Wool production in Dohne Merino, Dormer, Merino and South African Mutton Merino lambs

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Abstract

In this study, the wool growth of Dohne Merino, Dormer, Merino and South African Mutton Merino (SAMM) lambs reared on a feedlot diet (10.62 MJ ME/ kg feed, 20.7% crude protein) was monitored from about two months old until the lambs were shorn as yearlings. The 100 cm^2 patches on the left sides of the lambs were sheared monthly and the clippings were weighed to determine the wool growth rate. At approximately one year old, the lambs were shorn and the fleeces were weighed. A mid rib fleece sample was also retrieved from each lamb for quality analysis. Merino lambs presented the highest wool growth rates (12.943 g/day) and fleece weights (6.140 kg), whereas Dormer lambs exhibited the lowest values for these traits (8.487 g/day and 3.330 kg, respectively (P <0.05)). The lack of differences between Dohne Merino (9.720 g/day and 4.671 kg) and SAMM (10.553 g/day and 4.158 kg) lambs for these wool growth rate and fleece weight traits was attributed to disparities in live weight (86.8 kg and 105.2 kg, respectively (P <0.05), with heavier SAMM lambs offsetting the expected variations in fleece weight. Wool from Dohne Merino and Merino sheep had the finest fibre diameters (<21 µm), followed by SAMM wool (22–23 µm), with Dormers producing coarse wool (>27 µm). These results could be used as guidelines in sheep production to predict the income contribution of wool from these breeds.

Introduction

Wool continues to be an important fibre in textile production. The economic value of wool is influenced by intrinsic characteristics that meet processor capacities and consumer requirements (Holman & Malau-Aduli, 2012). The quantities of wool produced annually in the South African market declined from 1991 to 2005 (DAFF, 2018) as a result of increased stock theft, and because the meat price became the major source of income from sheep production. This has resulted in increased crossbreeding, with the use of terminal sires to improve growth and meat production of wool breeds (Cloete *et al.*, 2008). Wool production, however, complements lamb production in the total income generated when wool-type or dual-purpose dam lines are used in breeding programmes (Cloete, 2007). Wool production in South Africa has grown as a result of higher wool market prices. A total of 51600 tonnes of wool was produced in 2016/2017, producing revenue of ZAR4.2 billion (DAFF, 2018). The increased demand for South African wool by processors was also driven in part by the boycott on the Australian wool industry, which still practised mulesing as a method to control flystrike. For the past decade, consumers have viewed this practice as a violation of the welfare of sheep (Sneddon & Rollin, 2010).

The South African sheep industry consists of a range of breeds and production types. Wool-type breeds make up about 72% of the national flock (DAFF, 2018). According to the records of the National Small Stock Improvement Scheme, 49.7% of the dataset is made up of Merino and Dohne Merino breeds, with SAMM contributing 18.1% and Dormer breeds 7.1%, followed by Ile de France (2%), Merino Landsheep, and Afrino breeds which contribute less than 2% (Cloete *et al.*, 2014). The Letelle breed, a descendant of the Spanish Merino, contributes a small portion of the national flock with about 3000 registered ewes and about 100 registered rams (Van der Westhuizen *et al.*, 2019). The remainder of the

national flock is made up of breeds that are reared explicitly for meat production. The Merino is renowned as a wool breed, and produces heavy fleeces with a medium to fine fibre, depending on the line (Hogan *et al.*, 1979). Dohne Merino and South African Mutton Merino, with roots in the German Mutton Merino, are considered dual-purpose breeds. The Dohne Merino is oriented toward wool production (Cloete *et al.*, 1998; Cloete *et al.*, 2001), whereas the Mutton Merino tends toward meat production. The Dormer is regarded as a terminal sire meat breed, which was developed by crossing Dorset Horn rams with German Mutton Merino ewes (Van Wyk *et al.*, 2003). The result is a large framed sheep with good conformation and high growth rates that produces wool with a coarse fibre

