13^{a}	2.07±0.15^{a}
	Middle	12.72±0.24^{ab}	3.88±0.2^{b}	4.96±0.16^{b}	14.37±0.3^{b}	2.37±0.12^{b}	10.77±0.26^{b}	11.39±0.29^{b}	0.97±0.02	15.51±0.37^{b}	38.69±0.82^{a}	1.85±0.12^{b}	1.7±0.1^{b}
	End	12.45±0.33^{b}	3.3±0.27^{b}	4.76±0.19^{b}	14.26±0.36^{b}	1.8±0.16^{c}	10.27±0.37^{b}	11.09±0.4^{b}	1±0.65	15.29±0.45^{b}	34.83±1.17^{b}	1.68±0.16^{b}	1.53±0.15^{b}
P-value		0.0464	0.0001	0.0217	0.0001	0.0001	0.0002	0.0016	0.747	0.0001	0.0002	0.0128	0.0004
Factors		CH	UBL	UBR	UB	CS	MLD	LDT	DTG	LCH	LTP	UDL	UDR
Breed	Ghezel	0.95±0.056	21.5±3.33	21.01±3.46	20.61±3.02	2.41±0.2	11.38±0.45^{a}	9.44±0.46^{a}	9.34±0.4^{a}	3.06±0.31	0.42±0.019	12.89±0.55	12.71±0.6
	GH × MR	1.01±0.053	15.05±2.96	18.52±3.13	16.52±2.68	2.55±0.18	8.83±0.42^{b}	7.81±0.42^{b}	7.18±0.38^{b}	2.4±0.29	0.46±0.018	11.47±0.49	11.93±0.54
	MG × MR	0.96±0.050	23±57.3	17.97±3.11	20.71±2.69	2.45±0.17	9.37±0.4^{b}	8.64±0.41^{ab}	7.49±0.36^{b}	3.11±0.28	0.47±0.018	12.43±0.49	12.41±0.53
P-value		0.717	0.125	0.792	0.485	0.876	0.0007	0.0454	0.0007	0.179	0.198	0.298	0.619
Stage of lactation	Early	1.19±0.05^{a}	23.65±1.83^{a}	23.21±2.16^{a}	23.11±1.66^{a}	2.64±0.1	11.12±0.3^{a}	9.47±0.28^{a}	8.14±0.25	2.88±0.18	0.52±0.018	13.23±0.48^{a}	13.27±0.51^{a}
	Middle	0.9±0.03^{b}	17.06±0.08^{b}	15.76±2.27^{b}	15.93±1.92^{b}	2.57±0.08	9.25±0.34^{b}	8.33±0.3^{b}	7.9±0.24	2.92±0.21	0.45±0.012	12.05±0.3^{b}	11.96±0.3^{b}
	End	0.82±0.6^{c}	19.42±2.2^{b}	18.54±2.29^{ab}	18.86±1.97^{c}	2.21±0.22	2.22±0.42^{b}	8.09±0.38^{b}	7.97±0.39	2.78±0.24	0.39±0.017	11.78±0.38^{b}	11.82±0.41^{b}
P-value		0.0001	0.0002	0.002	0.0001	0.174	0.0001	0.0007	0.713	0.811	0.0001	0.0173	0.0176

TD: teat distance; TUB: teat-udder back distance; TUF: teat-udder front distance; MWU: maximum width udder; UWC: udder width–cleft distance; AW: attachment width; AH: attachment height; AW/AH: attachment width/attachment height; TCD: point under the tail-cleft distance or udder height; UC: udder circumference; HLC: height of left cistern; HRC: height of right cistern; CH: cleft height; UBL: udder balance of left; UBR: udder balance of right; UB: udder balance; CS: cleft surface; MLD: maximum lateral depth; LDT: lateral depth of teat level; LCH: lateral cistern height; DTG: distance teat-groin; LTP: lateral teat position; UDL: rear udder depth of left and UDR: rear udder depth of right.
GH × MR: Ghezel × Arkharmerino and MG × MR: Moghani × Arkharmerino.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).

Udder height and udder attachment had the most reduction during lactation, while teat size had only slightly modified in Spanish breeds (Caja *et al*. 2000). This process agrees with the loss of udder volume and milk yield but indicates a deterioration of udder morphology for milking machine as indicated by udder shape.

