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CROSSBREEDING OF IRANIAN FAT-TAILED SHEEP – IV. WOOL PRODUCTION OF KARAKUL, MEHRABAN, NAEINI AND THEIR RECIPROCAL CROSSES AT SIX AND FIFTEEN MONTHS OF AGE[1]

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Abstract – The grease wool production records (308 lambs at 6 months and 134 ewes at 15 months age) of three Iranian fat-tailed breeds of sheep (Karakul, Mehraban and Naeini) and their reciprocal crosses were analyzed.

Breed of sire had significant effect on grease fleece weight of ram lambs at 6 months of age, when weight of the lambs was not considered. The Karakul sired lambs produced significantly more grease wool than lambs sired by Mehraban, while Naeini breed was intermediate. The breed of dam had a highly significant effect on wool production and wool production per kilogram body weight of ram lambs at 6 months of age. The Karakul ewes had the best maternal influence on wool production of their male progeny at 6 months of age and Naeini ewes ranked last in this respect.

Significant heterosis effect on wool production was not observed among crossbred ram lambs. Karakul lambs were the best and Mehraban lambs were the worst wool producers among the straightbreds at 6 and 15 months of age. Two-year old ewes reared lambs which sheared significantly less wool as compared with 4 and 5-year old age groups.

INTRODUCTION

In the earlier papers of this series [5, 14] the growth performance of three Iranian fat-tailed sheep: Karakul, Mehraban and Naeini, and their reciprocal crosses were described. Although meat production of the native breeds of sheep should receive special attention in breeding plans, it is important that wool should not suffer when meat production is raised. The carpet industry has an important role in the economy of Iran. It should be considered that most of the native breeds of sheep are dual purpose and are mainly raised for meat and wool production. The objective of this study was to evaluate three of the native breeds of sheep for wool production during the first 15 months of age.

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MATERIALS AND METHODS

The grease wool production records of 308 lambs at 6 months and the subsequent wool production records of females at 15 months of age (134 samples) were used. The sheep were from three fat-tailed carpet-wool Iranian breeds of sheep: Karakul, Mehraban and Naeini and all their reciprocal crosses. Description of the breeds, pre-weaning and feedlot management of the lambs were reported earlier [4, 5, 14]. Briefly, Karakul and Naeini are range sheep whereas Mehraban is a farm sheep. All the ewes were run in a single flock in the Animal Experiment Station of Pahlavi University. The lambs were born single from December 1972 to February 1973. The lambs were creep-fed and weaned at 75±10 days of age. After weaning, the ram lambs were fed individually a fattening ration for 120 days. The crossbred ewe lambs were group fed the same ration as the ram lambs for 120 days in feedlot. Straightbred ewe lambs were grazed on available poor range and farm residuals, such as barley and wheat stubbles, during the summer. Some corn stubble and alfalfa residuals were available during the late summer and early fall. Then around the middle of the fall grazing was limited to the range. Since the available range was relatively small and poor in vegetation, grazing time was limited to approximately 8 hr per day in good weather conditions. Under this grazing system, 300 g alfalfa, 100 g barley and 250 g dried beet pulp were fed per head per day. Corn silage and wheat straw were also fed according to the grazing time and range condition. This system of feeding was continued until the ewes were out on barley pasture in the early spring. The ram lambs were slaughtered at the end of the feedlot period, but the crossbred ewe lambs were run with straightbred ewe lambs in a single flock.

The mature sheep were generally shorn once per year in late April, but the lambs were shorn twice a year, first during the summer and then in the next April for the second time. It is believed that the shorn lambs are more resistant to heat and grow faster during the hot weather.

In this experiment the ram lambs and the crossbred ewe lambs were shorn while the animals were in feedlot, when they were approx. six months old. The straightbred ewe lambs were shorn at the same age. Both the straightbred and crossbred female groups were shorn again in the next April, when they were approx. 15 months old. The animals were shorn with the commercial Iranian shearing device which resembles scissors with long blades. Although it is a common practice to wash the sheep a few days prior to shearing, these sheep were not washed. The animals were weighed within 10 days after shearing. No classical selection for production traits have been performed on mother, flock or lambs.

