Non-genetic factors affecting pelt traits in Karakul sheep

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Pelts of 2 465 lambs from a randomly bred Karakul flock were subjectively evaluated within 24 h after birth, over a two-year period. The data were analysed with year of birth, birth status, month born, age of the dam and sex of the lamb defined as fixed effects and birth mass as a covariant. Year of birth affected pelt traits significantly. Being born as a single or a twin had no significant effect on pelt traits. Month born had no significant effect on hair quality, hair length, skin thickness, occurrence of feathers and bandedness, and corkscrew, peppercorn, moiré and firtree pattern types. A significant linear effect was found for pattern ($P < 0,01$) and lyre pattern ($P < 0,05$), while significant quadratic effects were found for curl type ($P < 0,001$), hair thickness ($P < 0,05$), curl breadth ($P < 0,05$) and hair stiffness ($P < 0,05$), whereas lustre ($P < 0,05$) and metallic ($P < 0,05$) showed a significant cubic relationship with month born. Hair length and skin thickness increased linearly ($P < 0,01$) as age of the dam increased. Ram lambs had slightly better patterns, less bandedness, and shorter and thinner hair than ewe lambs.

Pelse van 2 465 lammers van 'n Karakoelkontrole-kudde is binne 24 h na lamming, subjektief oor 'n twee-jaarperiode geëvalueer. Die data is ontleed met jaar van geboorte, tipe geboorte, maand gebore, ouderdom van die moeder en geslag gedefinieer as vaste-effekte en geboortemassa as kovariant. Jaar van geboorte het pelseienskappe betekenisvol beïnvloed. Tipe geboorte het geen betekenisvolle invloed op pelseienskappe gehad nie. Maand gebore het geen betekenisvolle effek op haarkwaliteit, haarlengte, veldikte, voorkoms van vere en bande, kurktrekker-, peperkorrel-, moiré- en denneboompatroon gehad nie. 'n Betekenisvolle lineêre effek is gevind vir patroon ($P < 0,01$) en lierpatroon ($P < 0,05$), terwyl betekenisvolle kwadratiese effekte gevind is vir krultipe ($P < 0,001$), haardikte ($P < 0,05$), krulgrootte ($P < 0,05$) en haarstyfte ($P < 0,05$), teenoor maand gebore. Glans ($P < 0,05$) en metaalagtigheid ($P < 0,05$) het 'n betekenisvolle kubiese verwantskap met maand gebore gehad. Haarlengte en veldikte het lineêr toegeneem ($P < 0,01$) met toename in ouderdom van die ooi. Ramlammers het 'n effens beter patroon, minder bande, en korter en dunner hare as ooilammers gehad.

Keywords: Sheep, Karakul, pelt traits, non-genetic effects.

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Introduction

The Karakul pelt industry is an important branch of the South African animal industry, as the Karakul is at present one of the few sheep breeds which can be successfully farmed in the north-western Cape Province of South Africa and in the south of Namibia. It is primarily a pelt producer, with mutton as a secondary product. The pelt, however, is not an important daily commodity, but a fashion article dependent on the vagaries of the fashion market. This market requires an attractive product of exceptional quality which, to a large extent, is determined by quality of hair and the excellence of pattern.

Pattern and hair quality are both complex traits under poligenic control (Nel, 1966). To increase accuracy of selection, it is important that any non-genetic factors be identified and corrected before genetic parameters for pelt traits are calculated (Turner & Young, 1969). Estimates for all environmental factors have not been determined for pelt traits in Karakul sheep. Nel (1966) published estimates of the effect of year of birth, age of the dam and sex of the lamb on certain pelt traits, while Van Niekerk (1972) only took the effect of age of the dam and sex of the lambs into account in his study. However, both authors worked with populations that were subjected to selection. No report on the effect of type of birth on pelt traits and the effect of non-genetic factors on brittle hair, metallic, occurrence of feathers and bandedness, corkscrew, peppercorn, lyre, moiré and firtree pattern types could be found in the available literature. Russian and German literature was consulted but, because their methods of describing pelt traits differ from the method used in this study, only comparable references were cited. The purpose of this study therefore was to determine the effect of non-genetic environmental factors on all pelt traits in a random breeding control flock.

