Voluntary feed intake, body composition and efficiency of two Merino crossbreeds

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The voluntary feed intake, body composition and efficiency (ME intake/energy retention) of 10 Dorper × Merino and 10 Afrino × Merino lambs were studied. The age of experimental animals ranged from weaning at approximately 120 days, to about 240 days of age. The lambs were fed individually on a diet with a metabolizable energy content of 10,26 MJ/kg. Measurements were made continuously of livemass, voluntary intake and body composition using tritium dilution. The growth results were analysed and interpreted relative to percentage of mature mass to account for differences in size. The intake of the Afrino × Merino cross was the highest and the intake of rams was superior to that of ewes. The Afrino × Merino cross had the highest growth rate. It was also clear that the Afrino × Merino cross gained protein and fat at a faster rate than the Dorper × Merino cross. The efficiency, as defined here, was very similar in sex groups. It was concluded that in spite of mature mass as a scaling factor, body composition and voluntary feed intake were a major source of variation in determining efficiency.
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Vrywillige voerinname, liggaamsamestelling en doeltreffendheid (ME-inname/energie-retensie) van 10 Dorper × Merino- en 10 Afrino × Merino-lammers is bestudeer. Die ondersoek het gestrek vanaf speenouderdom op ongeveer 120 dae tot 240-dae-ouderdom. Die lammers is individueel gevoer op 'n dieet met 'n metaboliseerbare-energie-inhoud van 10,26 MJ/kg. Metings van lewende massa, vrywillige voerinname en liggaamsamestelling is onafgebroke met behulp van tritiumverdunning geneem. Die groeiresultate is ontleed en geïnterpreteer relatief tot persentasies van volwasse massa om grootte-effek uit te skakel. Die inname van die Afrino × Merino-kruising was deurgaans die hoogste, terwyl ramme 'n hoër inname as ooie gehad het. Die Afrino × Merino-kruising het die hoogste groeitempo, asook die hoogste proteïen- en vetdeponering gehad. Die doeltreffendheid, soos dit hier gedefinieer word, het weinig binne geslagsgroepe verskil. Die gevolgtrekking is gemaak dat die grootste bron van variasie in doeltreffendheid in die liggaamsamestelling en voerinname gesoek moet word.
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The effective use of crossbreeding in intensive farming enterprises requires knowledge of the growth patterns and feed efficiency of available breeds or crosses over a range of feeding levels and physiological stages.

The efficiency with which feed energy is utilized in growing sheep is a function of feed intake, body composition (Roux, 1976; Meissner, 1977; Meissner, Hofmeyr & Roux, 1977; Meissner & Roux, 1979; Meissner & Roux, 1983), and energy requirements for maintenance (Hofmeyr, 1972). This interelationship between feed efficiency and its causal components is influenced by both animal and nutritional factors. Differences between cattle breeds in the composition of growth can be explained largely by differences in frame size (Meissner, 1983). These differences tend to decline as growth proceeds, which suggests that the differences in energy requirements for growth also decline towards maturity. Apart from frame size most of the genotype variation in composition of growth of sheep can also be ascribed to production traits (woolled compared to non-woolled breeds), early and late-maturing mutton producers, and climatic extremes (Hofmeyr, 1972; Meissner, De la Ray, Gerhard & Van der Westhuizen, 1976; Meissner, 1983).

The object of this study was to quantify the feed intake, body composition and efficiency between two Merino crosses at comparable stages of the growth curve and to measure some factors known to affect growth and efficiency.

Two different types of Merino crossbred lambs were used as experimental material, viz. Dorper × Merino (D × M) and Afrino × Merino (A × M). Ten lambs of each of the two Merino crosses, five rams and five ewes, were used. The lambs were born and remained on Karooveld with the ewes until weaning at *ca* 120 days of age. The mean weaning masses recorded were 32,33 ± 2,30 kg (rams) and 27,69 ± 4,82 kg (ewes) for the A × M and 29,74 ± 4,18 kg (rams) and 26,73 ± 4,48 kg (ewes) for the D × M crosses, there being no significant differences between crosses and sexes.

During the trial the lambs were fed individually a diet consisting of 59% maize meal, 40% lucerne hay milled through a 13 mm sieve and 1% $CaCO_3$, having a ME of 10,26 ± 0,378 MJ/kg and a crude protein content of 11,13 ± 0,132%. Feed intake and livemass were measured weekly without prior fasting. Although this procedure is less reliable owing to differential gut full, a period of fasting could interfere with the measurement of 'true' *ad libitum* intake. By fitting a mathematical function to livemass data of several weeks (Meissner & Roux, 1979) the effect of measurement error is reduced. A standard digestibility trial at *ad libitum* feed intake was used to estimate the digestible energy (DE) content of the diet. The metabolizable energy (ME) intake of each lamb was computed from the DE intake multiplied by 0,82 (Blaxter, 1962). The cumulative ME intake of individual lambs prior to the commencement of the trail was calculated from the linear regression equation between ln(cumulative ME intake) and ln(bodymass) of Mutton Merino lambs as described by Meissner (1977). Body composition was estimated at 2 to 3-week intervals by the tritium dilution method (Meissner & Bieler, 1975).