Data were analyzed by the least-squares method as outlined by Harvey [8]. Since the post-weaning nutritional level was not the same for all the animals, separate analyses were made for different groups. The wool production records of ram lambs were analyzed by three different models. In the first model, constants were fitted for breed of sire, breed of dam, breed of sire X breed of dam interaction, age of dam, individual ram within breed of sire and regression of the traits on age at shearing. In the second model, constants were fitted for mating system (straightbred vs crossbred lambs or heterosis), age of dam and regression of the traits on age at shearing. In the third model, constants were fitted for breed groups (3 straightbred and 6 crossbred groups), age of dam and the regression of the traits on age at shearing. Records of crossbred and straightbred females were analyzed

separately. In each group, constants were fitted for breed groups, age of dam and regression of the traits on age at shearing. The traits studied were grease wool production and grease wool per kilogram body weight at shearing.

Heterosis exhibited by different crosses was estimated as the superiority of the mean of each cross over the average of the two straightbreds making up the cross. The maternal influence for each breed was estimated as the difference between the effect of dam and effect of sire of the same breed.

RESULTS AND DISCUSSION

Ram lambs

The analysis of variance of wool production records of ram lambs are shown in Table 1 and the least-squares constants are presented in Table 2.

Breed of sire. Breed of sire had a significant effect on grease fleece weight of ram lambs ($p < 0.05$). The lambs sired by the Karakul rams produced significantly more grease wool than lambs sired by Mehraban rams, but neither differed significantly from lambs sired by the Naeini breed. Since the sire contributed only genetically to the performance of the progeny, comparison between any two breed of sire would estimate the average genetic difference (general combining ability) of the two breeds.

Breed of sire did not have a significant effect on grease fleece per kilogram body weight of lambs at shearing. The results indicated that the observed differences between sire breeds for wool production was partly due to the difference in body weight of lambs.

Breed of dam and mothering ability. Breed of dam was the most important source of variation influencing grease fleece weight and grease fleece weight per kilogram body

Table 1. Least-squares analysis of variance for wool production of ram lambs at six months of age (mean squares)

Sources of variation	*d.f.*	Grease fleece weight	Grease fleece weight/ kg body weight
Breed of sire(S)	2	228424.0*	166.6
Breed of dam(D)	2	1887168.0†	1498.1†
S X D interaction	4	60076.0	16.7
Age of dam	2	218696.0*	169.3
Individual ram within breed of ram	19	146549.0†	135.6†
Regression on age at shearing (days)	1	740816.0†	248.1
Error	134	68904.4	62.7*

*Significant at $p < 0.05$.
†Significant at $p < 0.01$.

Table 2. Least-squares constants and standard errors for wool production of ram lambs at 6 months of age

Classification	No. of lambs	Grease fleece weight (g)	Grease fleece weight, g/kg body weight at shearing
Overall mean	165	1114.7 ± 42.8	33.6 ± 1.3
Breed of sire:			
Karakul	57	77.6 ± 38.7[a]*	2.2 ± 1.1[a]
Mehraban	57	−98.1 ± 99.4[b]	−2.6 ± 1.2[a]
Naeini	51	20.5 ± 35.2[a,b]	0.4 ± 1.0[a]
Breed of dam:			
Karakul	54	295.8 ± 40.1[a]	7.4 ± 1.2[a]
Mehraban	62	−69.2 ± 36.7[b]	−4.6 ± 1.1[b]
Naeini	49	−225.6 ± 49.8[c]	−2.8 ± 1.5[b]
Age of dam:			
2 years	74	−82.3 ± 32.7[a]	−2.2 ± 0.9[a]
3 years	47	11.8 ± 38.3[a,b]	−0.4 ± 1.1[a]
4–5 years	44	70.5 ± 47.4[b]	2.6 ± 1.4[a]
Mating system:†			
Straightbreds	90	−25.2 ± 22.9[a]	−0.5 ± 0.7[a]
Crossbreds	75	25.2 ± 22.9[a]	0.5 ± 0.7[a]
Regression on age at shearing		11.8‡	0.2‡

*All means within a particular subclass differ significantly ($p < 0.05$) except those followed by the same letter.

