EFFECT OF CROSSBREEDING ON LINEAR UDDER SCORES AND THEIR PHENOTYPIC RELATIONSHIPS IN IRANIAN FAT-TAILED EWE'S

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Abstract: Now, image processing is a better technique than the subjectively assessments for linear scoring of morphologic traits, especially in fat-tailed ewe's. The objective of this study was to assess this application in animal characterization on a case study in order to comparing of, udder morphological characteristics in two Iranian crossbred sheep populations including Ghezel-Arkhamerino (GH-MR; 25 ewes), Moghani-Arkharmerino (MG-MR; 25 ewes) and a pure one that was Ghezel ewes (20 ewes). Ten udder factors and five milk traits were measured on seventy ewes during three stages of lactation. Digital pictures were analyzed by Digimizer 3.6 software. Statistical analysis of udder liner scores was performed by using the MIXED procedure of SAS 9.1 software. Results showed that long udders were more frequent in the Ghezel ewes than in crossbred's ewes. Least variation was observed for teat placement score in Ghezel purebred ewes. The means of udder depth in the Ghezel ewes were larger than in the crossbreds (P<0.01). A positive correlation between left and right teat length scores were found in the all genetic groups (r_p=0.47-0.65). Milking rate (r_p= 0.81) and milking time (r_p= 0.37) showed significant correlations with milk yield (P <0.001). The most useful udder scores for predicting daily milk yield appears to be the left teat length, teat placement and attachment width in Ghezel ewes. Phenotypic correlations variations within linear scores and their relationships with daily milk showed the potential of improvement of these traits in breeding programs of dairy sheep.

Keywords: crossbreeding, milk yield, sheep, udder conformation traits

Introduction

Milking traits *(Sanna et al., 2001; Dzidic et al., 2004; Casu et al., 2010)* and udder morphology traits *(Rovai et al., 1999; Marie-Etancelin et al., 2003; Casu et*

al., 2010) are factors determining milking ability in dairy ewes. The transformation from hand to machine milking requires that the relationships among morphological udder characteristics and milk production be investigated *(Mavrogenis et al., 1988)*. A better understanding of morphological variations and milking traits would allow identifying those traits which are most suitable for a synchronous selection program *(Dzidic et al., 2004)*. Previously, breeding selection criteria were focused on production traits, which may have negatively affected the mammary morphology traits by increasing udder depth and reducing teat verticality. Thus, there is a need to introduce improve udder traits in sheep breeding schemes. Additionally, improved adaptation of udder morphology to machine milking may positively affect udder health *(Gutiérrez-Gil et al., 2008)*. In dairy sheep, the most important functional traits are those related to udder morphology, because they determine the machine milking efficiency of the animal and have a substantial effect on its functional lifetime *(Gutiérrez -Gil et al., 2008)*. The evaluation of udder morphology traits during lactation might be useful auxiliary traits for the genetic improvement of milking ability due to close genetic correlations *(Rovai et al., 1999)*.

Knowledge of milk yield, milking time and udder conformation is necessary for optimal adaptation of the milking environment to the needs of the animal *(Dzidic et al., 2004)*. In the last decades machine milking has been introduced more widely into dairy sheep husbandry. This evokes attention of breeders and scientists for morphological and functional characteristics of udder traits in order to enable an easy and uniform milking routine *(Milerski et al., 2006)*. It is important to investigate which traits show the closest relationships to machine milking ability, such as: udder and teat measurements, milking time, milk flow rate and their relationship to milk yield *(Peris et al., 1999)*. It is necessary to identify traits that are simple to measure and correlated with milk yield to select ewes for dairying from existing populations of sheep in Australia *(Morrissey et al., 2007)*. Several authors investigated the relationship between morphological udder traits and milkability or milk performance. Deep and well-attached udders are strongly correlated with high production *(Legarra and Ugarte, 2005)*. According to *Izadifard and Zamiri (1997),* correlations between udder's measurements and milk yield can be useful in preparation of cross breeding programmes. Cistern size and udder morphology traits are correlated with milk secretion rate and milk emission kinetics during machine milking in dairy sheep *(Ayadi et al., 2011)*. Phenotypic and genetic correlations indicate that selection for milk yield will produce worse udder morphology in dairy breeds, mainly in udder height and teat placement, giving as a result baggy udders which are inadequate for machine milking *(Caja et al., 2000)*. The purposes of the present study were to determine effective factors on linear udder score and evaluate their phenotypic relationships with milk traits in the Ghezel× Arkhamerino (GH-MR) and Moghani×Arkharmerino (MG-MR) crossbreds and the Ghezel purebred ewes.

