Non-genetic factors influencing growth and fleece traits in Afrino sheep

M.A. Snyman*
Grootfontein Agricultural Development Institute, Private Bag X529, Middelburg Cape, 5900 Republic of South Africa

G.J. Erasmus and J.B. van Wyk
Department of Animal Science, University of the Orange Free State, Box 339, Bloemfontein, 9300 Republic of South Africa

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Data, consisting of 4235 lamb records, obtained from the Foundation Afrino Sheep Stud at the Carnarvon Experimental Station, were used to investigate factors influencing birth weight, weaning weight, monthly body weight from five to 12 months, body weight at 18 months of age as well as clean fleece weight and mean fibre diameter at 16 months of age. Year/season of birth, sex and birth/rearing status of the lamb as well as age of dam and age of lamb were significant ($P < 0.01$) sources of variation for clean fleece weight and body weight at all ages. Mean fibre diameter was significantly ($P < 0.01$) influenced by year/season of birth, sex and age of lamb. Significant ($P < 0.01$) two-way interactions were found between year/season and sex and year/season and weaning status. Least-squares means (kg) for body weight were 4.84 ± 0.04 at birth, 29.55 ± 0.31 at weaning, 39.27 ± 0.41 at eight, 52.32 ± 0.52 at twelve and 54.13 ± 0.55 at eighteen months of age. For clean fleece weight and mean fibre diameter, least-squares means of 2.01 ± 0.09 kg and 21.47 ± 0.09 micron were recorded. The results are compared to those reported in the literature.

Data, bestaande uit 4235 lamrekords, verkry uit die Stigting Afrinoskaapstoetery te Carnarvon Proefstasie, is gebruik om faktore wat geboortegewig, speengewig, maandelikse liggaamsgewig vanaf die ouderdom van vyf tot 12 maande, 18 maande liggaamsgewig sowel as skoonvaggewig en gemiddelde veseldikte op ouderdom 16 maande beïnvloed, te ondersoek. Jaar/seisoen van geboorte, geslag en geboorte/speenstatus van die lam sowel as moederouderdom was betekenisvolle ($P < 0.01$) bronne van variasie vir skoonvaggewig en liggaamsgewig op alle ouderdomme. Gemiddelde veseldikte is betekenisvol ($P < 0.01$) beïnvloed deur jaar/seisoen van geboorte, geslag en ouderdom van die lam. Betekenisvolle ($P < 0.01$) tweerigtinginteraksies is gevind tussen jaar/seisoen en geslag en jaar/seisoen en speenstatus. Kleinste-kwadrate gemiddeldes (kg) vir liggaamsgewig was 4.84 ± 0.04 by geboorte, 29.55 ± 0.31 by speen, 39.27 ± 0.41 by 'n ouderdom van agt, 52.32 ± 0.52 by twaalf en 54.13 ± 0.55 by agtien maande. Vir skoonvaggewig en veseldikte is kleinste-kwadrate gemiddeldes van onderskeidelik 2.01 ± 0.09 kg en 21.47 ± 0.09 mikron verkry. Die resultate word vergelyk met dié wat in literatuur gerapporteer is.

Keywords: Afrino sheep, growth traits, wool traits, non-genetic factors.

* To whom correspondence should be addressed

Introduction

The Afrino is a composite breed developed at the Carnarvon Experimental Station. In a dual purpose sheep breed like the Afrino, the aim of the breeding programme should be to increase the efficiency of both market lamb and wool production. Since roughly 80% of the income from Afrino sheep is generated through mutton production, more emphasis should be placed on traits such as reproduction, growth and carcass quality. With regard to wool production, the quality of the fleece, in terms of particularly fibre diameter, is considered more important than the amount of wool produced.

The use of best linear unbiased prediction (BLUP) of breeding values has become an important tool in selection programmes. Since selection in Afrino sheep is partially based on body weights recorded at an early age, not only direct additive breeding values, but also maternal breeding values are of importance. To obtain the most accurate prediction of an animal's true breeding value, important non-genetic sources of variation must be identified and statistically reduced.