The relationships between ln(cumulative feed intake) and ln(bodymass) or ln(components of bodymass) describe a straight line when measured in temporal sequence on the same animal or group of animals (Roux, 1976, 1981; Meissner, 1977). The fit of these lines is usually extremely accurate. A fit of $r^2 = 0,96$ was recorded in this trial.

A two-way analysis of variance with crosses and sex as variables was used to test for differences between the values for slope (*b*) and intercept (*a*). The differences in *b* between crosses, were not significantly different. The values for *b* between sexes, however, differed significantly between the relationship with ln(protein), ln(fat), and ln(lean). Common values for *b* for crosses and sexes were calculated and were non-significant. Because the *b* parameters did not differ between crosses the differences between crosses on the log scale also stayed the same throughout the growth phase studied. The *a* values were then adjusted according to the common *b* values and the two-way analysis of variance procedure was again used to test for differences. These results are shown in Table 1.

The differences between the adjusted *a* values were not significant between crosses but differed highly significantly between sexes in the relationship with ln(bodymass), ln(protein), ln(fat), and ln(lean).

In the growth-with-time relationship ρ, x_0 and α_x are the determining parameters (Roux, 1976, 1981). These parameters in the relationship with ln(cumulative ME intake) and the parameters x_0 and α_x in the relationship with ln(bodymass), ln(protein), ln(fat), and ln(lean) were considered.

A two-way analysis of variance procedure was conducted. The parameter ρ did not differ significantly between crosses and sexes. With regard to x_0 no significant differences could be detected between crosses, but x_0 differed highly significantly in the relationship with protein between sexes. The parameter α did not differ significantly between crosses in the relationships with ln(cumulative ME intake), ln(bodymass), ln(protein), ln(fat), and ln(lean). The only significant differences between sexes were in the relationship with ln(bodymass), ln(protein), ln(fat), and ln(lean).

Because differences between crosses and sexes were to be compared at various stages, adjusted values for ρ, α and the mean x_0 were calculated. The parameter ρ was calculated as the mean between the crosses. The parameter α in the relationship ln(cumulative ME intake) was derived as described by Roux (1976). The values for ln(bodymass), ln(protein), ln(fat), and ln(lean) were calculated as described by Meissner (1977). The adjusted parameters in the growth-with-time domain are shown in Table 2.

It is generally accepted that large-frame types have higher

Table 1 Adjusted parameters of equations between ln(cumulative ME intake) (*x*), ln(bodymass), ln(protein), ln(fat), and ln(lean) (*y*) respectively.

		Afrino × Merino		Dorper × Merino		*F* values for differences between intercepts		
Components	Parameter	Rams	Ewes	Rams	Ewes	Cross	Sex	Interaction
ln(bodymass)	*a*	−0,102	−0,183	−0,102	−0,183	0,389	13,529[a]	0,045
	b	0,525	0,525	0,525	0,525			
ln(protein)	*a*	−1,214	−1,105	−1,214	−1,105	2,223	21,429[a]	0,039
	b	0,404	0,361	0,404	0,361			
ln(fat)	*a*	−4,968	−5,688	−4,968	−5,688	0,159	220,282[a]	0,068
	b	0,972	1,044	0,972	1,044			
ln(lean)	*a*	0,603	0,968	0,603	0,968	2,473	14,672[a]	0,234
	b	0,405	0,325	0,405	0,325			

[a]$P < 0,01$

Table 2 Adjusted parameters in the growth-with-time domain

		Afrino × Merino		Dorper × Merino	
Components	Parameter	Rams	Ewes	Rams	Ewes
ln(cumulative	ρ	0,9707	0,9707	0,9707	0,9707
ME intake)	α	9,664	9,532	9,477	9,466
	x_0	6,706	6,578	6,527	6,505
ln(bodymass)	α	4,971	4,821	4,873	4,786
	x_0	3,471	3,308	3,385	3,273
ln(protein)	α	2,690	2,336	2,614	2,312
	x_0	1,538	1,280	1,466	1,272
ln(fat)	α	4,425	4,265	4,243	4,194
	x_0	1,644	1,161	1,425	1,088
ln(lean)	α	4,516	4,065	4,441	4,048
	x_0	3,416	3,163	3,227	3,134

