Estimation of Genetic Parameters and Non-Genetic Factors for Milk Yield and Litter Size at Birth of Awassi Sheep in Drylands

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SUMMARY

The present study utilized 1195 records from 702 ewes of Awassi sheep progenies of 111 sires and 451 dams bred in the drylands at Al-Fjaj station, Jordan. The aim of this study was to estimate genetic parameters as well as to investigate non-genetic factors affecting milk yield (MK) and litter size at birth (LZB) using SAS and MTDFREML programs. Average of MK and LZB were 92.84 (kg) and 1.16, respectively. MK was high significantly (P<0.01) affected by parity, age of ewe, year of lambing, and lactation period, while only the year of lambing had a significant (P<0.05) effect on LZB. The heritability and repeatability were 0.07 and 0.10 for MK, while they were 0.05 and 0.25 for LZB. Genetic and phenotypic correlations between MK and LZB were 0.17 and 0.02, respectively. The research concluded that the herd is genetically homozygous and therefore there are a need to increase genetic variance by introducing improved rams and selected females.

Keywords: *Awassisheep, genetic parameters, non-genetic factors, litter size, milk yield.*

INTRODUCTION

Awassi sheep spread in most countries in Middle East. It produces meat, milk, and wool, and widely managed under traditional conditions. Several studies indicated that milk production and litter size are affected by environmental factors, which play an essential role on sheep survival, and production **(Čapistrák et al., 2002, Oravcová et al. 2006, Jawasreh et al., 2021)**. Sheep farming contributes significantly to the economy of dry and semi-arid areas, where there is a need to focus on sustainableof productivity by improving fertility performanceto enhance sheep production (**Arun et al., 2021**). Awassi sheep are considered a vital genetic resource and efforts to improve the breed's selective performance showedpositive results, where milk production andbody weight wereassociated with a positive trend in litter size. Improved Awassi milk production estimates showed lowheritability and outstanding contribution of non-genetic influences (**Galal et al., 2008**). Awassi is well adapted to harsh environmental conditions but is not high prolific (**Alkass et al., 2021**). Selection has improved the Awassi breed of milk production in some herds but uterine capacity is a desirable trait (**Gootwine, 2011**). This present research aimed to estimate genetic parameters as well as investigates non-genetic factors affecting milk yield (MK) and litter size at birth (LZB) as they are important in the economics of sheep farming in drylands.

MATERIALS AND METHODS

Animals

This study was conducted in the Al-Fjaj sheep farm of the Ministry of Agriculture, located 210 km south of Amman city, Jordan. Sheep were managed under a semi-intensive system, where they were allowed to graze in the morning for 4 hours and at the afternoon for 3 hours. Noting that pastures have poor nutrition during dry seasons, which begin shortly after therainy season. The feeding plan during the last two months of pregnancy was as follows, ewes were fed 0.5 kg of alfalfa and 1.5 kg of concentrated feed till birth. Sheep have free access to water and salt stones. Mating season begins during July or August to get a new lamb in December or January of each year, where a ram with an apron for testing ewes estrus. About 30 ewes were allocated to each stud ram according to reproductive competence while avoiding kinship. Ninety days after lambing, ewes were inseminated either naturally or by hormonal induced estrus.Each ewe was housed separately at lambing so that they could take care of their newborn lambs for a few days, and when they were strong, they go out to graze with their dams. Lambs were allowed to breastfeed for 15 days of age and then under went the conditional breastfeeding program. They were gradually separated from their mothers tillweaning (60 days) as follows, from 16 to 30 days of age left to nurse for 1 hour twice daily in the morning and evening. Then they were allowed to breastfeed after ewes milking in the morning from one month age until weaning. After weaning, the lambs were fed concentrates and hay with 0.25-0.35 kg of feed per day to ensure goodgrowth performance.

Data from the Jordanian Awassi sheep herd were obtained during the period from 2000 to 2007, which amounted 2866 records. Each record included pedigree information (ewe ID, sire, and dam), date of birth, lamb date, parity, litter size, and milk production. 1195 records from 702 ewes were analyzed. Daily milk production was recorded by weight of milk collected daily for each ewe. Ewes were milked twice daily after colostrum days until milk production decreased to about 200 grams per day or when it was dry off.