Currently, lamb meat prices are favourable, although income from wool has increased considerably over the last few years. As a result, many lamb producers opt to rear their lambs in intensive feedlot systems to improve production efficiency and maximize throughput. Feedlot lambs typically enter the feedlot at weaning (3 - 4 months old) and are marketed for slaughter at 4 - 6 months (Brand *et al.*, 2017), whereas in other extensive production systems, lambs are reared up to yearling age. In these systems, the lambs are shorn at eight months old or at one year to obtain a suitable fleece. In large commercial feedlots, there is the option of shearing lambs to enhance the income per lamb. But shearing lambs directly before entry to the feedlot would increase feed intake by stimulating cold stress (Çam *et al.*, 2007) and enhance production. Conversely, the additional protein and energy in the feedlot diet could result in greater wool growth (Cronje & Weites, 1990) and a heavier fleece at the end of the feeding period before slaughter. Regardless of the production system, and age of shearing of wool-type lambs in the system, it is important to be able to predict their wool production to determine the expected income and feasibility of the management strategy.

The aim of this study was to describe the wool growth rates of growing lambs, to model wool growth with age and bodyweight for Dohne Merino, Dormer, Merino, and SAMM lambs, and to describe the wool quality traits of yearling lambs of these breeds, reared on a feedlot diet for optimum growth, and the wool production of their dams, which were reared under the same conditions.

Materials and Methods

Ethical approval for this study was obtained from the Departmental Ethics Committee (DECRA R14/110 of Western Cape Department of Agriculture. The wool production characteristics of lambs from four breeds, namely Dohne Merino (ram = 5, ewe = 14), Dormer (ram = 9, ewe = 10), Merino (ram = 3, ewe = 2) and South African Mutton Merino (SAMM) (ram = 13, ewe = 7) were monitored from about 30 days old until they attained mature bodyweight (about one year old). The lambs were born from the same research flock, during the 2017 lambing season, and consisted of ewes and rams of breeds from sheep studs. The research flock, which contained 25 ewes per breed, was herded on Langgewens Research Farm (Western Cape Department of Agriculture) in the Swartland region of the Western Cape in South Africa (coordinates - 33.276833, 18.704252). A description of the management and nutrition of the flock and post-weaning feedlot nutrition of the lambs was outlined by Van der Merwe *et al.* (2019).

Throughout the study, these breeds were herded together. The ewes were synchronized and mated with rams from their breeds, and lambing occurred within a month in May - June 2017. Unfortunately, because of low lambing rates, particularly in the Merino, the number of lambs available for this study was lower than anticipated. Nonetheless, analysis was carried out to determine wool production at a given age or live weight. Only data from sheep that survived the entire rearing period from birth to yearling age were used in this study.

Wool growth rate was monitored with the patch technique (Langlands & Wheeler, 1968). A 100 cm^2 patch was demarcated with ink on the skin on the left side of the lambs in the centre of the mid rib region. The lambs were about two months old when the wool in the patch was cleared for the first time with an electric clipper (Andis Ultra Edge) with a 1.5 mm blade. After this initial clipping, the wool in the patches was clipped monthly. The wool was then weighed (greasy weight) with an electronic scale and corrected according to the 100 cm^2 surface area of the original patch. To determine fleece growth between clipping intervals in Dohne Merino, Dormer and SAMM lambs, this formula (Ferguson, 1958) was applied:

$$Total\ wool\ production = 6 \times W^{\frac{2}{3}} \times wool\ mass\ from\ 100\ cm^2\ area$$

Because Merino lambs have more skin folds, and thus a greater surface area, this formula was used to determine wool production of Merino lambs (Du Plessis, 1974):

$$Total\ wool\ production = 6.5 \times W^{\frac{2}{3}} \times wool\ mass\ from\ 100\ cm^2\ area$$

In both formulas, *W* denotes the weight (kg) of the lambs at the time of clipping. At about 12 months old (May 2018), the patches were clipped for the final time and the fleeces were sheared. The entire fleece of each animal was weighed on a platform scale to obtain the greasy fleece weight. A mid rib wool sample (about 75 g) was also taken from the right side of the animals to determine wool quality characteristics. The dams of these breeds were sheared during the spring months (September - October 2018) to obtain a year-

old fleece from mature ewes. The fleeces were weighed, and samples were extracted and sent to the Wool Testing Bureau SA (Port Elizabeth, South Africa) to determine clean yield, fibre length, fibre diameter and crimp frequency.