†Two different analyses were performed, one of the model has sire breed, dam breed and the interaction term, and the other has mating system. Other factors were similarly used in both analyses.

‡Significant at $p < 0.01$.

weight at shearing ($p < 0.01$). The Karakul ewes produced lambs with the highest amount of grease fleece weight, followed by the Mehraban and Naeini dams. The Karakul ewes produced lambs which sheared significantly higher amounts of grease wool per kilogram body weight as compared with the lambs born from Mehraban and Naeini ewes. No significant differences were observed between the lambs born from Naeini and Mehraban ewes for this trait. This was expected, because the Naeini lambs were significantly lighter than the Mehraban lambs [14].

The mothering ability estimates of the breeds are presented in Table 3. The Naeini ewes consistently had the poorest and the Karakul ewes had the best mothering ability among the three breeds. Since breed of sire was not a significant source of variation in grease fleece weight per kilogram body weight at shearing, it might be concluded that the maternal environment was the main factor affecting this trait.

Breed of sire X breed of dam interaction. This factor was not a significant source of variation for the traits studied and accounted for less than one per cent of the total

Table 3. Estimated mothering effect of the breeds for wool production

Breed	Grease fleece weight (g)	Grease fleece weight, g/kg body weight
Karakul	218.2	5.2
Mehraban	28.9	–2.0
Naeini	–246.1	–3.2

variation. The results confirmed that non-additive genes did not have an important influence on wool production of the lambs.

Heterosis. The differences between straightbred and crossbred lambs were negligible (Table 2). As pointed out earlier, the non-additive effect of genes was not considerable and therefore heterosis effect was not expected. The estimated actual amount of heterosis and per cent heterosis for the traits studied are shown in Table 4. Three out of six crosses showed some degrees of positive heterosis for each of the traits. All the crosses sired by the Naeini rams showed the highest amount of positive heterosis for grease fleece weight, whereas all the crosses produced by the Karakul ewes showed the highest amount of positive heterosis for grease fleece weight per kilogram body weight at shearing. Mating the Karakul rams with the other two breeds resulted in negative heterosis for all the traits. Crossing the Naeini rams with the Karakul ewes resulted in the highest amount of positive heterosis for grease fleece weight, whereas crossing the Mehraban rams with the Karakul ewes led to the highest amount of positive heterosis for grease fleece weight per kilogram body weight at shearing. In contrast, their reciprocals with the same genotype, Karakul X Naeini and Karakul X Mehraban, showed the highest negative heterosis for grease fleece weight and grease fleece weight per kilogram body weight, respectively. Although the degree of heterosis depends partly on the extent of gene frequency

Table 4. Heterosis effect, actual differences and per cent differences between crossbreds and average of constituent straightbreds for traits studied

Breed crosses*		Grease fleece weight		Grease fleece weight, g/kg body weight	
Sire	Dam	g	%	g	%
K	M	–14.6	–1.2	–1.9	–5.5
K	N	–158.8	–13.4	–1.4	–3.8
M	K	69.5	5.8	3.9	11.3
M	N	–61.1	–6.8	0.8	2.8
N	K	285.3	24.1	3.8	10.2
N	M	98.8	11.0	–1.2	–4.4
Average		36.5	3.2	0.7	1.8

*K = Karakul, M = Mehraban, N = Naeini.

differences between the two breeds and the degree of dominance [20], nevertheless it seems that maternal environment plays an important role in providing the proper opportunity for the genetic expression of lambs and contributes greatly to the phenotypic variation. The same conclusion was reached by Farid *et al.* [6] for growth performance of the lambs with the above genotypes. Hohenboken *et al.* [10] also reported significant differences for body weight and some carcass measurements between reciprocal crosses for per cent heterosis and concluded that it always favored the reciprocal whose female parent had the higher maternal effect.

