Iranian Journal of Applied Animal Science

Milk Traits and Their Relationship with Udder Measurements in Awassi Ewes

Research Article

K.Y. Merkhan[1*]

[1] Department of Animal Production, Faculty of Agriculture and Forestry, University of Duhok, Kurdistan Region, Iraq

Received on: 26 Jul 2013
Revised on: 20 Oct 2013
Accepted on: 30 Oct 2013
Online Published on: Sep 2014

*Correspondence E-mail: kawa.younis@uod.ac
© 2010 Copyright by Islamic Azad University, Rasht Branch, Rasht, Iran
Online version is available on: www.ijas.ir

ABSTRACT

Characteristic of the udder, milk traits and their relationship were investigated in 32 Awassi ewes raised in a commercial flock. Commencing one month after lambing milk yield was recorded at monthly intervals until the ewes were dried. Also, the udder traits were measured, including udder width, udder circumference, udder length, distance between teats and length and diameter of both teats. Results revealed that sex of lambs and stage of lactation affected (P<0.05) test day milk yield. The age of dam had no effect on test day milk yield, but affected (P<0.05) left teat diameter and right teat length. Also, sex of lambs affected (P<0.05) right teat length. As the milk yield increased there was an increase in udder circumference and teat diameter (P<0.05). Milk yield positively correlated with all udder measurements except with udder length and right teat length. Also, positive and high correlation coefficients were observed between udder circumference and udder width (r=0.679), distance between teat (r=0.699) and left teat diameter (r=0.417) as well as between udder width and distance between teats (r=0.732). A positive relationship (P<0.01) among teat measurements (r=0.596-0.908) was observed. According to the results of principal component analysis, udder circumference and right teat length were the best predictors for milk yield in Awassi ewes.

KEY WORDS Awassi ewe, milk trait, udder measurement.

INTRODUCTION

The Awassi is the main indigenous breed and comprises approximately 55-60% of the sheep population in Iraq (Alkass and Juma, 2005). In dairy animals, the udder is considered as one of the most important traits due to its physiological and functional characteristics (Mavrogenis *et al.* 1988). Therefore, the relationship of udder traits with milk yield and their usefulness for genetic improvement in sheep have been focused (Legarra and Ugarte, 2005; Iniguez *et al.* 2009; Kominakis *et al.* 2009). Some works show that milk yield in dairy sheep is positively correlated with udder and teat traits (Izadifard and Zamiri, 1997; Iniguez *et al.* 2009). However, Mavrogenis *et al.* (1989) noted a low correlation between milk production levels and udder traits. Moreover, there are many factors which may influence udder conformation and therefore, milking efficiency including genotype (Martinez *et al.* 2011), number of lactations (Gelasakis *et al.* 2012) and milk production (Fernandez *et al.* 1995). To our knowledge, the effects of some factors (*i.e.*, age of ewe, sex of lamb and level of milk yield) on udder conformation of Awassi sheep in Iraq has never been evaluated and reported.

Thus, the objectives of this study were to depict udder measurements and their relationships with milk yield of Awassi ewes and to evaluate factors which may affect them. Also, to develop a general descriptor of udder traits, using principal component analysis (PCA).

www.SID.ir

MATERIALS AND METHODS

Animals and management

The study was conducted in an Awassi commercial flock, where 32 ewes were randomly selected within a group of lambing date ranging from 10th to 16th of January, 2013. After lambing, all ewes were identified by ear tags: date of lambing and sex of lambs was recorded. Age of ewes was determined by dentition. The ewes were allowed to graze natural grass from morning to midday and then enclosed during afternoon. Thirty days after lambing, ewes started to be milked at monthly intervals and continued until the ewes were dried off according to ICAR (2007), and lambs were weaned at 3 months of age. The day before measurements, the lambs were separated from their dams at 7.00 p.m. and on the following morning (7.00 a.m.), ewes were manually milked.