Materials and Methods

Animals

The experimental flock had its origin in 1963 when breeding material was purchased from private breeders. Since 1970 it was used as a control flock in a selection experiment for pelt traits. The size of the control flock was kept at about 200 ewes. It was proposed that about 40 rams (20%) be used per annum. The aim was to keep every second ewe and every fourth ram lamb born of each ewe for replacement purposes. However, owing to sickness, deaths and management procedures, it was not possible to keep strictly to the said procedure and a more random replacement policy with the available animals was followed.

Three mating seasons were applied, viz. during January, August and May and, depending on the time of the year, mating took place over a period of 51 or 34 days. Individual mating was applied and 2 465 lambs were born during the 12-year period. During lambing, all pregnant ewes were kept on kraal to ensure the positive identification of lambs born and to ensure that all relevant data were collected within 24 h after birth.

Description of pelt traits

Hair quality and pattern are economically the most important pelt traits. According to Nel (1966), pattern can be defined as the design, extension and delineation of the curls.

Lambs were evaluated subjectively for pelt traits according to the method described by Nel (1966), as no method currently exists to evaluate pelt traits objectively. Pelt traits received a subjective score from 1 to 10. A score of 10 denotes an excellent pelt while a score of one denotes an inferior pelt in terms of pattern and hair quality. The score for hair quality was a combined estimate for lustre and hair stiffness (texture) on the body, chest, tail and hind legs. A combined score for hair quality on the extremities was given, while hair stiffness or texture of the hair was evaluated separately.

In the determination of the excellence of pattern, particular attention was paid to the type of pattern and the appearance, evenness and dispersion of S-hairs.

Curl type varied from smooth to developed curl according to the degree of development of the curls, and values scored were as follows (Nel, 1966):

Watersilk (plain/smooth)	1
Watersilk	2
Shallow watersilk	3
Shallow curl	4
Shallow developed	5
Developed shallow	6
Developed shallow (pipe)	7
Pipe curl	8
Pipe (peppercorn/corkscrew)	9
Peppercorn/corkscrew	10

Hair length was estimated by pulling a couple of hairs from the skin at the midrib area. Pelts with very short hair received a score of 1 and pelts with very long hair a score of 10.

Skin thickness was estimated by rolling the skin at the last rib on the side between the thumb and forefinger. A score of 1 indicates a very thin skin whereas a score of 10 indicates a very thick skin.

The term curl breadth includes curl size. Curl breadth is only used with the shallow curl types whereas curl size is used for the developed curl types. Curl breadth can be defined as the space or area occupied by the S-hairs, while curl size is determined by the height of the curl. Values found varied from 1 (very narrow or light) to 10 (very broad or heavy).

Hair thickness was estimated from a few hairs pulled from the midrib area. Values scored varied from 1 (very fine) to 10 (very thick).

Scores for brittle hair, lustre, metallic, feathers, bandedness, and lyre, moiré, firtree, corkscrew and peppercorn pattern types were given according to occurrence, from 1 for none up to 10 for extremely many.

Statistical analysis

Since most statistical procedures of analysis of variance are based on the assumption that the traits analysed are normally distributed, tests for normality were performed for all characters with Statgraphics (1986), a statistical computer program package.

The data were analysed with the LSML76 computer program of Harvey (1977). The following model was used:

$$Y_{ijklm} = \mu + a_i + c_j + d_k + f_l + g_m + b\,X_{ijklm} + e_{ijklm}$$

where

Y_{ijklm} = the observed value of a given dependent variable,
μ = the overall mean,
a_i = the fixed effect of the i-th year of birth,
c_j = the fixed effect of the j-th age of ewe,
d_k = the fixed effect of the k-th sex of the lamb,
f_l = the fixed effect of the l-th month of birth,
g_m = the fixed effect of the m-th type of birth,
b = continuous variable for birth mass,
X_{ijklm} = birth mass, and
e_{ijklm} = the random error.