Economic Evaluation

Revenue assessment of milk yield (MK), litter size at birth (LZB) andnumber of records (NR) was calculatedfrom parities according to two periods using the following equations:

$$Y_1 = \sum_{i=1}^{3} Xi \qquad Y_2 = \sum_{i=4}^{6} Xi$$

Where Y_1 is the first period containing the parities from 1 to 3 and $Y_2$is the second period containing the parities from 4 to 6. X_i is quantities of MK, LZB and NR in the two periods. To calculatethe loss in MK, LZB and NR between the two periods (Y3), Y_2 was subtracted from Y1. Also, the yield loss in one parity (Y4) was calculated by divided Y3/3. To obtain the loss cost for 95 records by Jordainan Dinar (Y5), Y4 was multiplied by current price per unit of production.

Statistical Analysis

The GLM procedure of SAS program **(version 9.1, 2006)** was used to determine fixed factors affecting investigated traits according to the following model:

$$Y_{ijkl} = \mu + P_i + A_j + YR_k + b(X_{ijkl} - \bar{X}) + e_{ijkl}, \quad \textbf{(model 1)}$$

Where, Y_{ijkl} is milk yield of l^{th} record of the i^{th}parity, j^{th} age and k^{th}year of lambing; μ is overall mean; P_i is effect of i^{th} parity, i=1, 2… ≥6; A_j is effect of j^{th} age of ewe, j=l, 2 …. ≥7; k^{th} is effect of lambing year, k=2000, … 2007; b=linear partial regression coefficient of lactation period on milk yield, X_{ijkl}=is lactation period/(day), $\bar{X}$ is grand mean of lactation period, and e_{ijkl} is effect of random error associated with l^{th} individual assumed normally distributed with (0, $I\sigma^2 e$).

Litter size at birth was analyzedby the same fixed effect except lactation period. The model was:

$$Y_{ijk} = \mu + P_i + A_j + YR_k + e_{ijk}, \quad \textbf{(model 2)}$$

Where, Y_{ijkl} is litter sizeof l^{th} record of i^{th} parity, j^{th} age of ewe and k^{th} year of lambing; other terms in this model are defined as in the model 1.

Heritability (h^2), genetic and phenotypic correlations and repeatability estimates of the studied variables were estimated from the animal model using Multiple trait animal model program, MTDFREML proposed by **Boldman *et al*. (1995)**. The linear animal model used for litter size at birth and milk yield was:

$$Y = X\beta + Z_a a + Z_c c + e, \quad \textbf{(model 3)}$$

Where, Y is a vector of observations; X is an incidence matrix for fixed effects; β is a vector of an overall mean and parity, age of ewe and year of lambing; Z_a is an incidence matrix for random effects; a is a vector of direct genetic effect of the animal; Z_c is the incidence matrix that associates the random permanent environmental effects to the observations; c is the vector of the permanent environmental effect of ewe, and e is a vector of random errors normally and independently distributed with zero mean and variance $I\sigma^2 e$.

RESULTS AND DISCUSSION

Table 1 shows number of pedigreesof ewes with complete production records, which averaged 1.7 per ewe, confirming the exclusion of most ewes after the second parity at an early stage of productive life in drylands.

Table 1. Pedigree analysis and description of the present data set.

Parameter	Number
Number of lactation records	1195
Number of ewes	702
Average number of lactation per ewe	1.7
Number of sires with progeny records	111
Number of dams with progeny records	451

Tables 2 and 3 show the analysis of variance for non-genetic factors affecting the studied traits as well as least square means and standard errors for these traits. Results in Table 2 indicated that the effect of parity and ewe age at lambing were found to be significant (P<0.05) on milk yield, while they had no significant effect on litter size (P>0.05). These results are in agreement with **Al-Najjar et al. (2021), Kassem et al. (2010), and Al-Samarai and Al-Anbari (2009)**. They reported that parity had a significant effect on the milk yield of Awassi sheep in Jordan, Syria, and Iraq,. While ewe agehad a significant effect on milk yield of Awassi sheep in Turkey and Iraq, according to **AL-Shaikh et al. (2019) and Ustuner and Oğan (2013)**, respectively. Also, Table 2 shows that the effect of lambing year was significant (P<0.01) on both milk yield and litter size at birth; this confirms that the environmental conditions play an important role in milk yield and litter size ofAwassi sheep in arid areas. These results are consistent with **Al-Najjar et al. (2021) and Ustuner and Oğan (2013)** who found that year of lambing had a significant effect on the milk yield of Awassi sheep in Jordan and Turkey, respectively. As well as the lambing year had affected litter size of Baluchi, Awassi, and Turkish Merino sheep in Iran, Palestine, Turkey (**Yadollahi et al., 2019; Ahmed and Abdallah, 2013 and Eküz et al., 2005**, respectively). Regarding the effect of lactation period, it had high significant effect on milk yield.