Age of dam. Age of dam had a significant effect ($p < 0.05$) on grease fleece weight but grease fleece weight per kilogram body weight was not influenced by this factor (Table 1). The lambs which were reared by two-year old ewes had a significantly lower amount of wool (152.8 g) as compared with those reared by the four and five-year old age group (Table 2). Reports on the effect of age of dam on wool production of progeny at 6 months of age are rare. Young *et al.* [21] reported the wool production of Australian Merino lambs at 6 months of age and found that age of dam significantly influenced grease wool production at this age. They reported that the lambs born to 2-year old ewes were 91 g lighter in grease fleece weight than the offsprings of older ewes. This difference is somewhat lower than the estimate reached in this study.

Breed groups. There were highly significant differences ($p < 0.01$) between breed groups of ram lambs for 6 months wool growth and wool production per kilogram body weight at shearing. Comparison between the three straightbreds indicated that the Karakul lambs produced significantly greater amounts of grease wool than the Naeini and Mehraban lambs which were similar (Table 5). The differences between the three breeds for wool production per kilogram body weight were significantly in favor of the Karakul followed by the Naeini and Mehraban lambs. This was expected since Mehraban was a heavier breed than Naeini [14] and consequently had more wool bearing surface area. It

Table 5. Least-squares means and standard errors for wool production of straightbred and crossbred ram lambs at 6 months of age

Breed groups† Sire X Dam	No. of lambs	Grease fleece weight, g	Grease fleece weight, g/kg body weight
K X K	32	$1486.8 \pm 65.4^{a*}$	43.8 ± 2.0^{a}
M X M	32	915.6 ± 63.6^{d}	25.0 ± 1.9^{d}
N X N	26	876.4 ± 73.9^{d}	$31.5 \pm 2.2^{c,b}$
K X M	18	$1186.6 \pm 78.6^{b,c}$	$32.5 \pm 2.4^{b,c}$
K X N	7	$1022.8 \pm 120.3^{b,c,d}$	$36.2 \pm 3.6^{a,b,c}$
M X K	9	$1270.7 \pm 103.3^{a,b}$	$38.3 \pm 3.1^{a,b}$
M X N	16	834.9 ± 82.3^{d}	$29.1 \pm 2.5^{c,d}$
N X K	13	1466.9 ± 89.0^{a}	41.5 ± 2.7^{a}
N X M	12	$994.8 \pm 87.9^{c,d}$	$27.0 \pm 2.6^{c,d}$

*All means differ significantly ($p < 0.05$) except those followed by the same letter.

†K = Karakul, M = Mehraban, N = Naeini.

might be concluded that the Karakul breed produced the highest amount of grease fleece per unit of skin surface area followed by the Naeini and Mehraban breeds. Makarechian *et al.* [13] reported the same pattern for wool production of ewes of these breeds.

Comparisons of different straightbreds and crossbreds with the same breed of dam indicated that except for the Karakul X Mehraban group which was significantly superior over the straightbred Mehraban for both grease fleece weight and grease fleece per kilogram body weight, the other breed groups did not show significant differences for either of the two traits. This was due to the fact that the maternal effect would primarily determine the wool production ability of the breeds. Since the Karakul lambs had the highest genetic potential for wool production and the Mehraban ewes had the least maternal effect on this trait, the Karakul X Mehraban group exceeded the straightbred Mehraban in wool production.

Ewe lambs

Straightbreds. There were highly-significant differences ($p < 0.01$) between the straightbreds for wool production traits from birth to 6 months, 6–15 months and from birth to 15 months (Table 6). The straightbred Karakul produced significantly the highest amount of grease wool in all the three periods, as compared with the Mehraban and Naeini lambs which were similar. This is in agreement with the previous results obtained for the ram lambs. When adjustments were made for body weight at shearing, no significant difference was observed between the Karakul and Naeini lambs for wool production at 6 months of age, but both were significantly superior to the Mehraban lambs. There were significant differences between the three breeds for grease fleece weight per kilogram body weight from 6–15 months and from birth to 15 months of age, in favor of the Karakul followed by the Naeini and Mehraban breeds.

Crossbred groups. The average grease fleece weight and grease fleece weight per kilogram body weight from birth to 6 months, 6–15 months and from birth to 15 months of age of the crossbred female groups, are shown in Table 7. There was not any significant difference between the different groups for the traits studied, except for grease fleece weight from birth to 15 months of age. The lambs born from the Mehraban ewes (Karakul X Mehraban and Naeini X Mehraban) produced significantly lower amounts of grease wool in this period than the other breed groups.