All possible interactions were included in the initial model. As birth mass influences pelts traits significantly (Nel, 1966), birth mass was included as a covariant in the model. Individual regressions for ewe age and month born were also fitted for the different pelt traits to investigate age and seasonal trends.

Results and Discussions

The relative frequency distribution, averages, standard deviation and coefficient of variation of the different pelt traits are presented in Table 1, while the coefficients of kurtosis and skewness and values of the standardized kurtosis and skewness are shown in Table 2. When values for the standardized coefficients are outside the range –2,0 to +2,0, the data may depart significantly from a normal distribution (Statgraphics, 1986).

Table 2 shows that only lustre had a normal distribution. Hair quality deviated slightly from normality, while the rest of the pelt traits depart significantly from a normal distribution. This was brought about by the fact that, in the majority of cases, some form of skewness was found and that some pelt traits had a flatter top than expected. Scores for brittle hair and for the different pattern types, i.e. corkscrew, peppercorn, lyre, moiré and firtree, concentrated near 1. According to Nel (1966), this may be due to the possible effect of directional selection. Harvey (1982) suggested that least squares analysis of discrete values is valid if the values scored are an indication of quantitative differences between classes.

The averages in Table 1 differ from those reported by Nel (1966) and Van Niekerk (1972), but agree well with those reported by Botma (1981). The average birth mass of lambs in this study was 4,59 ± 0,71, which agrees well with that reported by Nel (1966). Nel (1966), however, reported a lower average score for curl type, and higher average scores for pattern and hair quality, which were evaluated according to the same method as used in this study. Van Niekerk (1972) likewise reported lower scores than those found in this study for skin thickness, curl type, curl breadth, hair length and metallic in the Niemöller stud, whereas hair quality, pattern and lustre received higher scores than recorded here. These differences may have been caused by Van Niekerk's method of scoring, as his method differed slightly from the method used in this study. Where characters were scored from 1 to 10 in this study, he scored his lambs from 1 to 9 for skin thickness, curl type, curl breadth, hair length, pattern and hair quality, while the occurrence of metallic received a score from 1 to 5. Except for

Table 1 Frequency distribution of pelt traits

Pelt traits	Score 1	2	3	4	5	6	7	8	9	10	X̄ ± SD	CV (%)
Hair quality	0,2	2,4	16,9	33,8	28,3	15,2	2,9	0,2	–	–	4,46 ± 1,030	23,09
Hair quality at the extremities	0,2	2,4	16,2	36,9	35,8	8,0	0,5	–	–	–	4,32 ± 0,879	20,35
Hair stiffness	0,4	0,7	4,8	57,7	24,4	89,0	2,5	0,5	0,1	–	5,46 ± 0,884	16,19
Brittle hair	75,5	3,5	7,0	4,5	1,9	3,6	1,9	1,8	0,3	–	1,86 ± 1,732	93,12
Hair thickness	0,2	0,1	1,9	7,3	30,1	42,3	16,8	1,2	0,1	–	5,68 ± 0,899	15,83
Lustre	0,2	1,4	12,5	30,1	33,5	18,0	4,1	0,2	–	–	4,68 ± 1,022	21,84
Metallic	41,2	6,5	15,3	9,3	11,2	9,9	5,2	1,0	0,3	–	2,97 ± 1,976	66,53
Pattern	2,6	23,9	48,2	19,5	4,8	1,0	–	–	–	–	2,99 ± 0,829	27,73
Curl type	0,7	4,4	16,2	22,5	21,9	12,1	3,2	1,1	1,6	–	5,01 ± 1,585	31,64
Hair length	0,1	0,4	4,4	18,3	35,8	29,9	10,2	0,6	0,2	–	5,23 ± 0,999	19,10
Feathers	49,1	15,7	20,7	8,8	2,8	2,1	6,6	0,1	–	–	2,11 ± 1,271	60,24
Bandedness	32,9	11,2	17,2	17,5	8,7	7,5	4,1	0,9	0,1	–	3,01 ± 1,783	59,24
Curl breadth	0,1	0,4	5,6	22,5	48,2	15,3	6,0	1,2	0,5	0,1	4,95 ± 0,983	19,86
Skin thickness	0,1	0,2	3,9	10,5	29,5	38,1	16,7	1,0	–	–	5,55 ± 1,007	18,14
Pattern type:												
Corkscrew	93,4	1,2	2,2	1,1	0,5	1,2	0,2	0,1	0,8	–	1,19 ± 0,836	70,25
Peppercorn	97,8	0,4	0,7	0,3	0,3	0,2	0,2	0,1	0,1	–	1,07 ± 0,545	50,93
Lyre	94,3	3,7	1,2	0,5	0,1	0,1	0,1	–	–	–	1,08 ± 0,361	33,43
Moiré	99,6	0,1	0,2	0,1	–	–	–	–	–	–	1,00 ± 0,103	10,30
Firtree	99,6	0,2	0,1	0,1	–	–	–	–	–	–	1,01 ± 0,149	14,75