Table 3 shows that the overall mean of milk yield and litter size at birth were 92.84±1.09 kg and 1.16±0.01, respectively. These results are close to that obtained by **Ustuner and Oğan (2013)** who reported that milk yield was 96.5 kg for Awassi sheep in Turkey. The finding of litter size is in agreement with **Said et al. (1999) and Ahmed and Abdallah (2013)** who stated that litter size at birth was 1.15-1.25 and 1.08 on Awassi sheep in Palestine and Jordan. Also, Table 3 shows that the least square means (LSM) of the first three parities were less than the next parities (4, 5, 6), this indicates that ewes in advanced parities have better productivity, therefore it is necessary to take care of ewes to reach advanced parities in arid regions. Regarding the age of the ewes, the LSM of milk yield at the first four levels (1, 2, 3 and 4) was more than the following levels (5, 6 and 7), while the LSM of litter size at the first three levels (1, 2 and 3) wasless than the following levels (4, 5, 6 and 7) of the ewe's age. This indicates adecrease in milk yield while litter

Table 2. Analysis of variance for milk yield (MK), and litter size at birth (LZB) in Jordanian Awassi sheep.

Source of variance	Milk Yield (kg)			Litter Size at birth		
	DF	MS.	Prob.	DF	MS.	Prob.
Parity	5	4795.1	0.004	5	0.093	0.601
Age of ewe	6	3266.9	0.027	6	0.169	0.239
Year of lambing	7	11102.5	0.001	7	0.267	0.040
Lactation period	1	123140.4	0.001			
Residual	1175	1378.31		1176	0.1269	

Table 3. Least square means ± standard errors of litter size and milk yield inJordanian Awassi sheep.

Factors	NO.	LSM±SE	
		Milk Yield (kg)	**Litter Size at Birth**
Overall mean	**1195**	**92.84±1.09**	**1.16±0.01**
Parity			
1st	280	073.12^{b}±6.09	1.123±0.056
2nd	246	077.74^{b}±4.94	1.117±0.047
3rd	214	090.59^{C}±4.62	1.080±0.044
4th	156	112.78^{a}±5.49	1.183±0.052
5th	119	112.42^{a}±7.01	1.228±0.066
≥6th	180	114.41^{a}±8.32	1.197±0.078
Age of ewe			
1st	32	115.65^{a}±9.54	1.042^{a}±0.089
2nd	232	109.37^{a}±7.27	1.099^{a}±0.066
3rd	257	109.83^{a}±5.55	1.161^{a}±0.052
4th	206	105.82^{a}±4.79	1.263^{b}±0.046
5th	162	082.14^{b}±4.79	1.205^{a}±0.045
6th	128	079.74^{b}±6.13	1.180^{a}±0.057
≥7th	178	075.36^{b}±7.69	1.134^{b}±0.071
Year of Lambing			
1st	159	089.65^{a}±3.31	1.140^{ac}±0.032
2nd	117	083.54^{a}±3.99	1.169^{a}±0.035
3rd	187	107.24^{b}±3.07	1.204^{a}±0.029
4th	166	104.05^{b}±3.35	1.072^{bc}±0.030
5th	140	100.58^{b}±3.46	1.186^{a}±0.033
6th	141	101.43^{b}±4.07	1.132^{a}±0.032
7th	186	085.66^{a}±3.13	1.167^{a}±0.030
≥8th	99	102.60^{b}±4.04	1.170^{a}±0.038

Year of lambing ranged from 2000 to 2007. Means with different letters a, b and c are significantly different (P<0.05).

size increased after four years of ewes age. Therefore, in order for milk yield not to decline, the ewes had to reach advanced parities at the lowest possible age to be more profitable in drylands. Also, Table 3 shows that the LSM of lambing years fluctuated without a clear trend for each milk yield and litter size at birth, which confirms that they are affected by the condition of pastures, which formed an important part of the herd's feeding. Therefore, it is necessary to support feeding ewes in arid regions.