Udder traits

One month after lambing, the external udder traits were measured, including udder length (UL: from the fore attachment of the udder with the abdominal wall to the udder cleft) and udder circumference (UC) using a tape. Also, the left (LTL) and right teat length (RTL), diameter of left (LTD) and right teats (RTD), udder width (UW) and distance between teats (DBT) were measured by using caliper (Figure 1).

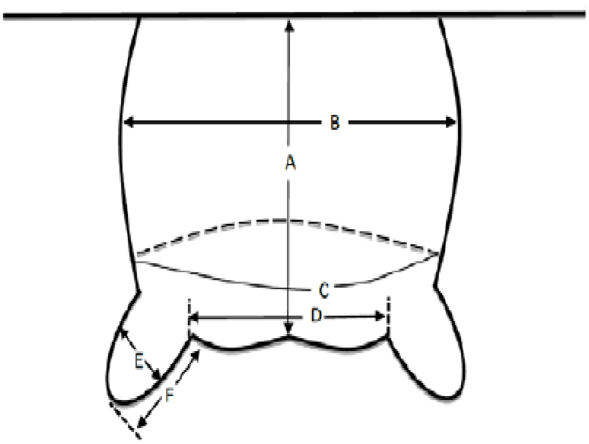

Figure 1 Morphological parameters measured on udder and teats of ewes
A: udder length; B: udder width; C: udder circumference; D: distance between teats; E: teat diameter and F: teat length

Data analysis

General linear model was used to estimate best linear unbiased estimates effects (SAS, 2002) to study the effect of dam age, sex of lambs and stage of lactation on test day milk yield (TDMY). The same model was used for analysis of pre-weaning milk yield (PREW), post-weaning milk yield (POSTW), total milk yield (TMY), peak milk yield (PMY), time to peak milk yield (TPMY) and lactation period (LP) excluding lactation stages. With udder measurements, the effect of milk yield level was added to the module.

Duncan multiple test was used to detect differences among means within each factor. Correlation coefficients among different milk traits with udder measurements were computed by Pearson's correlation method. A PCA on udder traits was performed to form new uncorrelated variables. The components were extracted by using the principal components method, and this was followed by a varimax rotation method to obtain orthogonal transformation matrix. Only principal components (PCs) with eigenvalues > 1 were considered.

Therefore, depending on the previous results of the analysis of PCs, selecting the best module by R-square value (R^2) and Akaike information criteria (AIC) was used to detect the best variables for prediction of milk traits by proc REG using SAS (2002).

RESULTS AND DISCUSSION

Descriptive statistics

Table 1 shows the means ± standard error, standard deviation and coefficient of variation of the milk and udder traits. Average TDMY, PREW, POSTW and TMY were 0.932, 102.36, 10.85 and 112.20 L, respectively throughout 124.71 d of LP.

Peak milk yield (1.467 L) was attained at day 88.06. Milk produced by Awassi ewes in the present study was higher than that recorded on the same breed in Iraq by other researchers. According to Alkass *et al.* (2009) and Al-Samarrae (2009), TMY was 85.64 kg and 51.47 kg during 132.36 and 87 days, respectively.

Milk traits

Results in the present study revealed no differences for PREW (102.94 L), POSTW (11.0 L), TMY (113.94 L), TDMY (0.957 L) and PMY (1.652 L) between 2 and 3 years old ewes (Tables 2 and 3). Similarly, Allah *et al.* (2011), Morsy (2002) and Hamdon (2005) concluded that there was no significant effect of the age of ewes on milk traits. Sex of lambs influenced TDMY (Table 2); ewes nursing female lambs had higher ($P<0.05$) TDMY than those nursing male lambs. This may be due to the superiority of teat size, particularly the RTL ($P<0.05$) of the ewes nursing female lambs (Table 4). Test day milk yield increased significantly ($P<0.01$) from 1st test (0.888 L) towards the PMY at 3rd test (1.458 L), and then declined until the ewes were dried off (Figure 2). Such increase may be attributed to the increase in number of the alveolar secretory cells per alveolus, and DNA frequency.

www.SID.ir

Table 1 (Means±SE), standard deviations (SD) and coefficient of variation (CV) for milk, udder and teat traits of Awassi ewes

