Effect of lambing season, year, gender and birth status on the wool characteristics of Merino ewes and lambs

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Abstract
A three- year (2017-2019) study was conducted on the Kokstad Research Station to investigate the effect of lambing season, year, sex and birth status on wool characteristics of Merino ewes and lambs. Data was collected from 2017 to 2019 using 107 ewes and 226 lambs that were born in autumn (AL 86), spring (SL 71) and all year round (YR 69) as lambing seasons. Greasy fleece weight (GFW) of ewes in SL were 0.3 kg lighter (*P<0.001*) than those in AL and YR. The clean wool weight (CFW) of ewes in AL and YR were 0.2 kg were heavier (*P<0.001*) than those in YR. The year of lambing had influence on wool traits in 2017, 2018 and 2019. In 2017, ewes mean FD (0.8, 1.3 µm) significantly (P<0.001) finer than in 2019 and 2018. There were positive (*P<0.001*) correlations (0.13 - 0.91) between FSD and FD, CVFD, CFW and also negative correlations (-0.13-0.59) between CF and FD, CVFD, CL, CFY, GFW in ewe wool traits. The GFW for lambs born in the SL were 0.3 kg lighter (*P<0.001*) than those in AL and YR. There was a moderate to high positive correlation coefficients (0.13 – 0.98) between FSD and FD, CVFD, CFW and also negative correlation coefficients (-0.13-0.77) between CF and FD, CVFD, CL, CFY, GFW in ewe wool traits. From the results, it is recommended that for communal farming systems serious consideration should be taken to implement specific breeding and lambing seasons to improve wool income.

Keywords: Greasy fleece weight, Clean fleece weight, Fibre diameter, Correlation coefficients
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Introduction
Wool production is one of the main sub-sectors of the South African livestock industry, which brings foreign exchange currency into the South Africa economy. The South African wool industry attracts foreign exchange currency from Asian, United States of America (US) and European Union (EU) markets due to its finer micron type and its internationally renowned status of high quality wool (Nkamisa, 2020). Moreover, the diversification of Australian-New Zealand sheep industry in favour of meat breeds, a response to export demand for lamb and mutton and the general decline in the sheep numbers due to drought contributed to lower wool production (Wilcox, 2018; Rowe, 2010). On the other hand, the surging global demand for South African wool was also prompted by the boycott of Australian wool due to the use of mulesing to control flystrike (Sneddon & Rollin, 2010). All these factors led to the South African wool being preferred by foreign markets. Despite all the positive spin offs to the wool industry in the past 5-6 years, the South African wool industry has been hit hard by foot mouth disease (FMD) in some parts of Limpopo neighbouring the Kruger National Park and the Northern parts of KwaZulu-Natal. This led to the Asian (China) markets imposing a wool import ban from South Africa due to the FMD outbreak (Sihlobo, 2020). These restrictions exacerbated the constraints faced by the wool industry while still recovering from the devastating following drought years (2014-2016), decline in sheep numbers, increased stock theft, low economic growth and uncertainty in the rand exchange rate (weak rand: dollar exchange rates).

Fibre characteristics from sheep wool can vary depending on the sheep breed, its age, the environmental grazing conditions, local market requirements, and export opportunities for the country of origin (Doyle *et al.*, 2021). The economically important traits of wool including clean fleece weight, mean fibre diameter, fibre diameter variability, fibre length, wool “style” (crimp frequency, crimp definition, crimp regularity, wool color, and dust penetration), and staple strength). Nutrition, genetic and environmental factors are major factors influencing wool quality and quantity (Khan *et al*, 2012).

Allden (2001) concluded that the available evidence points to a positive linear relationship between intake of digestible dry matter and wool growth. Increased wool production obtained by improved nutrition is almost invariably associated with an increase in the mean diameter of the fibres. Sheep subjected to good/poor or poor/good regimes grew similar amounts of wool, but the fleeces of the latter group consisted of fewer, coarser fibres (Schinckel & Short, 2001). Clean scoured yield (clean Fleece weight) is obviously important in determining the amount of finished product obtained from a given weight of greasy wool. Staple crimp, both with respect to frequency and amplitude, has traditionally been used as an indicator of fibre fineness. However, while the relationship with fineness frequently applies, it is by no means invariable (Khan *et al*, 2012). The fibre diameter is the most important wool trait, which affects the price of greasy and clean wool and will impact on the processing performance (AWTA, 2004). In the Australian Merino, a comparison of the fine, medium and strong wool strains shows an increasing clean fleece weight associated with increased fibre diameter, staple length and body weight (Williams, 2000). The wool quality and production, such as staple strength, length, and fleece weights, are manipulated by the timing of the shearing event (McGuirk et al., 1966). Inconsistent rainfall is a challenge to wool producers as pasture growth is limited by rainfall. Inconsistent pasture growth will lead to a decline in wool quality traits, such as staple strength, which is important for early stage processing (McGregor *et al*., 2016).

Wool production is influenced by the age and sex of animals, and by reproduction in the ewe. Less wool is grown by young animals per unit of feed intake, presumably due to competition for nutrients between follicles and other tissues. Maximum fleece weights in sheep have been observed as from three to five years of age, with variable rates of decline in wool production thereafter (Corbett, 2001). It has also been observed that adult wool production is less in sheep born and reared as twins than in single born lambs, and in sheep born to young ewes than in the progeny of mature ewes (Corbett, 2001).