The mean lactation period and regression coefficient of studied milk yield on lactation period are presented in Table 4. Results showed that the regression coefficient of milk yield during the lactation period was 0.4 kg which was significant, indicating that each one-day increase in lactation period resulted in an increase in milk yield by 0.4 kg. The mean of lactation period in the current study was 133.16 days. **Al-Najjar (2021), Al-Shaikh et al. (2019), Ustuner and Oğan (2013) and Kassem et al. (2010)** reported that the mean of lactation periods were 89.97; 120.27; 184.3 and 157.69 days for Awassi sheep in Jordan, Iraq, Turkey and Syria, respectively.

Genetic and phenotypic parameters of milk yield and litter size of Awassi sheep are presented in Table 5. The results showed that variances for milk yield were greater than that for litter size, therefore genetic selection for milk production may be more beneficial than litter size in arid regions. Heritability was low in both milk yield and litter size (0.07 and 0.05, respectively); for milk yield, this may be due to higher environmental impacts in drylands. Therefore, it is necessary to introduce improved rams from outside the herd to increase genetic variance and thus effectiveness of genetic selection. Similarly, the low h^2 estimates for milk yield (0.097 to 0.103 and 0.91 to 0.103) were reported by **Gootwine (2001),Galal et al. (2008) and Ahmed (2010)** on Awassi sheep. However, in many reports, h^2 of milk yield was 0.22, 0.47, 0.26, and (0.21-0.30) for Awassi and Boutsico sheep as declared by **AL-Shaikh et al. (2019), Al-Samarai and Al-Anbari (2009), Jawasreh and Khasawneh (2007) and Kominakis et al. (1998),** respectively. The h^2estimate of litter size at birth (Table 5) was close to that given by **Kominakis et al. (1998), Eküz et al. (2005) and Yadollahi et al. (2019)** (0.07, 0.0533 and 0.092) on Baluchi, Turkish Merino, and Boutsicosheep, respectively. Also, Table 5 shows that the repeatability of LZB (0.25) was greater than that obtained for milk yield (0.10). These results might reflect the LZB was more affectedby environmental conditions than milk yield in arid regions. **Kominakis et al. (1998)** **and Jawasreh and khasawneh (2007)** found repeatability of 0.27 and 0.32-0.38for total milk yield in Boutsico and Jordanian Awassi sheep. The repeatability of litter size at birth in the current study was higher than the estimates obtained by **Yadollahi et al. (2019); Eküz et al. (2005); Said et al. (1999)** on Baluchi (0.179), Turkish Merino (0.078) and Awassi Sheep (0.03), respectively.

Table 4. Regression coefficient (±SE) for milk yield on lactation period of Jordainian Awassi sheep.

Variable	Milk Yield	
	Mean±SE	b±SE
Lactation period	133.16±0.99/ days	0.40**±0.04 kg/day

**= significant at P<0.01.

Table 5. Genetic and phenotypic parameters of milk yield (MK) and litter size at birth (LZB) of Jordainian Awassi sheep.

Trait	$\sigma^2 a$	$\sigma^2 per$	$\sigma^2 e$	σ^2P	Rep	h^2	G_r	P_r
MK	89.86	0.364	1288.1	1378.3	0.10	0.07	0.17	0.02
LS	0.006	0.026	0.092	0.125	0.25	0.05		

σ^2a: Additive genetic variance, σ^2per: Perminant environmental variance, σ^2e: Error variance, σ^2p: phenotypic variance, Rep: Repeatability, h^2: Heritability, G_r: Genetic correlation and P_r: phynotypic correlation.