Milk-related Traits	Abbreviation	Mean±SE	SD	CV %
Test day milk yield (L)	TDMY	0.932±0.053	0.592	63.56
Pre-weaning milk yield (L)	PREW	102.36±7.52	42.58	41.60
Post-weaning milk yield (L)	POSTW	10.85±0.73	3.94	36.34
Total milk yield (L)	TMY	112.20±8.05	45.55	40.59
Peak milk yield (L)	PMY	1.467±0.014	0.648	44.17
Time to peak milk yield (day)	TPMY	88.06±2.76	15.62	17.74
Lactation period (days)	LP	124.71±0.67	3.84	3.08
Udder width (cm)	UW	10.82±0.27	1.54	14.21
Udder circumference (cm)	UC	34.22±0.68	3.87	11.31
Udder length (cm)	UL	10.36±2.51	0.44	24.27
Distance between teats (cm)	DBT	11.69±0.31	1.73	14.83
Left teat diameter (cm)	LTD	1.73±0.04	0.24	13.85
Right teat diameter (cm)	RTD	1.74±0.05	0.28	16.28
Left teat length (cm)	LTL	2.77±0.08	0.47	17.01
Right teat length (cm)	RTL	2.71±0.09	0.51	18.97

TDMY: test day milk yield; PREW: pre-weaning milk yield; POSTW: post-weaning milk yield; TMY: total milk yield; PMY: peak milk yield; TPMY: time to peak milk yield; LP: lactation period; UW: udder width; UC: udder circumference; UL: udder length; DBT: distance between; LTD: left teat diameter; RTD: right teat diameter; LTL: left teat length; RTL: right teat length.
SE: standard error.

Table 2 The effect of age of ewes and sex of lambs on some milk traits (Mean±SE)

Factors	Milk-related traits				
	No.	PREW (L)	POSTW (L)	TMY (L)	TDMY (L)
Age of ewes (year)					
2	5	101.74±41.15	10.16±2.76	109.87±43.98	0.936±0.209
3	19	102.28±6.29	10.95±0.78	112.08±6.49	0.921±0.056
4 and more	8	102.94±12.52	11.0±1.76	113.94±14.12	0.958±0.110
Sex of lambs					
Male	20	93.35±7.29	10.87±0.91	103.13±7.81	0.851±0.058[b]
Female	12	117.39±15.49	10.83±1.27	127.32±16.67	1.072±0.102[a]

PREW: pre-weaning milk yield; POSTW: post-weaning milk yield; TMY: total milk yield and TDMY: test day milk yield.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SE: standard error.

Table 3 Least-square means ± standard errors of peak milk yield (PMY), time to peak milk yield (TPMY) and lactation period (LP) as affected by the age of the ewes and sex of lambs

Factors	No.	PMY (L)	TPMY (day)	LP (days)
Age of the ewes (years)				
2	5	1.428±0.581	84.60±7.46	122.80±1.56
3	19	1.399±0.92	87.52±4.24	125.73±0.79
4 and more	8	1.652±0.232	91.50±1.59	123.50±1.59
Sex of lambs				
Male	20	1.368±0.131	86.85±3.98	124.75±0.87
Female	12	1.631±0.211	90.08±3.32	124.66±1.11

The means within the same column with at least one common letter, do not have significant difference (P>0.05).

While, during the late stage of lactation, the size of alveoli was reduced and the DNA was absent in several loci in the alveolar sections, and the connective tissue was increased concomitantly with the regression of the alveoli into the smallest size and reduced frequency of secretory cells (Elsayed *et al.* 2009). Mousa (1991) and Hassan (1995) reported that after the PMY, lactation decreased less or more rapidly depending on the breed.

Udder measurements

Morphological characteristics of the udder according to the age of the ewes are shown in Table 4.

Ewes of 3 years old had greater UW, UC, UL and DBT than ewes of 2, 4 years old and older (P>0.05). Left teat diameter and RTL increased (P<0.05) with age. However, as the age of ewes increased, no effects were observed for RTD and LTL. Similarly, James *et al.* (2009), Iniguez *et al.* (2009) and Gelasakis *et al.* (2012) indicated that udder characteristics were not affected by age of ewes or number of lactations.