Materials and Methods

This study was carried out at the animal research station, College of Agriculture in University of Tabriz. Seventy ewes were available in the experiment, out of them 20 Ghezel purebred ewes, 25 Ghezel × Arkharmerino and 25 Moghani × Arkharmerino crossbreds. All ewes were machine milked once a day during lactation. Animals were recorded repeatedly during their first and second lactations in three lactation stages, including early (week 2), middle (week 11) and end of lactation (week 23). Measured traits were linear udder traits, milking rate and time, milk composition and daily milk yield. Linear udder scores were derived from digital photos of each ewe directly taken before the machine milking. The linear assessment scheme contained ten characteristics of udder and teats including: udder depth (1-low, 9-high; UD), left and right cistern depth below the teat level (1-none, 9-high; LCD for left and RCD for right), teat placement (1- horizontal, 9-vertical; TP), left and right teat length (1-short, 9-long; LTL for left and RTL), udder attachment (1-narrow, 9-wide; UA), udder shape (1-bad, 9-ideal; US) by following the protocol proposed by *De la Fuente et al. (1996), and Ugarte (2007),* and teat vertical position of lateral view (1-high, 9-none; LD) and teat horizontal position of lateral view (1-frontal, 9-posterior; LTP) measured based on the protocol proposed by *Hajihosseinlo et al., (2012).* Four pictures of the udder were analyzed: fore and lateral views of the whole udder and two particular views of the right and left teat. *Digimizer 3.6* software was used for extraction and calculation of udder scores from digital pictures, and also milk composition, milking rate and machine milked time (second) were recorded in the 2nd, 11th and 23rd week postpartum.

Statistical analysis of udder liner scores was performed by using the MIXED procedure of *SAS 9.1 (2003).* The CORR procedure was applied for calculation of correlations between traits. The final regression equations of daily milk yield on udder linear scores were determined using the stepwise selection. The following statistical model was used:

$y_{ijklm} = \mu + B_i + S_j + P_k + An_l + B_i \times S_j + B_i \times P_k + e_{ijklm}$

Where: y_{ijklm}= dependent variables studied; μ= mean; B_i= fixed effect of genetic group (i=1, 2, 3); S_j= fixed effect of stage of lactation (j=1, 2, 3); P_k=fixed effect of parity (k=1, 2); An_l= random effect of animal; $B_i \times S_j$= interaction of breed with stage of lactation; $B_i \times P_k$ = interaction of breed with parity.

Results and discussion

Factors affecting udder scores traits

Least squares means of linear udder scores and daily milk yield for genetic groups, parity and different stages of lactation are summarized in Table 1. Least

squares means of daily milk yield and udder depth in the Ghezel ewes were higher than in crossbreds. The least squares mean of left teat position for Ghezel× Arkharmerino crossbreds was higher than for Moghani × Arkharmerino (P<0.05). The average cross-section areas of cistern were much larger in Ghezel than in crossbreds for both variants of scores, from the side and from the bottom. On the other hand, teats were positioned more horizontally in Ghezel ewes.

Table 1.Least squares means of linear udder scores and daily milk yield (DMY) for Ghezel (GH), Ghezel × Arkharmerino (GH-MR) and Moghani × Arkharmerino (MG-MR) ewes in different stages of lactation and numbers of parity.