Table 3 Mean growth variables calculated for growth at 20 and 40% of mature mass in Afrino × Merino and Dorper × Merino crosses

	Afrino × Merino				Dorper × Merino			
	Rams		Ewes		Rams		Ewes	
Variable	20%	40%	20%	40%	20%	40%	20%	40%
Mature mass (Exp α) (kg)[a]	152		129		139		125	
Mass	30,4	60,8	25,8	51,6	27,8	55,6	25,0	50,0
ME intake (MJ/d)	10,2	21,2	8,8	18,4	8,6	17,7	8,3	17,3
% Protein	14,6	12,4	13,6	11,0	14,9	12,7	13,7	11,1
% Fat	15,4	27,8	12,1	24,0	14,3	25,7	11,7	23,3
% Lean	90,6	77,3	85,5	65,6	92,4	78,9	86,4	66,4
Gain in protein (g/d)	22,6	21,4	16,1	14,5	20,9	19,8	15,7	14,2
Gain in fat (g/d)	57,3	114,6	41,5	9,2	48,3	96,2	38,9	86,1
Gain in lean (g/d)	141	133	77	78	130	122	89	76
Gain in mass (g/d)	201	223	172	192	182	202	166	186
Gain in energy (MJ/d)	2,8	5,1	2,0	3,9	2,4	4,3	1,9	3,8
% of ME retained	27,5	24,0	22,7	21,2	27,9	24,3	22,9	21,9
% of ME lost	72,5	76,0	77,3	78,8	72,1	75,7	77,1	78,1
MJ ME/MJ gain in energy	3,6	4,2	4,4	4,7	3,5	4,1	4,3	4,6

[a]Exp α: Mature mass was assumed to be the exponent of α mass

basal energy expenditures than small-frame types if correction for size is made through metabolic mass ($W_{kg}^{0,75}$) (Anderson, 1978). Meissner, Van Staden & Pretorius (1982) pointed out that corrections through metabolic mass do not correct to the same physiological age as does a particular percentage of mature mass or the same growth interval as defined by the autoregressive analysis. According to Meissner, *et al.* (1982) the growth rate of $w(t)$ can be written as:

$$\frac{dw}{dt} = \gamma\ (\alpha_w - w(t)) \qquad \ldots (1)$$

Equation (1) is the basis of the criteria of interbreed comparisons suggested by Taylor (1965; 1971). In Equation (1) the arithmetic scale gives the distance between $w(t)$ and α as a proportion. This has the advantage that differences in α_w are eliminated by taking proportions. In this study a percentage of the exponent α_w, called mature mass, was used as basis of comparison. The growth interval considered was between 20 and 40% of mature mass.

According to Table 3 it is clear that the A × M cross has the highest intake and that the intake of rams was superior to that of ewes. The growth rate of A × M was also higher than that of the D × M cross.

From Table 3 it is clear that the A × M cross rams gained protein at a faster rate than the D × M cross rams at the same mature mass. The differences between ewes were very small. According to the gain in fat deposition the A × M cross showed the highest values. It was also clear that the rams from the A × M cross had the highest growth rate in lean, whilst the values of the D × M cross ewes were the highest.

Béranger (1976) concluded that statistical variation is reduced when comparing growth and efficiency if comparisons between genotypes (crosses) are made at the same percentage of mature mass or metabolic age but still does not account for all the variation. The remaining differences are in the composition of gain and that the energetic efficiency of protein deposition is lower than that of fat. Moreover, as protein in lean is associated with three times its mass of water, in terms of gain in bodymass, efficiency should theoretically increase as protein content of gain increases. Therefore animals such as A × M cross rams, with a high growth rate in lean (Table 3), should be more efficient than the D × M cross lambs. This is not the case, however, because the efficiency (ME intake/energy retention) of the two different ram groups was exactly the same (Table 3). A possible explanation for this is the higher fat gain of the A × M cross rams. The results in Table 3 indicated small differences in energy loss between the two crosses in spite of vast differences in body composition. The differences in sex groups were very small. Part of this energy lost is termed maintenance expenditure. Owing to the curvilinear form of the loss in energy, the acceptance of a constant fasting heat expenditure is difficult to justify. Therefore in spite of using mature mass as a scaling factor, body composition and voluntary feed intake were a major source of variation in determining efficiency.

According to the present results either of the two crosses can be used when considering efficiency. If mass gain, especially of lean meat, as well as a better quality of wool is desired, the Afrino seems to be a more suitable breed for the purpose of crossbreeding. This research was conducted under intensive conditions with high-quality feed and one can only speculate on the outcome of a similar experiment under extensive conditions.

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