Udder and teat measurements tended to be greater as milk yield increased (Table 4). The differences between them were not significant except for UC, LTD and RTD (P≤0.05).

www.SID.ir

Table 4 Least-square means ± standard errors of udder and teat measurements as affected by the level of milk yield, age of ewes and sex of lambs

Factors		Udder measurements				Teat measurements			
		UW (cm)	UC (cm)	UL (cm)	DBT (cm)	LTD (cm)	RTD (cm)	LTL (mm)	RTL (cm)
Milk yield (L)	No.								
> 100	12	10.58±0.49	32.44±1.24^{b}	9.77±0.59	11.29±0.41	1.58±0.05^{b}	1.56±0.05^{b}	2.60±0.12	2.55±0.13
100-150	15	10.81±0.29	34.80±0.69^{ab}	10.25±0.69	11.72±0.48	1.80±0.05^{a}	1.82±0.06^{a}	2.88±0.12	2.75±0.12
< 150	5	11.44±1.04	36.76±2.01^{a}	12.10±1.19	12.57±0.93	1.90±0.14^{a}	1.90±0.21^{a}	2.90±0.28	3.01±0.32
Age of ewes (year)									
2	5	10.48±1.28	33.56±3.54	9.98±1.00	11.40±1.13	1.61±0.12^{b}	1.59±0.12	2.58±0.26	2.56±0.16^{b}
3	19	11.02±0.27	34.94±0.59	10.80±0.57	12.02±0.36	1.71±0.04^{ab}	1.73±0.05	2.77±0.11	2.60±0.10^{ab}
4 and more	8	10.57±0.49	32.92±1.07	9.55±0.97	11.11±0.57	1.87±0.10^{a}	1.85±0.14	2.92±0.12	3.08±0.21^{a}
Sex of lambs									
Male	20	10.82±0.32	34.23±0.81	10.49±0.60	11.72±0.39	1.70±0.04	1.70±0.04	2.68±0.07	2.58±0.09^{b}
Female	12	10.82±0.51	34.20±1.26	10.14±0.64	11.65±0.52	1.79±0.09	1.81±0.11	2.93±0.18	2.94±0.17^{a}

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
UW: udder width; UC: udder circumference; UL: udder length; DBT: distance between; LTD: left teat diameter; RTD: right teat diameter; LTL: left teat length and RTD: right teat length.

Similarly, Fernandez *et al.* (1995) reported that milk yield had the greatest influence on udder size. However, Gootwine *et al.* (1980) did not find any relationship between milk yield and udder shape for Assaf sheep. According to the sex of lamb, with the exception of the RTL, there was no significant effect on all udder measurements (Table 4).

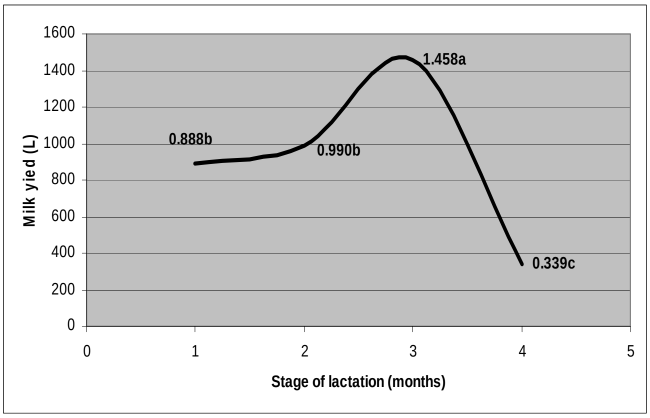

Figure 2 Test day milk yield (L) throughout different stages of lactation

Correlation coefficient among milk trait and udder characteristics

In the present study, initial milk yield (IMY), PREW and TMY were positively correlated (P<0.01) with UW, UC, DBT, LTD and RTD (Table 5).