Table 2 Coefficients of kurtosis and skewness for the different pelt traits

Pelt trait	Coefficient of Kurtosis	Coefficient of Skewness	Standardized Kurtosis	Standardized Skewness
Hair quality	−0,23	0,12	−2,39	2,67
Hair quality at extremities	−0,06	−0,18	−0,67	−3,72
Hair stiffness	3,20	0,59	33,18	12,23
Brittle hair	3,90	2,18	40,33	45,13
Hair thickness	0,97	−0,49	10,04	−10,22
Lustre	−0,18	0,00	−1,88	−0,00
Metallic	−0,87	0,61	−9,07	12,63
Pattern	0,65	0,44	5,81	9,26
Curl type	0,06	0,27	0,67	5,68
Hair length	0,14	−0,15	1,52	−3,18
Occurrence of:				
Feathers	1,18	1,22	12,24	25,35
Bandedness	−0,60	0,58	−6,30	12,07
Curl breadth	1,62	0,43	16,81	8,98
Skin thickness	0,09	−0,44	0,98	−9,23
Pattern type:				
Corkscrew	27,90	5,08	288,48	105,18
Peppercorn	109,02	9,67	1127,11	200,06
Lyre	64,66	6,90	668,50	142,676
Moiré	369,74	18,64	3822,46	385,49
Firtree	1030,99	29,48	10658,40	609,724

metallic, the difference between the two methods is not large enough to account for the differences encountered in the different studies. These differences indicate that Nel (1966) and van Niekerk (1972) worked with populations that had larger proportions of shallow type animals which were selected for pattern and hair quality. In Nel's study, more than 51% of lambs had a score of 4 for curl type.

The coefficient of variation of curl type in this study was about the same as that found by Nel (1966). The coefficient of variation of hair quality and pattern was, however, higher while that of curl size and hair length was lower than that reported by Nel (1966). This again indicates that his population was selected for hair quality and pattern.

Brittle hair, corkscrew, peppercorn, lyre, moiré and firtree pattern types had low scores because of the high proportion of pelts with a score of 1 for these traits. However, there are indications that sufficient variation exists in these traits for selection to act upon.

Probability values for fixed variables for the different pelt traits are presented in Table 3. Values smaller than 0,05 indicate significant differences at the 5% level while values smaller than 0,01 indicate significant differences at the 1% level. No significant interaction was found in this study. This agrees largely with the results of Van Niekerk (1972) who only found a significant sex × age of ewe interaction at the 5% level.