The data were analysed with SAS version 7.1 (SAS Institute Inc., Cary, North Carolina, USA). Wool growth rates (g/day) were averaged across the monthly clippings for each animal to determine average wool growth rates. Using the PROC GLM function of SAS, wool growth rates and quality characteristics were analysed with the main effects of breed and sex, and the breed by sex interaction using type three sums of squares. For the wool characteristics of the mature ewes, only the main effect of breed was included in the analysis. The Bonferroni test method was used to determine significant differences between the main effects at 95% level (P <0.05). Monthly fleece growth values were deducted from the fleece weight at shearing (about one year old) to estimate the cumulative fleece weight at the points of patch clipping. Linear regressions to model the changes in greasy fleece weight and clean fleece weight with age and bodyweight were developed for each animal using PROC REG. The linear parameter estimators were then compared for differences with the main effects of breed and sex. The results are presented as least square means and standard errors.

Results and Discussion

No significant interactions between the effects of breed and sex were observed in wool growth and quality traits. At the start of the study, Dormer lambs were older than Dohne Merino and SAMM lambs, which were older than Merino lambs (P <0.001). However, the bodyweights of the lambs did not differ (P =0.122) at the start of the monitoring period (Table 1). The average age of the lambs at shearing was 349 days, which was taken as an indication of one-year-old fleece weight. At shearing, Dormer and SAMM sheep were significantly heavier than the Dohne Merino and Merino breeds. Also, rams were on average 18.3% heavier than ewes (P <0.001). The greasy fleece weight of rams was 14.4% heavier than that of ewes (P <0.05), which was primarily because the rams were larger than the ewes. Merino lambs produced the heaviest fleeces, whereas the fleece weights of Dohne Merino and SAMM lambs did not differ significantly, and Dormers, as expected, produced the lightest fleece (P <0.001). *Cloete et al.* (2001) and Cloete *et al.* (2003) also observed that Dohne Merino yearlings and ewes produced heavier fleeces than the SAMM. The lack of differences in fleece weight between the Dohne Merino and SAMM breeds may result because of compensatory differences in bodyweight. This hypothesis is supported by the observation of a positive correlation (r = 0.32) between yearling weight and clean fleece weight in Dohne Merinos (Van Wyk *et al.*, 2008). As yearlings, ram lambs presented greater wool growth than ewe lambs.

Table 1 Age and bodyweight of lambs at approximately two months old and at shearing at approximately one year old with greasy fleece weight of ram and ewe lambs of various breeds

Main effect		Initial age, days	Initial weight, kg	Shearing age, days	Shearing weight, kg	Greasy fleece weight, kg
Sex	Ewe	57 ± 1.6	16.7 ± 1.15	347 ± 1.7	85.4 ± 2.29	4.22 ± 0.18
	Ram	55 ± 1.5	16.9 ± 1.15	345 ± 1.5	104.5± 2.12	4.93 ± 0.17
	P-value	0.488	0.911	0.646	<0.001	0.006
Breed	Merino	43[c] ± 3.2	14.8 ± 2.16	333[c] ± 3.3	82.6[b] ± 4.61	6.14[a] ± 0.36
	Dohne Merino	57[b] ± 1.7	16.0 ± 1.15	347[b] ± 1.8	86.8[b] ± 2.46	4.67[b] ± 0.19
	SAMM	58[b] ± 1.7	17.1 ± 1.11	348[b] ± 1.7	105.2[a] ± 2.37	4.16[b] ± 0.19
	Dormer	66[a] ± 1.6	19.3 ± 1.08	357[a] ± 1.8	105.3[a] ± 2.45	3.33[c] ± 0.19
	P-value	<0.001	0.122	<0.001	<0.001	<0.001

[a-b] Means with a common superscript were not different at P =0.05

Whereas the weight of the fleece harvested at first shearing may be influenced by body size at shearing, the wool growth rate of lambs may elicit a better indication of wool production characteristics (Table 2). A tendency was observed for ram lambs to have a higher growth rate per surface area than ewes (P =0.070). The average monthly fleece growth and average wool growth rates of ram lambs were

significantly higher than those of ewe lambs. Merino lambs showed the highest rates (P <0.05) in wool growth per surface area, average monthly fleece growth, and average wool growth rate. The wool growth rate of Dohne Merino and SAMM lambs did not differ (P >0.05) in growth rate per surface area, monthly fleece growth or average wool growth rate. The wool growth of Dormer lambs was lower than that of the other breeds, although the average wool growth rate of Dormer lambs did not differ significantly from that of Dohne Merino lambs. Previously, Du Plessis and De Wet (1981) reported a higher wool growth rate of 27.13 g/day for Merino lambs. However, the low number of Merino lambs in this study cannot be regarded as a complete representation of the variability in Merino lambs; and the rates observed here still resemble those previously reported for Merino stud ewes of various genotypes (11.81 - 20.00 g/day) (Hogan *et al.*, 1979).