Also, LTL was positively correlated with IMY (r=0.463; P<0.01), PREW (r=0.378; P<0.05) and TMY (r=0.395; P<0.05).

Iniguez *et al.* (2009) observed correlations of UC, UW and teat width with milk yield on day 70 and TMY. Similarly, Izadifard and Zamiri (1997) indicated that several udder measures were highly correlated with milk production, especially UC (r=0.72).

Table 5 Correlation coefficients between milk traits with udder measurement in Awassi ewes

Milk-related traits	IMY	PREW	TMY
UW	0.525**	0.484**	0.469**
UC	0.621**	0.613**	0.610**
UL	0.181	0.300	0.321
DBT	0.550**	0.464**	0.457**
LTD	0.579**	0.550**	0.553**
RTD	0.520**	0.469**	0.480**
LTL	0.463**	0.378*	0.395*
RTL	0.276	0.284	0.301

IMY: initial milk yield; PREW: pre-weaning milk yield; TMY: total milk yield; UW: udder width; UC: udder circumference; UL: udder length; DBT: distance between teats; LTD: left teat diameter; RTD: right teat diameter; LTL: left teat length and RTL: right teat length.
* (P<0.05) and ** (P<0.01).

Correlation coefficient among udder measurements

The correlation coefficients among udder characteristics are given in Table 6.

Udder width was positively correlated with UC (r=0.679; P<0.01), DBT (r=0.732; P<0.01) and LTL (r=0.347; P<0.05). Also, UC was positively correlated with DBT (r=0.699; P<0.01) and LTD (r=0.417; P<0.01). Teat measurements were positively correlated (P<0.01) among each other. Similarly, Iniguez *et al.* (2009) found a similar trend of correlation coefficient of UC with UW, UL, TW and TL. Similar relationships were observed between UW with UC and TL by Fernandez *et al.* (1995) in Churra sheep, by Kominakis *et al.* (2009) in Frizarta sheep and by Altinckic and Koyuncu (2011) in Kivircik ewes. The strong correlation coefficient of teat measures is in agreement with findings of Kominakis *et al.* (2009).

Principal component analyses

The component matrix describing correlations between the PCs and the udder traits are given in Table 7. Only the first two components had eigenvalues > 1 and were found meaningful due to the limited measurements (8 measures) and thus were retained for orthogonal rotation.

www.SID.ir

Table 6 Correlation coefficients among udder measurement[1] in Awassi ewes

	UW	UC	UL	DBT	LTD	RTD	LTL
UC	0.679**	-	-	-	-	-	-
UL	0.012	0.250	-	-	-	-	-
DBT	0.732**	0.699**	0.242	-	-	-	-
LTD	0.302	0.417**	0.120	0.269	-	-	-
RTD	0.220	0.332	0.078	0.270	0.908**	-	-
LTL	0.347*	0.193	0.062	0.111	0.685**	0.596**	-
RTL	0.129	-0.064	0.027	-0.084	0.677**	0.657**	0.792**

UW: udder width; UC: udder circumference; UL: udder length; DBT: distance between teats; LTD: left teat diameter; RTD: right teat diameter; LTL: left teat length and RTL: right teat length.
* (P<0.05) and ** (P<0.01).

The four teat measurements, (*i.e.,* LTD, RTD, LTL and RTL) were found to charge on the first component with charging factors ranging from 0.832 (LTL) to 0.880 (LTD).

Table 7 Rotated factor pattern and final communality estimates (c) from principal components analysis on udder measurements

Udder measurements	Component		Final communality estimates (c)
	1	2	
UW	0.269	**0.881**	0.808
UC	0.191	**0.789**	0.740
UL	0.047	0.149	0.112
DBT	0.110	**0.824**	0.739
LTD	**0.880**	0.308	0.904
RTD	**0.839**	0.233	0.852
LTL	**0.832**	0.265	0.738
RTL	**0.877**	0.004	0.831
Eigenvalue	3.431	1.837	-
Variance explained (% total)	3.065	2.323	-

UW: udder width; UC: udder circumference; UL: udder length; DBT: distance between teats; LTD: left teat diameter; RTD: right teat diameter; LTL: left teat length and RTL: right teat length.