Environmental effects

Year of birth

Year of birth had no significant effect on brittle hair, peppercorn, moiré and firtree pattern types, whilst significant

Table 3 Probability values (P) of significance for fixed variables for the different pelt traits

Pelt traits	Year	Age of dam	Sex	Month born	Type of birth
Hair quality	0,00	0,68	0,18	0,09	0,62
Hair quality at the extremities	0,00	0,43	0,06	0,01	0,37
Hair stiffness	0,01	0,80	0,01	0,02	0,73
Brittle hair	0,20	0,25	0,92	0,06	0,32
Hair thickness	0,00	0,70	0,00	0,05	0,13
Lustre	0,00	0,25	0,58	0,05	0,14
Metallic	0,00	0,35	0,33	0,01	0,13
Pattern	0,00	0,45	0,02	0,01	0,91
Curl type	0,00	0,64	0,00	0,00	0,38
Hair length	0,00	0,00	0,00	0,44	0,58
Feathers	0,00	0,23	0,25	0,28	0,56
Bandedness	0,02	0,09	0,00	0,11	0,35
Curl breadth	0,00	0,67	0,32	0,01	0,22
Skin thickness	0,00	0,00	0,00	0,26	0,78
Pattern types:					
Corkscrew	0,01	0,12	0,08	0,51	0,86
Peppercorn	0,67	0,62	0,49	0,41	0,91
Lyre	0,00	0,92	0,02	0,05	0,51
Moiré	0,23	0,99	0,15	0,09	0,83
Firtree	0,60	0,87	0,53	0,53	0,30

differences were found between years for the other traits. However, significant differences between years are normal phenomena and are normally caused by fluctuating environmental conditions that are difficult to control and will therefore not be discussed any further.

Month born

According to Viljoen *et al.* (1958) and Steyn (1972), most pelt traits are affected by feeding conditions. Scheepers (1964) found that feeding level had no significant effect on skin thickness, hair thickness or hair length. As feeding conditions follow a seasonal pattern, it follows that season may affect pelt traits. Table 3 shows that month born had no significant effect ($P > 0,05$) on hair quality, hair length, brittle hair, skin thickness, occurrence of feathers, bandedness, corkscrew, peppercorn, moiré and firtree pattern types. As indicated in Table 4, a significant linear effect for month born was found for pattern ($P < 0,01$) and lyre pattern ($P < 0,05$), while significant quadratic effects were found for curl type ($P < 0,001$), hair thickness ($P < 0,05$), curl breadth ($P < 0,05$) and hair stiffness ($P < 0,05$). Lustre ($P < 0,05$) and metallic ($P < 0,05$) showed a significant cubic relationship with month born. Although these trends are significant, the effects were actually very small and negligible.

Age of the dam

Age of the dam had a significant linear effect only on hair length ($P < 0,01$) and skin thickness ($P < 0,01$). The regression equations are given in Table 4, and show that hair length and skin thickness increased linearly with age of the dam.

This result agrees with the results of Botma (1981), Nel (1966) and Van Niekerk (1972) who reported the same type of relationship for hair length. Matter (1965) also indicated that lambs born from ewes 6 to 10 years of age, had longer hair than lambs born from ewes younger than 6 years of age. Botma (1981), Nel (1966) and Van Niekerk (1972) likewise found significant age trends for curl type, while only Nel (1966) reported a significant age trend for curl breadth that reached a peak at 5 years of age. Van Niekerk (1972), however, found that age of the dam had a negative influence on hair quality and lustre, but found no significant effect on skin thickness. Botma (1981), who worked on the same dataset as used in the present study (but only on data collected from 1970 up to 1977), found that age of the dam had a significant effect on curl type and curl breadth. This study does not show the same effect.