	Least squares means										
	DMY(gram)	UD	LTL	RTL	TP	LTP	US	RCD	LCD	UA	LD
Genetic groups											
GH	734[a]	3.09[a]	4.44	4.39	4.49[b]	3.64[ab]	3.64	2.33	2.34[ab]	4.18	3.80[a]
GH-MR	497[b]	2.55[b]	4.39	4.38	5.40[a]	3.89[a]	3.90	2.18	2.02[a]	4.05	4.31[ab]
MG-MR	569[b]	2.70[b]	4.54	4.56	4.90[ab]	3.22[b]	3.22	2.35	2.67[b]	3.98	4.43[b]
Parity											
First	650[a]	2.97[a]	4.54	4.5	4.9	3.56	3.79[a]	2.34	2.39	4.21	4.14
Second	550[b]	2.6[b]	4.38	4.38	4.97	3.59	3.33[b]	2.24	2.3	3.92	4.23
Stage of lactation											
Early	868[a]	3.15[a]	3.96[a]	3.93[a]	3.68[a]	2.53	3.04[a]	2.56[a]	2.55[a]	4.65[a]	4.74[a]
Middle	674[b]	2.74[b]	4.59[b]	4.52[b]	5.12[b]	2.52	2.29[b]	2.26[ab]	2.39[ab]	3.91[b]	4.1[b]
End	260[c]	2.71[b]	4.82[b]	4.88[c]	5.9[b]	3.69	2.14[b]	2.03[b]	2.10[b]	3.65[b]	3.70[b]

Different letters in the same column for each effect differ significant at P <0.05. Udder depth (UD), left and right teat length (LTL and RTL), teat placement (TP), teat horizontal position of lateral view (LTP), udder shape (US), left and right cistern depth (LCD and RCD), udder attachment (UA) and teat vertical position of lateral view (LD).

The distributions of the frequency of udder linear scores in genetic groups are showed in Figure 1. 75- 95% ewes had score 2 and 3 for udder shape score. Long udders (udder depth scores ≤ 4) were more frequent in the Ghezel ewes than in crossbred's ewes. The lowest variations were observed for teat position scores. These differences may be due to the genetic differences between the three populations.