Table 2 Measures of wool growth rate for ram and ewe lambs of various breeds measured over a ten-month period

Main effect		Wool growth per surface area, mg/cm^2/day	Calculated monthly fleece growth, g	Calculated wool growth rate, g/day
Sex	Ewe	1.030 ± 0.0366	299.8 ± 11.47	9.43 ± 0.38
	Ram	1.107 ± 0.0337	360.8 ± 10.54	11.42 ± 0.35
	P-value	0.070	<0.001	<0.001
Breed	Merino*	1.351[a] ± 0.0741	409.5[a] ± 23.21	12.94[a] ± 0.77
	Dohne Merino**	1.059[b] ± 0.0396	306.3[b] ± 12.41	9.72[bc] ± 0.41
	SAMM**	1.025[b] ± 0.0381	333.3[b] ± 11.92	10.55[b] ± 0.40
	Dormer**	0.839[c] ± 0.0373	272.0[c] ± 11.68	8.49[c] ± 0.39
	P-value	<0.001	<0.001	<0.001

SAMM: South African Mutton Merino
[a-b]Means with a common superscript were not different at P =0.05
*Calculated using formula: total fleece growth = 6.5 x lamb weight$^{2/3}$ x wool mass from 100 cm^2 clipping
**Calculated using formula: total fleece growth = 6 x lamb weight$^{2/3}$ x wool mass from 100 cm^2 clipping

Linear regressions were fitted to model the cumulative fleece weight data as functions of the age and bodyweight of the lambs at sampling. The parameter estimates were compared to determine the effects of sex and breed (Table 3). Models that described the increase in greasy fleece weight with age as predictor showed that the intercepts did not differ with sex (P =0.794), whereas the slope for ram lambs was greater than for ewe lambs (P <0.001). Merino and Dohne Merino lambs showed higher (P <0.05) intercept values than Dormer and SAMM lambs. Merino lambs presented a steeper slope, followed by SAMM and Dohne Merino (0.0098) lambs, and Dormers had the shallowest slope (P <0.001). Using weight as a predictor, neither intercept nor slope varied with sex (P >0.05). The intercept value of Dohne Merino lambs was markedly higher than that of Dormer and SAMM lambs, whereas that of Merino lambs did not differ from t the other breeds (P >0.05). Again, Merinos presented higher values for the slope and Dormers had the lowest value (P <0.05). The slope for Dohne Merinos differed from Merinos and Dormers (P <0.05), but did not differ (P >0.05) from SAMM lambs, which differed from Merinos (P <0.05). In predicting the clean fleece production of the lambs, no differences were observed between rams and ewes for either of the parameter values when age or bodyweight was used as a predictor (P >0.05). When age was used as a predictor of clean fleece weight, Merinos and Dohne Merinos had higher intercept estimates than Dormer or SAMM (P <0.05). Merinos had a significantly higher slope than the other breeds. When bodyweight was used as a predictor of clean fleece weight, the Dohne Merinos presented the highest intercept estimate and Dormer and SAMM lambs the lowest P <0.05), whereas that of Merinos did not differ from the other breeds (P >0.05). The slope of the Merino lambs for predicting clean fleece weight from bodyweight was markedly higher than that of the other breeds, which did not differ (P >0.05). Because farmers work primarily with greasy fleece weight when evaluating wool yield, the functions were developed to predict greasy fleece weight from age or bodyweight of the lambs. Moderate to high R^2 coefficients of determination were obtained for these regression functions, indicating that a large portion of the variation was accounted for by the models.