Le Roux & Van der Westhuizen (1970) also reported changes in pelt traits in lambs of ewes that lambed for six consecutive years. They showed that hair quality, hair thickness, skin thickness and hair length decreased significantly from the third- until the fifth-born lamb in comparison to the first-born lamb. These discrepancies may have been caused by the fact that ewes used in the study of Le Roux & Van der Westhuizen (1970) lambed on veld while the animals of this study were supplemented during times of food shortages.

Sex of the lamb

Ram and ewe lambs differed significantly (Table 5) for pattern ($P < 0,05$), curl type ($P < 0,01$), hair length ($P < 0,01$), hair thickness ($P < 0,01$), skin thickness ($P < 0,01$), bandedness ($P < 0,01$), hair stiffness ($P < 0,05$) and lyre pattern, which supports the findings of Nel (1966) and Van Niekerk (1972). However, Nel (1966) reported that sex of the lamb also had a significant effect on hair quality, whereas Van Niekerk (1972) did not find sex of the lamb to influence hair quality significantly. Contrary to the above-mentioned results, Viljoen *et al.* (1958) found no significant differences between sexes for skin thickness, hair thickness and hair length. It is, however, not clear from their publication whether these pelts were subjectively evaluated or objectively scored, which makes it difficult to come to a conclusion.

This study showed that hair quality did not differ significantly between sexes, but hair quality at the extremities showed a

Table 4 Regression equations of effects which had a significant effect on pelt traits

Pelt trait	Equation
Independent variable (X): Month born	
Pattern	$Y = 3{,}024 - 0{,}0369(X - 6{,}5)$
Lyre pattern	$Y = 1{,}084 - 0{,}0079(X - 6{,}5)$
Curl type	$Y = 5{,}366 - 0{,}0240(X - 6{,}5) - 0{,}0289(X - 6{,}5)^2$
Hair thickness	$Y = 5{,}770 + 0{,}0142(X - 6{,}5) - 0{,}0075(X - 6{,}5)^2$
Curl breadth	$Y = 4{,}840 + 0{,}0224(X - 6{,}5) - 0{,}0114(X - 6{,}5)^2$
Hair stiffness	$Y = 5{,}567 + 0{,}0044(X - 6{,}5) - 0{,}0099(X - 6{,}5)^2$
Lustre	$Y = 4{,}625 + 0{,}0410(X - 6{,}5) + 0{,}0035(X - 6{,}5)^2 - 0{,}0036(X - 6{,}5)^3$
Metallic	$Y = 2{,}958 - 0{,}1396(X - 6{,}5) + 0{,}0041(X - 6{,}5)^2 + 0{,}0091(X - 6{,}5)^3$
Independent variable (X): Age of the dam	
Hair length	$Y = 5{,}235 + 0{,}0504(X - 6{,}5)$
Skin thickness	$Y = 5{,}560 + 0{,}0298(X - 6{,}5)$

Table 5 Least square means (±*SE*) of pelt traits of ram and ewe lambs

Pelt traits	Ram	Ewe
Hair quality	4,64 ± 0,185	4,58 ± 0,185
Hair quality at the extremities	4,48 ± 0,144	4,41 ± 0,145
Hair stiffness	5,30 ± 0,149[a]	5,40 ± 0,149[b]
Brittle hair	1,76 ± 0,254	1,77 ± 0,256
Hair thickness	5,55 ± 0,153[a]	5,76 ± 0,154[b]
Lustre	4,78 ± 0,189	4,75 ± 0,190
Metallic	2,87 ± 0,338	2,95 ± 0,339
Pattern	2,94 ± 0,149[a]	2,84 ± 0,149[b]
Curl type	4,89 ± 0,295[a]	5,36 ± 0,296[b]
Hair length	5,21 ± 0,165[a]	5,54 ± 0,165[b]
Feathers	2,07 ± 0,206	2,01 ± 0,207
Bandedness	2,87 ± 0,295[a]	3,45 ± 0,297[b]
Curl breadth	5,10 ± 0,169	5,14 ± 0,170
Skin thickness	5,27 ± 0,149[a]	5,53 ± 0,149[b]
Pattern types:		
Corkscrew	1,22 ± 0,104	1,32 ± 0,104
Peppercorn	1,05 ± 0,067	1,07 ± 0,067
Lyre	1,09 ± 0,064[a]	1,06 ± 0,064[b]
Moiré	1,01 ± 0,016	1,00 ± 0,016
Firtree	1,01 ± 0,017	1,01 ± 0,017

[a, b] Means with different superscripts differ significantly from each other.