Right teat length

Left teat length

Teat placement

Teat horizontal position of lateral view

Udder shape

Right cistern depth

Left cistern depth

Udder depth
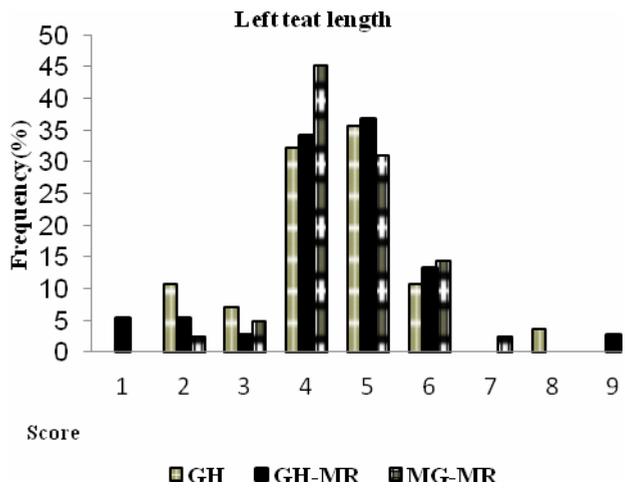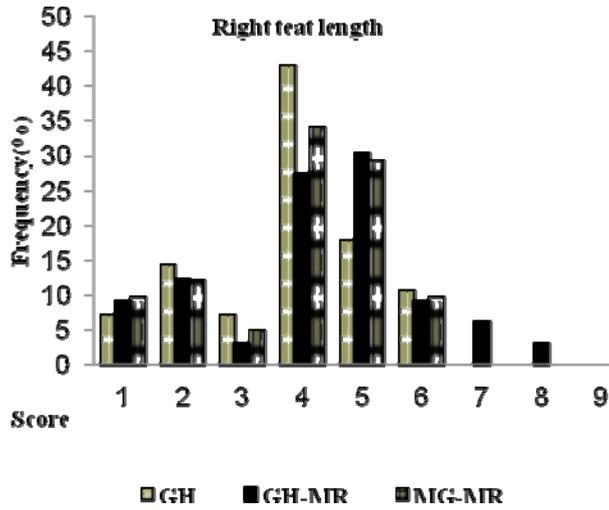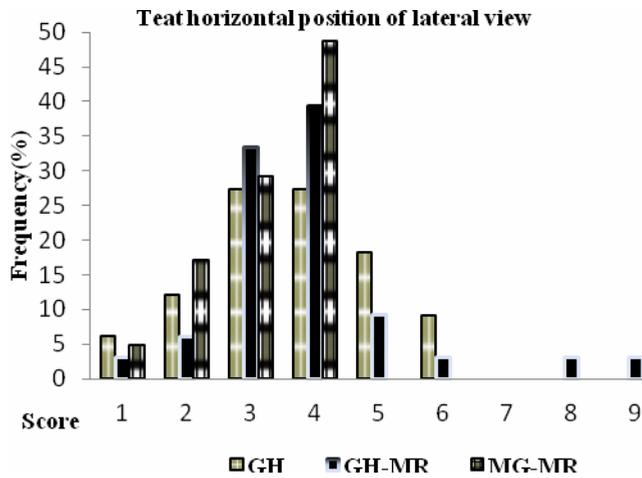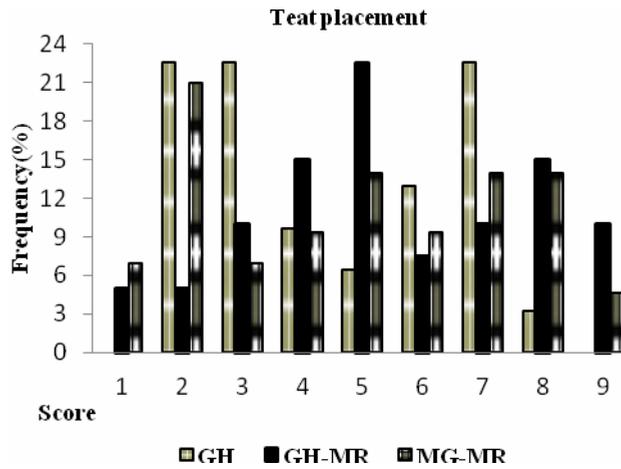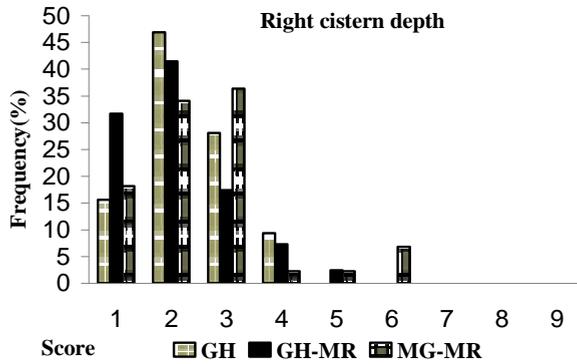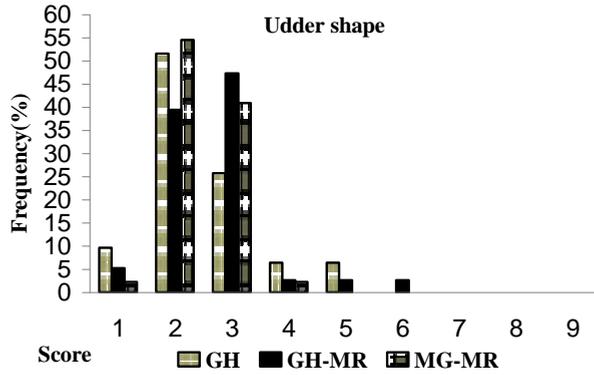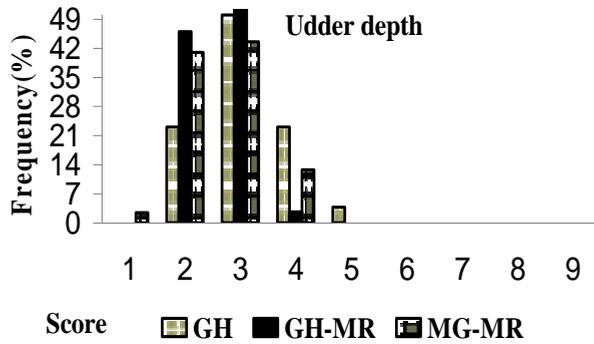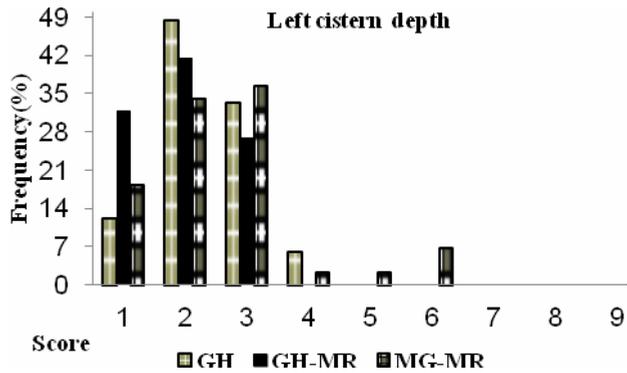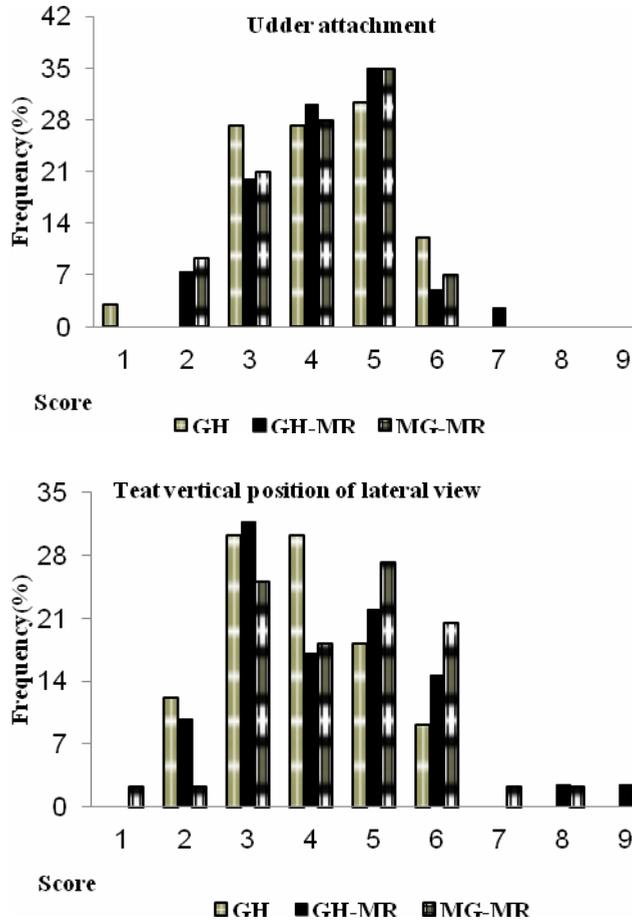
Figure 1. Frequent distribution of linear scores for Ghezel×Arkhamerino (GH-MR), Moghani× Arkharmerino (MG-MR) crossbreds and purebred Ghezel ewes (GH).