The purpose of this study was to quantify the effect of non-genetic factors such as year of birth, sex and birth status of the lamb and age of dam on various growth and fleece traits in Afrino sheep, in order to construct an operational model for the accurate estimation of genetic parameters and prediction of breeding values.

Material and methods

Location

Data were obtained from the Afrino flock kept on natural pasture at the Departmental Experimental Station near Carnarvon (30° 59′ S, 22° 9′ E) in the North-western Karoo region of the Republic of South Africa. The natural pasture consists of mixed grass and karoo shrub and is described by Acocks (1988) as arid karoo. The climate is characterized by severe winters and hot summers. The average annual rainfall is 209 mm and it occurs mainly during the autumn months. The official grazing capacity is 5.5 ha/small stock unit.

Animals, management and selection procedures

Development of the Afrino, which involved various breed crosses, started in 1969. In 1976 it was decided that the combination of 50% S A Mutton Merino, 25% Merino and 25% Ronderib Afrikaner best fulfilled the requirements set for the new white woolled mutton breed and only this cross was retained for further up-grading and development (Olivier *et al.*, 1984; Badenhorst, 1989).

The number of ewes mated, sires used and lambs born from 1972 to 1992 are summarized in Table 1.

Rams were randomly allocated and hand-mated to the ewes. Until 1981, most rams were used for up to four or five years. Since 1982, most rams have been replaced annually.

Table 1 Number of ewes mated, sires used and lambs born in the Carnarvon Afrino flock from 1972 to 1992

Year/season[a]	No. of ewes	No. of sires	No. of lambs
1972-1	48	5	32
1973-1	50	5	14
1974-1	68	7	51
1974-2	7	4	8
1975-1	72	10	77
1975-2	17	8	26
1976-1	100	7	39
1976-2	45	7	57
1977-2	53	8	45
1978-2	130	11	129
1979-1	135	16	137
1979-2	57	10	73
1980-2	205	12	294
1981-2	168	9	211
1982-2	195	14	299
1983-2	177	12	150
1984-2	191	11	262
1985-2	190	9	305
1986-2	184	9	295
1987-2	166	8	275
1988-2	199	8	339
1989-2	222	12	334
1990-2	232	9	327
1991-2	222	12	310
1992-2	213	10	251

[a] -1 = autumn lambing season
-2 = spring lambing season

However, some of the rams — one or two per year — were used for two consecutive years.

All lambs were identified at birth and birth weights, as well as sex, birth status and pedigree information, were noted. Lambs were weaned at approximately 100 days of age and kept up to the age of 18 months. Monthly body weights from five to 12 months of age were recorded for all lambs. At 16 months of age, clean fleece weight (CFW) and mean fibre diameter measurements were recorded under the National Woolled Sheep Performance and Progeny Testing Scheme as follows:

CFW = Greasy fleece weight (adjusted to 365-days wool growth) × Clean yield percentage (16% moisture regain).

Mean fibre diameter was determined on the midrib fleece sample by the air-flow procedure using a WIRA fineness meter.

Selection during the early stages of the experiment was aimed mainly at growth rate of lambs, reproductive performance of ewes and freedom of kemp and coloured fibres. At eighteen months of age, subjective selection was done and all animals with poor conformation, coarse wool and an excessive amount of kemp or coloured fibres were culled. Rams were then selected on the basis of post-weaning growth rate. Initially, ewes were not selected for growth performance in order to allow for a rapid increase of the breeding flock.

Statistical analysis

To eliminate inclusion of first-cross progeny, only data collected from 1975 to 1992 on the Afrino flock were used in this study. Before editing, the data consisted of 4235 individual lamb records, the progeny of 146 sires and 946 dams. For each of these lambs, full pedigrees were available. Data on the following traits were available: birth weight (BW); weaning weight (WW); monthly body weight from five to 12 months of age (W5 to W12) and 18 month body weight (W18); clean fleece weight (CFW); and mean fibre diameter (MFD).