Table 3 Linear equations that predict greasy and clean fleece weight from age and bodyweight of ram and ewe lambs of various breeds

Main effect	Greasy fleece weight based on age		R^2	Clean fleece weight based on age		R^2
	Intercept	Slope		Intercept	Slope	
Ewe	0.616 ± 0.191	0.0096[b] ± 0.0004	0.444	0.384 ± 0.106	0.0062 ± 0.0003	0.479
Ram	0.548 ± 0.176	0.0115[a] ± 0.0004	0.439	0.408 ± 0.099	0.0068 ± 0.0003	0.334
P-value	0.794	<0.001		0.872	0.300	
Merino	1.146[a] ± 0.384	0.0131[a] ± 0.0008	0.616	0.758[a] ± 0.211	0.0081[a] ± 0.0006	0.499
Dohne	0.940[a] ± 0.205	0.0098[bc] ± 0.0004	0.504	0.722[a] ± 0.120	0.0060[b] ± 0.0003	0.455
SAMM	0.130[b] ± 0.197	0.0105[b] ± 0.0004	0.620	0.076[b] ± 0.108	0.0059[b] ± 0.0003	0.550
Dormer	0.112[b] ± 0.205	0.0086[c] ± 0. 0004	0.656	0.028[b] ± 0.115	0.0060[b] ± 0.0003	0.686
P-value	0.005	<0.001		<0.001	0.012	

Main effect	Greasy fleece weight based on weight		R^2	Clean fleece weight based on weight		R^2
	Intercept	Slope		Intercept	Slope	
Ewe	0.388 ± 0.183	0.0395 ± 0.0016	0.328	0.256 ± 0.096	0.0252 ± 0.0012	0.375
Ram	0.432 ± 0.168	0.0384 ± 0.0015	0.395	0.342 ± 0.090	0.0230 ± 0.0011	0.252
P-value	0.858	0.613		0.520	0.193	
Merino	0.690[ab] ± 0.367	0.0552[a] ± 0.0033	0.666	0.479[ab] ± 0.192	0.0341[a] ± 0.0024	0.578
Dohne	0.786[a] ± 0.196	0.0385[b] ± 0.0017	0.524	0.634[a] ± 0.110	0.0235[b] ± 0.0014	0.427
SAMM	0.097[b] ± 0.188	0.0340[bc] ± 0.0017	0.658	0.046[b] ± 0.099	0.0193[b] ± 0.0012	0.478
Dormer	0.067[b] ± 0.195	0.0282[c] ± 0.0018	0.678	0.038[b] ± 0.105	0.0193[b] ± 0.0013	0.622
P-value	0.029	<0.001		<0.001	<0.001	

[a-c] Regression coefficients with a common superscript were not different at $P = 0.05$

Sex did not influence fibre diameter or its standard deviation (SD), coefficient of variation (CV), comfort factor, or crimp frequency ($P > 0.05$) (Table 5). However, the clean yield of ewe lambs was 8.6% higher than that of rams, with ewes presenting higher staple lengths than rams ($P < 0.05$). Wool samples from Dormer lambs had the thickest fibre diameters, with the greatest SD and CV, and the lowest comfort factor ($P < 0.05$). After the Dormer lambs, wool from SAMM lambs presented a greater fibre diameter than that of Dohne Merino and Merino lambs ($P < 0.05$). Wool samples from Dohne Merino, Merino, and SAMM lambs did not differ significantly in SD, CV, or comfort factor. The clean yield of SAMM yearling wool was markedly lower than that of the Merino. The staple length of yearling Merino wool was longer than that of SAMM wool ($P < 0.05$), whereas that of Dohne Merino and Dormer wool did not differ from any of the breeds ($P > 0.05$). Crimp frequency did not vary with sex ($P = 0.395$) or breed ($P = 0.461$).

The bodyweights of SAMM ewes were significantly higher than those of Dormer ewes, which were heavier than those of Dohne Merino and Merino ewes (Table 6). Merino ewes produced the heaviest greasy and clean fleece weights, followed by Dohne Merino and SAMM ewes, which were heavier than fleeces from Dormer ewes ($P < 0.05$). Merino ewes presented higher clean yields, followed by Dohne Merinos, and wool from SAMM and Dormer ewes presented the lowest clean yields ($P < 0.05$).