Correlation between linear udder scores and milk traits

Correlation analyses were done for the examined genetic groups separately in Tables 2, 3 and 4 for Ghezel, Ghezel × Arkharmerino and Moghani × Arkharmerino, respectively. Positive phenotypic correlation was found between daily milk yield and udder shape in Ghezel, Moghani × Arkharmerino (P<0.01) and Ghezel × Arkharmerino (P> 0.05). In all genetic groups, positive phenotypic correlations found between right and left cistern depth score and also left and right of teat length scores were detected, that suggesting that they are nearly identical traits. The high coefficient of variation for the all linearly scored traits is probably due to the high individual variability between ewes.

Table 2. Phenotypic correlation coefficients between subjectively assessed linear scores treats and daily milk yield for Ghezel ewes

Linear scores	RTL	LTL	TP	LTP	US	RCD	LCD	UA	LD	Daily milk
UD	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
RTL		0.490**	0.402*	n.s.	n.s.	n.s.	n.s.	n.s.	-0.387*	-0.544**
LTL			n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
TP				n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-0.451**
LTP					n.s.	n.s.	-0.377*	n.s.	n.s.	n.s.
US						n.s.	n.s.	0.528**	n.s.	0.450**
RCD							0.652***	n.s.	n.s.	n.s.
LCD								n.s.	n.s.	n.s.
UA									n.s.	0.471**
LD										n.s.

*P<0.05; **P<0.01; ***P<0.001; n.s.: Non Significant. Udder depth (UD), left and right teat length (LTL and RTL), teat placement (TP), teat horizontal position of lateral view (LTP), udder shape (US), left and right cistern depth (LCD and RCD), udder attachment (UA) and teat vertical position of lateral view (LD).

Table 3. Phenotypic correlation coefficients between subjectively assessed linear scores of udder traits for Ghezel × Arkharmerino ewes.