Data were edited to force sires nested within year/season. For sires used in more than one year/season, the data of the year/season in which each sire had the most progeny records were retained. Furthermore, all records from sires with less than five progeny were deleted. The following data sets were used for the various analyses: 3340 records for birth weight; 3122 for weaning weight; 2958 for monthly body weight from five to 12 months of age and 2996 for 18 month body weight, clean fleece weight and mean fibre diameter.

In an analysis of variance, using mixed model least-squares procedures (Harvey, 1990), the following general model was fitted for each trait:

$$Y_{ijklm} = \mu + r_i + ys_j + s_k + ws_l + (yss)_{jk} + (ysws)_{jl} + (sws)_{kl} + b_1AD + b_2AD^2 + b_3AL + e_{ijklm}$$

where

Y_{ijklm} = trait of the m'th animal of the l'th birth/rearing status of the k'th sex of the j'th birth year/season of the i'th sire

μ = overall mean

r_i = random effect of the i'th sire with zero mean and variance $I\sigma^2_r$

ys_j = fixed effect of the j'th birth year/season

s_k = fixed effect of the k'th sex

ws_l = fixed effect of the l'th rearing status (birth status in the case of BW)

$(yss)_{jk}$ = effect of the interaction between the j'th birth year/season and the k'th sex

$(ysws)_{jl}$ = effect of the interaction between the j'th birth year/season and the l'th rearing status

$(sws)_{kl}$ = effect of the interaction between the k'th sex and the l'th rearing status

b_1, b_2 = linear and quadratic regression of the appropriate deviation from the mean of age of dam (AD)

b_3 = linear regression coefficient of the appropriate deviation from the mean of age at recording (AL; except for BW) and

e_{ijklm} = random error with zero mean and variance $I\sigma^2_e$

Results and discussion

Model specification

Significance levels obtained after fitting the model for each trait are summarized in Table 2.

From Table 2 it is evident that year/season of birth, sex and birth/rearing status of the lamb had a significant ($P < 0.001$) influence on body weight at all ages as well as on CFW. MFD was significantly influenced by year/season of birth and sex of lamb. Age of dam had a significant quadratic effect on all traits, with the exception of MFD, while age at recording significantly influenced all traits for which it was included.

Two-way interactions

For all traits, the interaction sex*WS was non-significant and can therefore be ignored in all cases. Significant two-way interactions between year/season of birth and sex for WW, W5 to W12, W18, CFW and MFD, and between year/season of birth and rearing status for WW, W5 to W12 and W18 were found.

The significant two-way interaction of YS*sex for body weight can most probably be explained as follows: Ram lambs were consistently heavier than ewe lambs. However, during favourable years this difference was much more accentuated. It seems reasonable to assume that under good feeding conditions, the full growth potential of the rams could be expressed. The significance ($P < 0.001$) of the YS*sex interaction pertaining to CFW, was probably due to the fact that in some years rams had a higher and in other years a lower CFW than ewes, although in most years there was no significant difference in CFW between the two sexes. The same applies to MFD, where ewes generally had a higher MFD when compared to rams.

Table 2 Model specification for BW, WW, W5–W12, W18, CFW and MFD

	BW		WW		W5 – W12		W18		CFW	MFD
Effect	*df*	*P*	*df*	*P*	*df*	*P*	*df*	*P*		
YS	18	***	17	***	18	***	16	***	***	***
Sex	1	***	1	***	1	***	1	***	**	***
BS	1	***								
WS			2	***	2	***	2	***	***	ns
YS*sex	18	ns	17	**	18	***	16	***	***	**
YS*WS	18	ns	31	***	31	***	30	*	ns	ns
Sex*WS	1	ns	2	ns	2	ns	2	ns	ns	ns
Regr										
Age (L)			1	***	1	***	1	***	***	***
AD (L)	1	***	1	**	1	***	1	**	**	ns
AD (Q)	1	***	1	***	1	***	1	*	***	ns
Error	3168		2936		2771		2810			

df = Degrees of freedom
YS = Year/season of birth
BS = Birth status
WS = Rearing status
AD = Age of dam
* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; ns = $P > 0.05$