The genetic correlation between milk yield and litter size at birth (0.17) was higher than phenotypic correlation (0.02); this confirms that genetic selection for milk yield was positively related to litter size in drylands. **Kominakis et al. (1998)** reported that the genetic and phenotypic correlation between milk yield and litter size at birth on Boutsico sheep was 0.13 and 0.19, respectively. **Prpic et al. (2016)** stated that ewes with twin and triplet lambs had significantly higher milk yields than ewes with single lamb. A strong physiological relationship between the number of fetuses, placental mass, and hormonal function is in development of mammary gland during pregnancy, In addition, a positive relationship between birth litter size and milk yield is a result of prolactin stimulation of udder (**Assan, 2020**).

Comparison of milk yield, litter size and their economic values between parities from 1 to 3 and parities from 4 to 6 according to Jordanian Awassi sheep are presented in Table 6. The average number of lactation per ewe was 1.7 as mentioned in Table 1; this may be due to the exclusion of ewes during the first three parities because some of them were not viable in the drylands. This negatively reflected economy of the herd, with an amount of 4074.55 and 2258.25 Jordanian Dinars, through the last three parities for milk yield and litter size at birth, respectively.

Table 6. Comparison of milk yield, litter size and their economic values between parities From 1 to 3 and parities from 4 to 6 according to Jordanian Awassi sheep.

Comparison	**Records Number**	**Milk yield, (kg)**	**Litter Size**
Parities (1, 2, 3), Period 1 (Y1)	740	67697.28	826
Parities (4, 5, 6), Period 2 (Y2)	455	43248.91	555
Loss between the two periods (Y3)	285	24448.37	271
Loss in a parity (Y4)	95	8149.1	90.33
Unit price, JOD		0.50	25
Loss cost for 95 records, JOD (Y5)		4074.55	2258.25

JOD is Jordanian Dinar

CONCLUSIONS

Milk yield is influenced by environmental factors more than litter size at birth. Genetic variance is low for both, therefore improved rams for litter size at birth could be introduced to increase genetic variance as well as selecting females to maximize returns. Selection applied to litter size improves milk production (positive genetic relationship) in drylands.

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تقدير المعالم الوراثية والعوامل غير الوراثية لصفتي إنتاج الحليب وحجم البطن عند الميلاد للأغنام العواسى في الأراضي الجافة

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المُلخّص العربى

استخدم فى هذه الدراسة عدد 1195 سجل للأغنام العواسى ناتجة من عدد 702 نعجة بنات 111 كبشاً و451 أم، والمرباة في محطة الفجاج الموجودة ضمن الأراضي الجافة، المملكة الأردنية الهاشمية. إستهدفت هذه الدراسة تقدير المعالم الوراثية وكذلك دراسة العوامل غير الوراثية التي تؤثر في إنتاج الحليب (MK) وحجم البطن عند الميلاد (LZB) وذلك باستخدام برامج SAS وMTDFREML. أوضحت النتائج أن متوسط إنتاج اللبن وحجم البطن عند الميلاد بلغ 92.84 /كجم و1.16، على التوالي. تأثرت صفة إنتاج اللبن معنوياً بكل من ترتيب موسم الولادة وعمر النعجة وسنة الولادة وطول موسم الحليب، بينما كان فقط لسنة الولادة تأثير معنوي على صفة حجم البطن عند الميلاد. بلغت قيم المكافئ الوراثي والمعامل التكرارى 0.07 و0.10 لصفة إنتاج اللبن، بينما بلغت هذه القيم 0.05 و0.25 لصفة حجم البطن عند الميلاد. بلغت قيم الارتباطات الوراثية والمظهرية 0.17 و0.02 بين صفة إنتاج اللبن وحجم البطن عند الميلاد، على التوالي. خلصت نتائج البحث إلى أن القطيع متماثل وراثياً وبالتالي يحتاج القطيع إلى زيادة التباين الوراثي عن طريق إدخال كباش عواسي مُحسّنة لصفة حجم البطن عند الميلاد وكذلك انتخاب الإناث من نعاج القطيع التي حققت أربعة مواسم إنتاجية متتالية على الأقل وذلك لزيادة العائد من أغنام العواسي في الأراضي الجافة.

الكلمات المفتاحية: أغنام العواسى، المعالم الوراثية، العوامل غير الوراثية، حجم المواليد، إنتاج الحليب.