Similar to yearling lambs, mature Merino and Dohne Merino ewes produced the finest wool, followed by SAMM ewes, and Dormer ewes produced the coarsest fibres ($P < 0.05$). Wool from Dormers had higher ($P < 0.05$) SD for fibre diameter than that from SAMM ewes, which was higher than Dohne Merino and Merino ewes. The CV for fibre diameter were lowest ($P < 0.05$) for wool from Merino ewes. Wool from Dormer sheep had a significantly lower comfort factor than the other breeds. Merino and Dohne Merino wool samples displayed a significantly lower crimp frequency than that of SAMM and Dormer samples.

Table 5 Wool quality traits of one-year-old ram and ewe lambs of various South African wool sheep breeds

Main effect		Fibre diameter, µm	SD of fibre diameter, µm	CV of fibre diameter, %	Comfort factor, %	Clean yield, %	Staple length, mm	Crimps per cm
Sex	Ewe	23.7 ± 0.52	4.2 ± 0.18	17.4 ± 0.43	85.1 ± 2.33	65.4 ± 1.84	146.69 ± 5.621	4.6 ± 0.4
	Ram	23.9 ± 0.49	4.1 ± 0.17	16.7 ± 0.44	84.8 ± 2.19	59.8 ± 1.73	130.80 ± 5.183	4.1 ± 0.4
	P-value	0.798	0.727	0.265	0.912	<0.001	0.042	0.395
Breed	Merino	19.6^c ± 1.03	3.1^b ± 0.37	15.6^b ± 0.94	99.6^a ± 4.65	61.9^a ± 3.68	158.97^a ± 11.295	4.1 ± 0.8
	Dohne Merino	21.0^c ± 0.59	3.4^b ± 0.21	16.0^b ± 0.53	96.9^a ± 2.66	62.5^{ab} ± 2.10	141.67^{ab} ± 6.037	4.1 ± 0.4
	SAMM	23.3^b ± 0.53	3.8^b ± 0.19	16.4^b ± 0.48	96.9^a ± 2.38	56.5^b ± 1.89	121.74^b ± 5.801	5.0 ± 0.4
	Dormer	31.3^a ± 0.57	6.4^a ± 0.20	20.3^a ± 0.51	46.4^b ± 2.55	69.6^{ab} ± 2.01	132.61^{ab} ± 6.012	4.3 ± 0.4
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	0.018	0.461

SD: standard deviation, CV: coefficient of variation, SAMM: South African Mutton Merino
[a-c] Values with a common superscript were not different at *P* =0.05

Table 6 Wool quality traits of mature ewes for various South African wool sheep breeds

Trait	Merino	Dohne Merino	SAMM	Dormer	*P*-value
Body weight	71.5^c ± 1.5	73.5^c ± 1.4	88.0^a ± 1.6	80.7^b ± 1.6	<0.001
Greasy fleece weight, kg	5.22^a ± 0.13	4.42^b ± 0.12	3.37^b ± 0.13	2.76^c ± 0.14	<0.001
Clean fleece, kg	3.73^a ± 0.11	2.93^b ± 0.10	2.01^b ± 0.11	1.57^c ± 0.11	<0.001
Fibre diameter, µm	18.3^c ± 0.3	18.2^c ± 0.3	21.8^b ± 0.4	27.9^a ± 0.4	<0.001
SD of fibre diameter, µm	3.0^c ± 0.1	3.3^c ± 0.1	3.9^b ± 0.1	5.3^a ± 0.1	<0.001
CV of fibre diameter, %	16.3^b ± 0.4	18.0^a ± 0.4	17.9^a ± 0.4	19.1^a ± 0.4	<0.001
Comfort factor, %	99.7^a ± 1.8	99.5^a ± 1.6	98.0^a ± 1.8	68.8^b ± 1.9	<0.001
Clean yield, %	71.2^a ± 1.3	66.3^b ± 1.1	59.3^c ± 1.3	56.2^c ± 1.3	<0.001
Staple length, mm	158.7^a ± 4.1	146.6^{ab} ± 3.7	131.7^{bc} ± 4.2	125.9^c ± 4.3	<0.001
Crimps per cm	4.9^b ± 0.17	4.6^b ± 0.15	7.2^a ± 0.17	7.2^a ± 0.17	<0.001

SD: standard deviation, CV: coefficient of variation, SAMM: South African Mutton Merino
[a-c] Values with a common superscript were not different at *P* =0.05