Table 3 Least-squares means (SE), coefficients of variation (CV%) and least-squares estimates for BW, WW, W5-W12, W18, CFW and MFD by sex and birth/rearing status[a]

Trait	LS (SE)	CV%	Rams	Ewes	Single	Multiple	
BW	4.84 (0.04)	16.22	0.135	–0.135	0.415	–0.415	
Trait	LS (SE)	CV%	Rams	Ewes	S/S	M/S	M/M
WW	29.55 (0.31)	17.34	1.149	–1.149	2.738	1.263	–4.001
W5	30.95 (0.36)	15.79	1.492	–1.492	2.315	1.237	–3.552
W6	33.38 (0.35)	14.97	1.916	–1.916	1.958	1.395	–3.353
W7	36.57 (0.38)	13.53	2.120	–2.120	1.837	1.249	–3.086
W8	39.27 (0.41)	13.17	2.197	–2.197	1.739	1.249	–2.988
W9	42.35 (0.44)	12.33	2.291	–2.291	1.519	1.305	–2.824
W10	45.96 (0.47)	12.55	3.417	–3.417	1.461	1.140	–2.601
W11	48.81 (0.50)	12.93	4.138	–4.138	1.115	1.536	–2.651
W12	52.32 (0.52)	12.99	4.501	–4.501	1.529	1.149	–2.678
W18	54.13 (0.55)	14.86	5.935	–5.935	1.418	0.739	–2.157
CFW	2.01 (0.03)	17.26	0.030	–0.030	0.090	–0.015	–0.075
MFD	21.47 (0.09)	6.21	–0.214	0.214	–0.052	–0.001	0.053

[a] Multiple = Lambs born as twins or triplets
S/S = Single born, single raised lambs
M/S = Multiple born, single raised lambs
M/M = Multiple born, multiple raised lambs

The interaction YS*WS was significant for all body weights (except birth weight). Single born and raised lambs (S/S) were consistently heavier than multiple born and raised lambs (M/M). The multiple born single raised lambs (M/S) were heavier than S/S lambs in some years; some years closer to S/S lambs in body weight, while closer to M/M lambs in other years. M/S lamb groups for the various years differed probably as a result of variation in the time they were single. Some M/S lambs were raised as single lambs from birth, some from within a week after birth, while others became single when approaching weaning.

Least-squares means

Least-squares means, coefficients of variation (CV%) and least-squares estimates for the effects of sex and birth/rearing status of the lamb are presented in Table 3. The estimates are expressed as deviations from the least-squares mean. The effect of year/season of birth is obvious and well documented and will therefore not be discussed here.

Ram lambs were heavier than ewe lambs at birth and remained heavier throughout their lives. The 0.27 kg difference recorded at birth had already increased to 2.30 kg at weaning. Thereafter it increased progressively to a difference of 11.87 kg in body weight at 18 months of age. Similar differences in body weight between ram and ewe lambs were recorded for several other South African sheep breeds (Heydenrych, 1975; Fourie & Heydenrych, 1982; Cloete & De Villiers, 1987; Badenhorst, 1989; Van Wyk *et al.*, 1993).

Rams produced fleeces which were 0.06 kg heavier and 0.21 micron finer than those produced by the ewes.

Multiple born lambs were 0.83 kg lighter at birth than single born lambs (Table 3). At weaning, S/S lambs were 4.8% (1.48 kg) and 26.4% (6.74 kg) heavier than M/S and M/M lambs respectively, while M/S lambs had a 20.6% (5.26 kg) advantage over their M/M counterparts. These differences decreased gradually to 1.2% (0.68 kg), 6.9% (3.58 kg) and 5.6% (2.90 kg) respectively at 18 months of age. Similar to the foregoing, significant effects of birth/rearing status on body weight at various ages are well documented for different sheep breeds (Shelton & Campbell, 1962; Bichard & Cooper, 1966; Wiener & Hayter, 1974; Olson *et al.*, 1976; Fourie & Heydenrych, 1982; Shrestha & Vesely, 1986; Cloete & De Villiers, 1987; Mavrogenis, 1988; Boujenane *et al.*, 1991; Van Wyk *et al.*, 1993).