Means of udder circumference, udder length, udder depth, udder width, mean teats length, udder right depth, udder left depth, right teat length, left teat length, at two weeks postpartum and two weeks post-weaning in Ghezel ewes were 50.9 and 36.3, 16.6 and 12.3, 14.8 and 13.3, 7.7 and 5.9, 14.7 and 13.1, 14.9 and 13.5, respectively

(Izadifard and Zamiri, 1997). The range of udder height, udder width in 'Lori Bakhtiari' ewes was from 15.3 to 24.4 cm and 15.1 to 18.4, respectively (Sadeghi *et al.* 2013). Maximum and minimum average of udder width was found in Lacaune (130.31±1.302 mm) and Tsigai ewes (103.51±1.276 mm), respectively (Makovicky *et al.* 2013).

Teat angle and small cistern size were compatible with a good morphological aptitude for milking, particularly in Chilota, which evidenced a higher milk yield than Suffolk Down (Marie-Etancelin *et al.* 2002).

The traits defining udder size diminished throughout lactation, this reduction being particularly evident at the end of postpartum. Udder size variation was compatible with the reduction of milk yield potential according to Martinez *et al.* (2011).

The regression models were used for estimation of daily milk yield (for each breed) from related variables (udder measurements). By forward regression analysis model, significant (independent) variables (TO, AW, DRT and TUB for Ghezel breed; WMRT, CS, UDL and AW/AH for GH-MR and ART, DTG, WMRT and US for MG-MR), among all udder measurements, were included in multiple regression analysis model. Prediction equation for forward regression analysis models for each breed can be written as follows:

Daily milk yield$_{\text{Ghezel}}$= -2989.92 + 10.43$_{\text{TO}}$ + 90.87$_{\text{AW}}$ + 6.89$_{\text{DRT}}$ + 175.89$_{\text{TUB}}$ (R^2_{adj}= 0.80)
Daily milk yield$_{\text{GH-MR}}$= 2239.83 - 597.72$_{\text{WMRT}}$ + 163.27$_{\text{CS}}$ - 53.43$_{\text{UDL}}$ - 838.53$_{\text{AW/AH}}$ (R^2_{adj}=0.61)
Daily milk yield$_{\text{MG-MR}}$= -66.34 + 7.73$_{\text{ART}}$ - 66.95$_{\text{DTG}}$ - 411.3$_{\text{WMRT}}$ + 31.64$_{\text{US}}$ (R^2_{adj}= 0.48)
Where:
TO: teat opening.
AW: attachment width.
DRT: direction of the right teat.
TUB: teat-udder back distance.
WMRT: width at the medium point of the right teat.
CS: cleft surface.
UDL: rear udder depth of left.
AW/AH: ratio attachment width to attachment height.
ART: angle of right teat.
DTG: distance teat-groin.
WMRT: width at the medium point of the right teat.
US: udder circumference.

A moderate association between the udder measurements and daily milk yield in the Ghezel breed could be established in the present study as reflected by the fact that they jointly explained as high as 0.80 of the variation of the test day milk yield.

Right udder depth and length of right and left udders were appeared to be the most useful of the udder measurements taken in daily milk yield in two weeks postpartum in Ghezel breed (Izadifard and Zamiri, 1997).

There was an appropriate udder balance and height in Ghezel sheep. This may be tended to more milk production in Ghezel than GH-MR and MG-MR crossbreds. Udder morphology characteristics were affected on milking efficiency and indirectly on milk yield. Therefore, the relevant measurement should be considered into breeding schemes for improving dairy sheep. This study reveals that such measurements can be provided by analyzing of digital images. This was another optimistic application of image processing in animal sciences.

CONCLUSION

Results of the present experiment showed that udder morphological traits are related to daily milk yield and play evident roles in dairy sheep. Picture analysis technique provides a great amount of measurements and has the advantage of a greater feasibility compared to direct measure of the udder. Once the picture taking and analysis techniques settled, this tool would benefit of a higher objectivity compared to the scoring.

ACKNOWLEDGEMENT

The authors would like to thank gratefully Khalatposhan station members for their useful suggestions and supports.

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