Linear scores	RTL	LTL	TP	LTP	US	RCD	LCD	UA	LD	Daily milk
UD	n.s.	n.s.	n.s.	n.s.	0.561***	0.444**	0.510**	n.s.	n.s.	0.405*
RTL		0.474**	n.s.	n.s.	n.s.	n.s.	-0.392*	n.s.	-0.370*	-0.382*
LTL			n.s.	0.484**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
TP				n.s.	n.s.	n.s.	n.s.	n.s.	-0.412**	n.s.
LTP					n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
US						0.362*	0.333*	n.s.	n.s.	n.s.
RCD							0.653***	n.s.	0.354*	n.s.
LCD								n.s.	n.s.	n.s.
UA									n.s.	n.s.
LD										n.s.

*P<0.05; **P<0.01; ***P<0.001; n.s.: Non Significant. Udder depth (UD), left and right teat length (LTL and RTL), teat placement (TP), teat horizontal position of lateral view (LTP), udder shape (US), left and right cistern depth (LCD and RCD), udder attachment (UA) and teat vertical position of lateral view (LD).

Table 4. Phenotypic correlation coefficients between subjectively assessed linear scores of udder traits for Moghani × Arkharmerino (MG-MR) ewes.

Linear scores	RTL	LTL	TP	LTP	US	RCD	LCD	UA	LD	Daily Milk
UD	n.s.	n.s.	n.s.	n.s.	n.s.	0.464**	0.382*	0.394*	0.474**	n.s.
RTL		0.653***	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
LTL			n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
TP				n.s.	n.s.	-0.471**	n.s.	n.s.	n.s.	-0.437**
LTP					0.523***	n.s.	-0.483**	n.s.	n.s.	n.s.
US						n.s.	n.s.	n.s.	n.s.	0.404**
RCD							0.762***	n.s.	n.s.	n.s.
LCD								n.s.	n.s.	n.s.
UA									n.s.	n.s.
LD										n.s.

*p<0.05; **p<0.01; ***p<0.001; n.s.: Non Significant. Udder depth (UD), left and right teat length (LTL and RTL), teat placement (TP), teat horizontal position of lateral view (LTP), udder shape (US), left and right cistern depth (LCD and RCD), udder attachment (UA) and teat vertical position of lateral view (LD).

Correlation coefficients between milk dependent characteristics mutually are summarized for all genetic groups in Table 5.Milking rate and daily milk yield were highly correlated (r = 0.81, P < 0.001). Protein percentage was silently negative correlated with daily milk yield.

Table 5. Phenotypic correlation coefficients between daily milk yield and compositions, milking rate and milking time.

	Milking rate	Milking time	Fat%	Protein %	Dry matter%
Daily milk	0.811***	0.373**	n.s.	-0.201*	n.s.
Milking rate		n.s.	n.s.	n.s.	n.s.
Milking time			n.s.	n.s.	n.s.
Fat%				n.s.	n.s.
Protein%					0.204*

*P<0.05; ***P<0.001; n.s.: Non Significant.

Correlation between milk yield and linear udder scores during of lactation

Phenotypic correlation coefficients between linear udder scores and daily milk yield during of lactation are summarized in Table 6. The approaching to end of lactation, numbers of significant phenotypic correlations between daily milk yields with linear udder scores were decreased.

Table 6. Phenotypic correlation coefficients between linear udder scores with daily milk yield various stages of lactation

	Stage of lactation		
Effect	Early	Middle	End
Udder depth	n.s.	0.374**	n.s.
Right teat length	-0.281*	n.s.	n.s.
Left teat length	n.s.	n.s.	n.s.
Teat position	n.s.	-0.310*	n.s.
Teat horizontal position of lateral view	n.s.	n.s.	n.s.
Udder shape	0.462**	n.s.	0.346**
Right cistern depth	0.306*	n.s.	n.s.
Left cistern depth	0.324*	n.s.	n.s.
Udder attachment	n.s.	n.s.	n.s.
Teat vertical position of lateral view	n.s.	n.s.	n.s.

*p<0.05; **p<0.01; n.s.: Non significant.