This component was thus considered as the "teat dimensions" variable. The second component was composed by the "udder measurements" with the highest loading results for UW (0.881), followed by DBT (0.824) and finally UC (0.789).

In the present work, the PCA was used to originate the limit factors of PCs that keep as much of the information included in the udder traits and make additional hypothesis concerning morphological models for Awassi ewes. The two PCs represent teat dimensions and udder measurements.

The selection for a single trait is not the desirable option because selecting for a single trait could lead to deterioration of the correlated traits. So, the PCs could be used for selection purposes on genetic improvement programs (Gelasakis *et al.* 2012). It is difficult to use linear combination of directly measured udder traits on genetic improvement programs. Only one of the PCs can be used depending on the selection purposes. Therefore, the number of measurements needed could be reduced and be a feasible alternative for few selected traits (Gelasakis *et al.* 2012).

Table 8 presents the number of dependent (milk traits) and independent (udder and teat measurements) variables, R^2 and AIC.

Table 8 Prediction variables of milk traits according to the subset variable selection module

Dependent variable	Independent variable	R^2 (×100)	AIC[1]
TMY	UC, RTL	48.95	227.87
IMY	UC, LTD	51.05	365.44
TDMY	UC, RTL	48.05	361.45
PREW	UC, RTL	48.20	224.08
PMY	UC, RTL	38.82	403.59

[1] Akaike information criteria.
TMY: total milk yield; IMY: initial milk yield; TDMY: test day milk yield; PREW: pre-weaning milk yield; PMY: peak milk yield; UC: udder circumference; LTD: left teat diameter and RTL: right teat length.

Depending on the results obtained by PCA, the maximum R^2 and the smallest AIC were used to selecte the best model for predicting milk traits from udder and teat measurements. Therefore, the best set for predicting TMY, IMY, TDMY, PREW and PMY was UC as the second factor of PCs (udder measurements); first factor of PCs was the RTL, which was the best predictor for milk traits, except for IMY which was LTD. So, the module UC and RTL variables were optimal and sufficient to explain milk traits in Awassi sheep. Similarly, Kominakis *et al.* (2009) used three selection methods to predict TDMY (first and second test) by different body and udder measurements, and observed that UC was one of the predictors in all selected module in Frizarta dairy sheep.

CONCLUSION

Udder characteristics were found to be highly correlated with milk yield in Awassi sheep. The two main principal component obtained was udder measurements and teat dimension. The best predictors for milk traits were found to be: udder circumference and left teat diameter. The udder circumference can be included in genetic improvement programs for milk traits. Further studies are needed to detect body measurements, morphological and linear score of udder and their relationship with milk traits and body weights of different sheep breeds in Iraq.

www.SID.ir

ACKNOWLEDGEMENT

The author wishes to thank Prof. Dr. Jalal E. Alkass, Department of Animal Production, Faculty of Agriculture and Forestry, Duhok University for his valuable help in reading the manuscript.

REFERENCES

Alkass J.E., AL-Azzawi W.A.R. and AL-Tayy H.M. (2009). Milk production in Awassi sheep and their crosses with Assaf under accelerated lambing system. *J. Zankoy Sulaimani*. **12(1),** 7-12.

Alkass J.E. and Juma K.H. (2005). Small ruminant breeds of Iraq. Pp. 63-101 in Characterization of Small Ruminant Breeds in West Asia and North Africa. L. Iniqueze, Ed. West Asia. International Center for Agriculture Research in the Dry Areas, Alepo, Syria.

Allah M.A., Abass S.F. and Allam F.M. (2011). Factors affecting the milk yield and composition of Rahmani and Chios sheep. *Int. J. Livest. Prod*. **2(3),** 24-30.

Al-Samarrae S.H. (2009). Breed variation in milk production between Awasi and Karrdi sheep. *J. Diala*. **37,** 23-28.