The overall means of the wool production of the crossbreds at different stages were higher than the corresponding fleece weights of the straightbreds, which could be as a result of the different post weaning nutritional levels of the two groups rather than the presence of heterosis effect. This conclusion is based on the non-significant heterosis which was observed for wool production of ram lambs. The positive effect of crossbreeding and heterosis on wool production of yearlings is evident. Sidwell *et al.* [15] reported that the two-breed crosses and three-breed crosses produced significantly more grease fleece than the purebreds (3.91, 3.72 and 3.4 kg, respectively). Their report indicated that most of the crossbred groups showed some degree of positive heterosis, among them the Hampshire X Columbia-South dale exceeded the other by 0.9 kg (26.8%) superiority over the average of two parental breeds. Fahmy *et al.* [2] reported that Merino X Barki breed group showed 21% heterosis and Fahmy and Bernard [3] reported that Oxford X Suffolk

Table 6. Least-squares means and standard errors for wool production of straightbred ewe lambs from birth to 6 months, 6–15 months and birth to 15 months of age

Classification	No. of observations	Grease fleece weight (g)			Grease fleece weight, g/kg body weight at shearing		
		Birth to 6 months†	6–15 months‡,§	Birth to 15 months‡	Birth to 6 months†	6–15 months‡,§	Birth to 15 months‡
Overall mean	74	754.7 ± 30.1	835.4 ± 28.5	1592.8 ± 53.4	30.4 ± 1.1	23.9 ± .8	45.7 ± 1.5
Breed:							
Karakul	18	945.3 ± 65.7[a]*	1051.5 ± 62.1[a]	2004.6 ± 116.5[a]	38.4 ± 2.3[a]	31.6 ± 1.7[a]	60.4 ± 3.2[a]
Mehraban	32	603.4 ± 44.9[b]	712.1 ± 42.9[b]	1323.6 ± 80.6[b]	19.3 ± 1.6[b]	16.3 ± 1.2[b]	30.2 ± 2.2[b]
Naeini	24	715.2 ± 51.1[b]	742.7 ± 49.6[b]	1450.1 ± 93.1[b]	33.4 ± 1.8[a]	23.9 ± 1.4[c]	46.3 ± 2.6[c]
Age of dam:							
2 years	28	704.8 ± 48.3[a]	773.8 ± 45.2[a]	1478.4 ± 84.8[a]	29.6 ± 1.7[a]	22.1 ± 1.3[a]	42.6 ± 2.4[a]
3 years	26	816.3 ± 50.6[a]	844.3 ± 49.2[a]	1654.1 ± 92.2[a]	31.4 ± 1.8[a]	23.9 ± 1.4[a]	46.8 ± 2.5[a]
4–5 years	20	742.3 ± 61.5[a]	888.2 ± 59.5[a]	1645.8 ± 111.7[a]	30.0 ± 2.2[a]	25.5 ± 1.7[a]	47.6 ± 3.1[a]
Regression of trait on wool growth period		0.85	4.02	–	0.04	−0.58	–

*All means within a particular subclass differ significantly ($p < 0.05$) except those followed by the same letter.

†Average wool growth period was 196 days.

‡Number of observations 72.

§Average wool growth period was 277 days.

Table 7. Least-squares means and standard errors for wool production of crossbred ewe lambs from birth to 6 months, 6–15 months and birth to 15 months of age