Regression equations were built (Stepwise method) for estimation of daily milk yield from related parameters. The following equations were obtained when all udder scores were included as independent variables:

Daily milk yield $_{Ghezel}$= 886.29-86.77$_{RTL}$-93.34$_{TP}$+ 119.59 $_{UA}$ ($R^2_{adjusted}$ = 0.68) (1)

Where: RTL is right teat length; TP is teat placement; UA is attachment width.The most useful udder scores for predicting daily milk yield appears to be the right teat length, teat placement and attachment width in Ghezel ewes.

Regression equations were not reliable for crossbreds due to low R^2_{adj}. Furthermore udder depth appears to be the most useful of the udder scores for predicting milking rate in the Ghezel purebreds ($R^2_{adj}= 0.56$; $P<0.01$). However, the utilization of these equations for practical purposes needs to be investigated further as the sample size in this study was rather small.

Discussions

Evaluation of udder morphology can be performed by subjective assessment of udder traits using linear scales *(De la Fuente et al., 1996)* or by direct measurements of the udder *(Marie-Etacelin et al., 2003)*. Direct measurements provide objective information, but they are time consuming and laborious for applying on a large scale *(De la Fuente et al., 1996)*. On the other hand, linear traits are more useful for large scale evaluations, but rely on subjective information. The stage of lactation *(De la Fuente et al., 1996; Caja et al., 2000)*, parturition number *(Serrano et al., 2002; De la Fuente et al., 1996; Gelasakis et al., 2012)* and animal *(Gelasakis et al., 2012)* had significant effects on linear udder scores.

Marie-Etacelin et al. (2003), reported that mean teat position, udder cleft, udder depth and udder attachment in the Lacaune and Sarda ewes were 7.28 and 7.79, 5.65 and 6.25, 6.42 and 6.29 and 5.19 and 4.05 scores, respectively. *Milerski et al. (2006)*, reported that line scores for Lacaune ewes were larger than for improved Walachian and Tsigai ewes for udder depth, cistern depth, udder attachment, udder shape and udder position, while for teat size and udder cleft the scores were lower. Average udder depth, udder attachment, teat placement, teat size and udder shape in Churra ewes were 5.16, 5.14, 4.48, 4.78, and 4.76, respectively *(De la Fuente et al., 1996)*. No significant difference were detected between teat position score in Churra ewes by Fernandez et al. (1995), and teat left and teat right in Chios ewes by *Gelasakis et al. (2012)*, according to our results.

According to *Fernandez et al. (1997)*, verticality teats were favourable for machine milking contrary to the results of present study (horizontal teats). The distribution of the most frequent score in the Sarda × Lacaune backcross ewes and their progeny was slightly different. In the Sarda × Lacaune crossbreeds 45% of ewes had score of 7. Short udders were more frequent in the Sarda × Lacaune ewes *(Casu et al., 2010)*, compared to our results for Ghezel × Arkharmerino crossbred. Udder depth was lowest variation in the Lori Bakhtiari ewes, where 85% of ewes had score 2 and 3 *(Sadeghi et al., 2013)*.

Linear Scores

Milerski et al. (2006), describe significant phenotypic correlations between udder depth and attachment score for Tsigai ($r_p= 0.67$) and Walachian ($r_p= 0.54$),

but no significant relationship was detected for Lacaune ewes. There was no significant phenotypic correlation between udder depth and teat position according to the results of *Fernandez et al. (1997), and McKusick et al. (2000)*. Significant phenotypic correlations were found between udder shape with teat placement, teat size, udder depth and udder attachment *(De la Fuente et al., 1996)*. Phenotypic correlations between teat placement score and teat size score for each genetic groups were positive and contrary with *Fernandez et al. (1997)*, results. The high changes of phenotypic coefficient for linear udder scores was due to the high individual variability present in the morphological traits of the population used and has been reflected in the scoring of linear udder traits.

Milking characteristics

Results of phenotypic correlations between milking traits in sheep and goat breeds found in literature are quite inconsistent (*Sung et al., 1999; Sinapis et al., 2007 and Sinapis, 2007*). Positive and significant (P<0.001) correlations were observed between all milking traits in the Istrian dairy crossbreed ewes by Dzidic et al. (2004). The authors describe a positive phenotypic correlation between milking time and rate with milk volume and a negative phenotypic correlation between milk compositions with milk volume. The high positive and significant phenotypic correlation between milking rate and daily milk yield can be explained by direct linear relationship between them.