Altinckic S.O. and Koyuncu M. (2011). Relationship between udder measurements and the linear scores for udder morphology traits in Kıvırcık, Tahirova and Karacabey Merino ewes. *Kafkas Univ.Vet. Fak. Derg*. **17(1),** 71-76.

Elsayed E.H., El-Shafie M.H., Saifeluasr E.O.H. and Abu El-Ella A.A. (2009). Histological and histochemical study on mammary gland of Damascus goats through stage of lactation. *Small Rumin. Res*. **85,** 11-17.

Fernandez G., Alvarez P., San Primitivo F. and de la Fuente L.F. (1995). Factors affecting variation of udder traits of dairy ewes. *J. Dairy Sci*. **78,** 842-849.

Gelasakis A.I., Arsenos G., Valergakis G.E., Oikonomou G., Kiossis E. and Fthenakis G.C. (2012). Study of factors affecting udder traits and assessment of their interrelationships with milking efficiency in Chios breed ewes. *Small Rumin. Res*. **103,** 232-239.

Gootwine E., Allef B. and Gadeesh S. (1980). Udder conformation and its heritability in the Assaf cross of dairy sheep in Israel. *Ann. Genet. Sel. Anim*. **12,** 9-15.

Hamdon H.A.M. (2005). Productive and reproductive traits of Chios and Farafra sheep under subtropical Egyptian conditions. Ph D. Thesis. Assiut Univ., Egypt.

Hassan H.A. (1995). Effects of crossing and environmental factors on production and some constituents of milk in Ossimi and Saidi sheep and their crosses with Chios. *Small Rumin. Res*. **18,** 165-172.

ICAR. (2007). International Committee for Animal Recording. Guidelines. Available at: http://www.waap.it/sheep_enquiry/documents/sheep_enquiry_example. Accessed Jun. 2008.

Iniguez L., Hilali M., Thomas D.L. and Jesry G. (2009). Udder measurements and milk production in two Awassi sheep genotypes and their crosses. *J. Dairy Sci*. **92,** 4613-4620.

Izadifard J. and Zamiri M.J. (1997). Lactation performance of two Iranian fat-tailed sheep breeds. *Small Rumin. Res.* **24,** 69-76.

James I.J., Osinowo O.A. and Adegbasa O.I. (2009). Evaluation of udder traits of west African Dwarf (WAD) goats and sheep in Ogun state, Nigeria. *J. Agric. Sci. Environ.* **9(1),** 75-87.

Kominakis A.P., Papavasiliou D. and Rogdakisa E. (2009). Relationships among udder characteristics, milk yield and, non-yield traits in Frizarta dairy sheep. *Small Rumin. Res.* **84,** 82-88.

Legarra A. and Ugarte E. (2005). Genetic parameters of udder traits, somatic cell score and milk yield in Latxa sheep. *J. Dairy Sci*. **88,** 2238-2245.

Martinez M.E., Calderon C., Barra R., Fuente L.F. and Gonzalo C. (2011). Udder morphological traits and milk yield of Chilota and Suffolk Down sheep breeds. *Chilean J. Agric. Res.* **71(1),** 90-95.

Mavrogenis A.P., Papachristoforou C. and Lysandrides P. (1988). Environmental and genetic factors affecting udder characters and milk production in Chios sheep. *Genet. Sel. Evol.* **20(4),** 477-488.

Mavrogenis A.P., Papachristoforou C., Lysandrides P. and Roushias A. (1989). Environmental and genetic effects of udder characteristics and milk production in Damascus goats. *Small Rumin. Res.* **2(4),** 333-343.

Morsy A.H.A. (2002). Evaluation of prolific and non-prolific breeds of sheep under the environmental condition of middle Egypt. Ph D. Thesis. El-Minia Univ., Egypt.

Mousa M.T. (1991). Effect of crossing Ossimi, Awassi and Chios sheep on some productive traits. Ph D. Thesis. Assiut Univ., Egypt.

SAS Institute. (2002). SAS®/STAT Software, Release 6.12. SAS Institute, Inc., Cary, NC.

Archive of SID

www.SID.ir