Table 6 Least square means (±*SE*) of pelt traits of single and twin-born lambs

Pelt traits	Singleton	Twin
Hair quality	4,64 ± 0,181	4,59 ± 0,196
Hair quality at the extremities	4,43 ± 0,142	4,45 ± 0,156
Hair stiffness	5,36 ± 0,146	5,34 ± 0,160
Brittle hair	1,84 ± 0,248	1,68 ± 0,278
Hair thickness	5,72 ± 0,151	5,60 ± 0,165
Lustre	4,84 ± 0,187	4,70 ± 0,201
Metallic	2,78 ± 0,332	3,05 ± 0,362
Pattern	2,90 ± 0,144	2,89 ± 0,159
Curl type	5,14 ± 0,290	5,11 ± 0,312
Hair length	5,40 ± 0,163	5,35 ± 0,177
Feathers	2,06 ± 0,202	2,01 ± 0,223
Bandedness	3,24 ± 0,290	3,09 ± 0,319
Curl breadth	5,18 ± 0,166	5,07 ± 0,182
Skin thickness	5,41 ± 0,146	5,39 ± 0,159
Pattern types:		
Corkscrew	1,28 ± 0,104	1,21 ± 0,122
Peppercorn	1,07 ± 0,067	1,10 ± 0,089
Lyre	1,09 ± 0,062	1,07 ± 0,069
Moiré	1,01 ± 0,016	1,00 ± 0,020
Firtree	1,01 ± 0,017	1,00 ± 0,019

significant effect at the 6% level. As hair quality and hair quality at the extremities are genetically and phenotypically highly correlated (Nel, 1966; Van Niekerk, 1972), this is an indication that sex of the lamb may have a significant effect on hair quality, which was undetected because of the low accuracy of the subjectively evaluation process of the pelt.

In general it would appear that ram lambs had slightly better patterns, less bandedness, shorter and thinner hair, and therefore somewhat softer pelts than ewe lambs.

Type of birth

No comparative values to illustrate the effect of type of birth on pelt traits could be found in the literature, probably because of the low percentage twins found in the Karakul under extensive conditions. Potapov (1966) indicated that a higher percentage of pelts from singletons and twins were top grade than of lambs in larger litters. He, however, did not indicate whether significant differences excist between singletons and twins.

The least square means and standard errors of the least square means for singletons and twins are shown in Table 6.

No significant differences were found for any trait, which indicates that differences between singletons and twins are mainly due to differences in birth mass.

Although not significant, Table 6 shows that multiple births do not influence the pattern of the pelt to the same extent as the hair traits. This implies that twin-born lambs produce pelts with slightly shorter and softer hair than singletons.

Conclusion

This study provides estimates of the effect of non-genetic environmental factors on pelt traits in a Karakul flock not subjected to selection. Adjusting pelt traits for birth mass resulted in no significant differences between singletons and twins. Brittle hair and firtree pattern are the only two pelt traits that are not significantly ($P < 0,05$) affected by environmental effects as identified in this study. All the other pelt traits are, to some extent, affected by the year of birth, age of the dam, season, sex or type of birth. To increase accuracy of selection for pelt traits, it would therefore be essential that corrections be made for these environmental effects.

Discrepancies were found for the effect of age of the dam on hair quality and on pattern, compared to results in the literature. This can probably be ascribed to genetic differences between populations and to the fact that birth mass was used as a covariant in the statistical analysis of this study.

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