Correlation between milk and udder linear scores during lactation

Izadifard and Zamiri (1997), the largest correlation coefficient with udder shape in an early stage of lactation (r = 0.46, *P* < 0.01). However, in the early stage of lactation, several udder measurements were correlated with the yield milk. A high phenotypic correlation was between milk yield with depth (*r* = 0.75) and circumference (*r* = 0.72) of the udder in early stage of lactation *(Izadifard and Zamiri, 1997)*. In Australian Merinos *(Bencini and Purvis, 1990)* udder volume and milk yield in the first nine weeks of lactation were significantly correlated (r = 0.71).

The relationship between the linear scores with milk production could be established jointly explained 68% of the variation of the daily milk yield(s) for Ghezel ewes. Arkharmerino breed is a wool sheep that has not been selected for dairy production traits, so it seems that, reducing of correlation in the Ghezel × Arkhamerino and Moghani × Arkharmerino crossbred ewe's in comparisioin with Ghezel was due to crossbreeding of Ghezel and Moghani with Arkharmerino. Moderate and high association between the udder measurements and milk production explained 45% and 72% of the variation of the milk yield for Frizarta *(Kominakis et al., 2009)* and Ghezel *(Izadifard and Zamiri, 1997)* dairy sheep, respectively.

Conclusion

Results of the present experiment showed that udder morphological traits are related to daily milk yield and play evident roles in dairy sheep. The subjectively appraised linear scores for cistern udder (left and right) showed high correlations (r_p = 0.65 – 0.76) in all genetic groups, therefore, this trait may be useful to simplify the design of the udder assessment scheme. It seems that the used current linear scoring system yields useful information for evaluating and improving for Ghezel × Arkhamerino, Moghani × Arkharmerino and Ghezel ewes in Iran. Nevertheless, for the final designing of linear scoring scheme in Iran try to increase the knowledge of relationships between udder trait assessments and milk yield and/or machine milk flow characteristics is needed. The knowledge of the relationships between morphological udder traits would permit to predict future correlated responses in milk-oriented selection schemes. Results of the present study showed that milk potential for Ghezel ewes can be estimated with reasonable accuracy by reducing udder characteristics.

Uticaj ukrštanja na linearne ocene vimena i njihove fenotipske odnose kod ovaca iranske masno-repe rase

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Rezime

Obrada slike je sada bolja tehnika nego subjektivna procena za linearnu ocenu morfoloških osobina, posebno kod ovaca iranske masno-repe rase. Cilj ove studije bio je da proceni ovu aplikaciju u karakterizaciji životinja na studiji slučaja, kako bi se poredile morfolške karakteristike dve iranske ukrštane populacije ovaca uključujući Ghezel - Arkhamerino (GH - MR; 25 ovaca), Moghani - Arkharmerino (MG- MR ; 25 ovaca) i ovce čiste rase - Ghezel (20 ovaca). Deset faktora vimena i pet osobina mleka su mereni na sedamdeset ovaca tokom tri faze laktacije. Digitalne fotografije su analizirane Digimizer 3.6 softverom. Statistička analiza linearnih ocena vimena je izvedena korišćenjem MIKSED postupka SAS 9.1 softvera. Rezultati su pokazali da su dugačka vimena češća u Ghezel ovaca nego u ovaca meleza. Najmanje varijacije zabeleženo je za položaj sisa kod čistokrvnih ovaca rase Ghezel. Srednje vrednosti za dubinu vimena u Ghezel ovaca bile su veće nego u meleza (P<0,01). Pozitivna korelacija izmeđulinearnih ocena dužine levih i desnih sisa utvrđeni su u svim genetskim grupama (r_p=0.47-0.65). Brzina muže (r_p= 0.81) i trajanje muže (r_p = 0.37) pokazuju značajne korelacije sa prinosom mleka (p<0,001). Najkorisniji linearni rezultati osobina vimena za predviđanje dnevnog prinosa mleka je, kako se čini, dužina levih sisa, položaj sisa

i širina vezevimena u Ghezel ovaca. Varijacije fenotipskih korelacije unutar linearnih rezultata i njihova povezanost sa dnevnim prinosom mleka pokazale su potencijal u unapređenja ovih osobina u programima oplemenjivanja muznih ovaca.

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