Classification	No. of observations	Grease fleece weight (g)			Grease fleece weight, g/kg body weight at shearing		
		Birth to 6 months†	6–15 months‡,§	Birth to 15 months‡	Birth to 6 months†	6–15 months‡,§	Birth to 15 months‡
Overall mean	69	932.0 ± 29.3	903.7 ± 36.9	1832.8 ± 59.8	32.4 ± 1.1	25.1 ± 1.1	50.7 ± 1.9
Breed group (Sire X Dam):							
Karakul X Mehraban	10	820.5 ± 73.8[a]*	801.7 ± 86.1	1621.3 ± 139.5[a]	29.5 ± 2.6[a]	23.1 ± 2.7[a]	46.4 ± 4.4[a]
Karakul X Naeini	15	952.4 ± 62.5[a]	886.6 ± 76.1[a]	1836.6 ± 123.3[b]	35.3 ± 2.3[a]	25.7 ± 2.4[a]	53.2 ± 3.9[a]
Mehraban X Karakul	14	1116.6 ± 67.8[a]	1112.0 ± 89.4[a]	2231.0 ± 144.9[b]	35.4 ± 2.4[a]	27.6 ± 2.8[a]	55.3 ± 4.5[a]
Mehraban X Naeini	6	871.4 ± 97.9[a]	884.7 ± 123.3[a]	1746.6 ± 199.8[b]	31.7 ± 3.5[a]	24.8 ± 3.8[a]	49.2 ± 6.3[a]
Naeini X Karakul	9	959.6 ± 78.8[a]	960.6 ± 95.7[a]	1911.6 ± 155.1[b]	34.5 ± 2.8[a]	28.0 ± 3.0[a]	55.3 ± 4.9[a]
Naeini X Mehraban	15	871.4 ± 61.1[a]	776.7 ± 71.7[a]	1648.0 ± 115.2[a]	27.8 ± 2.2[a]	21.2 ± 2.2[a]	45.0 ± 3.6[a]
Age of dam:							
2 years	29	888.3 ± 44.3[a]	890.6 ± 52.5[a]	1778.1 ± 85.0[a]	30.5 ± 1.6[a]	24.4 ± 1.6[a]	48.6 ± 2.6[a]
3 years	19	983.5 ± 59.6[a]	882.6 ± 74.2[a]	1862.1 ± 120.2[a]	34.0 ± 2.2[a]	23.4 ± 2.3[a]	49.5 ± 3.7[a]
4–5 years	21	924.1 ± 58.3[a]	937.9 ± 71.5[a]	1858.3 ± 115.9[a]	32.6 ± 2.1[a]	27.4 ± 2.2[a]	54.0 ± 3.6[a]
Regression of trait on wool growth period		2.24	5.66	–	–0.16	0.12	–

*All means within a particular subclass differ significantly ($p < 0.05$) except those followed by the same letter.

†Average wool growth period was 194 days.

‡No. of observations 62.

§Average wool growth period 278 days.

cross and its reciprocal showed 17% heterosis for wool production. Galal *et al.* [7] reported 19.4% heterosis in progeny of crossing the Egyptian Ossimi X Barki breeds.

The average grease fleece weight from birth to 15 months of age was higher than the average semi-washed fleece weight of the yearling and mature ewes of the same breeds as reported by Makarechian *et al.* [13]. The observed difference might be due to the better nutritional level of the former group.

Age of dam. Age of dam did not have a significant effect on wool production of her female offspring at different stages, although the lambs reared by the mature dams tended to produce more fleece. The relatively few number of observations may prevent detecting small differences. Most of the reports on the effect of age of dam on wool production of progeny measured between one to one and half years of age, indicated that the lambs born from 2-year old ewes cut less grease fleece than the progeny of adult ewes, but the differences were not significant in some cases. Kassab and Karam [11] in Barki sheep. Terrill *et al.* [17] in Rombouillet, Vesely *et al.* [18] in Rambouillet, Romnelet and Canadian Corriedale, and Sidwell *et al.* [15] in 14 different purebred, two-breed and three-breed crosses did not find any significant difference. Terrill *et al.* [16] in Columbia and Targhee, Lambe *et al.* [12] in Suffolk, Hampshire and Southdown, Hazel and Terrill [9] in Rambouillet, Vesely *et al.* [19] in Rambouillet, Romnelet, Columbia, Targhee and Suffolk, and Fahmy *et al.* [2] in Merino, Awassi, Barki and their crosses found significant difference for this factor. Brown *et al.* [1] reported that the progeny of 2-year old ewes cut 6.4% less fleece than the progeny of adults and concluded that the main source of difference was a lower total fiber number of the younger group.

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