S/S lambs produced fleeces which were 0.105 kg and 0.165 kg heavier than M/S and M/M lambs respectively. Fleeces of M/S lambs were 0.090 kg heavier than those of M/M lambs. Rearing status had no significant effect on mean fibre diameter in this study.

Age of dam and age of lamb at recording

Regression coefficients for age of dam (b_1 and b_2) and age of lamb at recording (b_3) are summarized in Table 4.

Regression coefficients calculated for body weight on age of dam (Table 4) were lower than those reported by Olson *et al.* (1976). Performance of progeny from two-year-old and 7-year and older ewes generally differ significantly from that of 3- to 6-year-old ewes (Shelton & Campbell, 1962; Bichard & Cooper, 1966; Fourie & Heydenrych, 1982; Shrestha & Vesely, 1986; Cloete & De Villiers, 1987; Mavrogenis, 1988; Schoeman, 1990; Boujenane *et al.*, 1991; Van Wyk *et al.*, 1993). A possible explanation for the results obtained in this study is that ewes had been mated at 18 months of age for the first time. At that stage, they had nearly reached mature weight and consequently did not suffer more than the older ewes from the stress of pregnancy and lactation. Furthermore, owing to the harsh grazing conditions at Carnarvon, teeth wear easily and no ewes older than six years were kept in the flock.

Age at recording had a significant influence on all traits analysed. From Table 4 it is evident that this influence became smaller with age, but it never disappeared completely.

Table 4 Regression coefficients[a] for age of dam and age of lamb for BW, WW, W5–W12, W18, CFW and MFD

Trait	b_1	b_2	b_3
BW	0.224D-3 (0.027D-3)	–0.026D-5 (0.005D-5)	
WW	0.427D-3 (0.159D-3)	–0.151D-5 (0.027D-5)	0.211 (0.009)
W5	0.546D-3 (0.164D-3)	–0.118D-5 (0.028D-5)	0.188 (0.009)
W6	0.511D-3 (0.168D-3)	–0.114D-5 (0.029D-5)	0.184 (0.009)
W7	0.585D-3 (0.174D-3)	–0.094D-5 (0.030D-5)	0.171 (0.009)
W8	0.591D-3 (0.179D-3)	–0.134D-5 (0.030D-5)	0.163 (0.009)
W9	0.667D-3 (0.187D-3)	–0.142D-5 (0.032D-5)	0.153 (0.009)
W10	0.670D-3 (0.201D-3)	–0.126D-5 (0.034D-5)	0.140 (0.012)
W11	0.683D-3 (0.212D-3)	–0.083D-5 (0.036D-5)	0.125 (0.013)
W12	0.693D-3 (0.226D-3)	–0.107D-5 (0.039D-5)	0.117 (0.014)
W18	0.566D-3 (0.232D-3)	–0.076D-5 (0.040D-5)	0.090 (0.014)
CFW	0.040D-3 (0.016D-3)	–0.011D-5 (0.003D-5)	0.004 (0.001)
MFD			0.014 (0.004)

[a] b_1 = Age of dam (linear)
b_2 = Age of dam (quadratic)
b_3 = Age of lamb (linear)

Conclusion

The results obtained in this study confirm the importance of non-genetic factors as sources of variation in body weight and fleece traits of Afrino sheep. Year/season of birth, sex and birth/rearing status of the lamb as well as age of dam and age of lamb were important sources of variation for CFW and body weight at all ages. MFD was significantly ($P < 0.001$) influenced by year/season of birth, sex and age of lamb. These factors should therefore be included in an operational model fitted for the estimation of genetic parameters or prediction of breeding values for Afrino sheep. Failure to do so could result in the impediment of selection progress owing to the use of inaccurate genetic parameters and breeding values in the selection programme.

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