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 reli-
able 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 composition in 2nd, 11th and 23rd weeks. Milking time (total time of yielding statistical model was used).

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).
- \( \mu \): 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).
- \( GEN \times LS \): interaction of genotype with stage of lactation (fixed effect).
- \( GEN \times P \): 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 was used.
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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.

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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 (WMRT), 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).
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 machines 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$_{Ghezel} = -2989.92 + 10.43\text{TO} + 90.87\text{AW} + 6.89\text{DRT} + 175.89\text{TUB} (R^2_{adj}=0.80)$

Daily milk yield$_{GH-MR} = 2239.83 - 597.72\text{WMRT} + 163.27\text{CS} - 53.43\text{UDL} - 838.53\text{AW/AH} (R^2_{adj}=0.61)$

Daily milk yield$_{MG-MR} = -66.34 + 7.73\text{ART} - 66.95\text{DTG} - 411.3\text{WMRT} + 31.64\text{US} (R^2_{adj}=0.48)$

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.

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**REFERENCES**