Merino yearlings and ewes produced wool with the finest fibre diameters (<20 µm), with the lowest level of variation. Yearling Dohne Merino and SAMM lambs produced wool with a medium fibre diameter, whereas that of Dohne Merino lambs was significantly finer than SAMM wool. In the mature ewes, Dohne Merino wool samples presented a fine fibre diameter, similar to that of the Merino ewes (18 µm), whereas SAMM ewes produced wool with a medium fibre diameter. Dormer sheep produced wool with a coarse fibre diameter (>27 µm) and low comfort factor. Such coarse wools with low comfort factors are not suitable for fabrics that have direct contact with the skin, and are more suited to the manufacturing of carpets and blankets. The national average fibre diameter for Dohne Merino stud ewes was reported to be 19.4 µm (Van Wyk *et al.*, 2008). Snyman *et al.* (1998) reported that fibre diameter of Merino ewes varied (19.8 - 23.0 µm) among South African research flocks. Unfortunately published literature could not be found for wool traits of Dormer sheep, though its ancestor the Dorset Horn produces coarse wool with fibre diameters greater than 29.0 µm (Steinhagen *et al.*, 1986).

The clean yield of Merino ewe wool remained similar to studies from the Elsenburg flocks, which ranged from 71% to 74% (Brand *et al.*, 1999; Cloete *et al.*, 2003; Matebesi–Ranthimo *et al.*, 2017). The clean yield of Dohne Merino was estimated to be 68% (Steinhagen & De Wet, 1986; Cloete *et al.*, 2003). The clean yield of the SAMM breed has also been presented as 60 - 64% of the greasy fleece weight (Brand *et al.*, 1999; Cloete *et al.*, 2003). The yields for Dohne Merino and SAMM fleeces were slightly lower than those reported in the literature. Clean yields for fleece from Dormer sheep have not been documented, but this study noted clean yields of 69.6% for yearlings and 56.2% for ewes. Merino wool samples had higher staple lengths than Dohne Merino wool, followed by SAMM and Dormer wool. The staple lengths of wool from the yearling lambs resembled those of the ewes from the same breeds, which were shorn 12 months earlier. The crimp frequency was traditionally used as an indirect selection criterion for fibre diameter. However, it has a greater association with fibre curvature (Hatcher & Atkins, 2000). An increase in curvature may result in an increase in the incidence of fibre breakages (Holman & Malau-Aduli, 2012). Wool from yearling lambs did not vary in crimp frequency. However, in mature ewes, Merino and Dohne Merino wool displayed lower crimp frequencies than Dormer and SAMM wool. Merino and Dohne Merino wool is thus expected to display less curvature and should be less susceptible to fibre breakage.

Wool growth rates, staple lengths and fleece weights of the Merino were greater than those of the other breeds and presented greater clean yield, finer fibre diameter and low crimp frequency. Wool growth rates of Dohne Merino lambs, and fleece weights did not differ (P <0.05) from those of SAMM lambs, although staple lengths of Dohne Merino wool were longer than those of SAMM wool. The SAMM yearlings and mature ewes were heavier than their Dohne Merino counterparts. So size may have offset differences in fleece weight. Because staple lengths differ, it was expected that when correcting for bodyweight, Dohne Merinos would produce a heavier fleece than SAMM sheep. Dormer sheep have not been bred for wool production and thus, they produce a lighter fleece with coarser fibre. Because Dormer lambs are mostly slaughtered at a young age soon after weaning, the income derived from wool production would be negligible.

Conclusion

Producers can use these results to predict wool yield at a given age or weight and thus the financial contribution of wool for these breeds. The study should be repeated to increase the database and obtain more reliable estimates. In particular, this should be performed for Merino lambs, because Merino lines in South Africa vary in wool production.

Authors' Contributions

DAVdM collected and analysed the data, interpreted the results and wrote the initial draft of the manuscript; TSB conceptualized the hypotheses, designed the trials, and collaborated in the interpretation of the results; LCH collaborated in the interpretation of the results and critical review of the manuscript. All authors have read and approved the finalized manuscript.

Conflict of Interest Declaration

The authors declare that they have no affiliations with organisations with financial or non-financial interest in the matter described in this manuscript.

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