In KwaZulu-Natal (KZN), wool producers are mostly concentrated in the highland areas in the grassland biome (Magawana *et al*., 2021). These producers can be classified into commercial and communal sectors. The commercial sector contributes significantly to the South African wool industry and this could be attributed to the managerial control over resources in terms of planned breeding seasons, rotational grazing camps, water resources and the use of planted pastures during critical periods to offsets feed shortages in winter (Magawana *et al*., 2021). In contrast, communal producers are constrained by the fact that the land as a resource to farm with, is shared among the community members. This adds to a further burden to the sheep and wool producers in this category, as factors such as rotational grazing practices and breeding seasons, which are the corner stone of the successful and competitive wool industry, cannot be implemented. Consequently, the contribution of these communal producers in KZN wool industry is minimal. Most of the communal farmers that participate in the KZN wool industry are from two Districts (Harry Gwala and Umzinyathi). Moreover, in a study conducted by Magawana *et al* (2021), a year round lambing season proved to be less efficient, in terms of low conception (58.4%), weaning (65.5%) and high lamb mortality rates (34.7%). While in the same study, commercially run sheep flocks were more efficient in terms of conception (80%), weaning (97.7%) and lamb mortality rates (3.3%). However, following up on the study by Magawana *et al* (2021), it was found that there is a paucity of information investigating the impact of lambing season on wool characteristics of Merino ewes and their lambs. Hence, the objective of this study was to investigate the impact of a year round lambing season system, gender, year, birth status on the wool characteristics of Merino ewes and their lambs.

Materials and methods

The study was approved by KZN Department of Agriculture and Rural Research Project Committee with project number AS-S08/03K and was conducted at Kokstad Research Station (S30º 31´12.86, E29º 24´36.78) in the East Griqualand Grassland biome of KwaZulu-Natal as described by Mucina & Rutherford (2006). The average annual rainfall is 800 mm and altitude is 1340-1830 m above sea level. The vegetation of Kokstad Research Station is classified into two types: Gs12-East Griqualand Grassland and Gs10-Drakensberg Foothill Moist Grassland (Mucina & Rutherford, 2006). The study was carried over a period of three years namely 2017-2019 with 107 Merino ewes and 226 lambs used for the study (Magawana *et al*., 2021). The three lambing seasons used in the study were spring lambing (SL), autumn lambing (AL) and year round (YR) as described by Magawana *et al.* (2021). The sheep were run under commercial management systems. The management of animals, vaccination programmes, veld management plans (veld grazing conditions and planted pastures) were reported by Magawana *et al.* (2021).

The ewes used in the study were shorn once a year at the beginning of September. AL, SL and YR lambs were shorn at six months of age. The greasy fleece weight of each sheep was weighed using a digital scale (Gallagher W210, Australia) and fleece samples were collected through the mid-side sample technique as described by the Wool Testing Bureau of South Africa. Approximately 100g of a fleece sample from each ewe as well as the lamb was collected and put into a zip-top plastic bag and labelled before being transported to the Wool Testing Bureau (Port Elizabeth, South Africa) for the analysis of greasy fleece weight (GFW), fibre diameter (FD), clean fleece yield (CFY), Coefficient of variance of fibre diameter (CVFD), standard deviation of fibre diameter (SDFD), comfort factor (CF) and crimp length (CL). Clean fleece weight (CFW) was determined by multiplication of yield percentage by greasy fleece weight as described by Ferguson *et al*. (2011). The wool characteristics for ewes and lambs were determined annually in September across three years (2017-2019). Ewes and lamb's production performances were measured in the study and reported by Magawana *et al*. (2021) where the SL born lambs tended to perform better from birth to weaning (90 days) than those lambs born in autumn or year round. However, spring born lambs performed poorly post-weaning at 180 days as compared with autumn and year round lambs. However, low ewe reproductive efficiency and high lamb mortality in the YR lambing group were of concern. In this paper only the wool production performance of ewes and their lambs is reported.

The data from the three lambing seasons was analysed using GenStat, 18th edition statistical software (Payne *et al*., 2016). Data analysis utilized an unbalanced design (Genstat regression) to analyse GFW, FD, CFY, CVFD, SDFD, CF and CL of Merino ewes and lambs. Treatment means were compared at the 5% level of significance.

Results & Discussion

The AL and SL ewes had a higher greasy fleece weight at shearing, 0.1and 0.5 kg lower than those in the YR lambing treatment respectively (Table 1). These results are within the expected greasy fleece weight (GFW) of 3-5 kg for commercial wool enterprises (Mciteka, 2005; Marais, 2007). However, the relatively higher YR GFW was not expected, since the YR treatment simulated communal sheep production, where greasy fleece weight reported to range from 2 to 3 kg per ewe (Mvinjelwa *et al*., 2014). This could be attributed to lower stocking rate of the research station, good veld management practices, species composition and diversity of the grazing camps. The year on year variation can be explained by the fact that the annual rainfall data for of the first two years of the study was relatively higher (864.6 mm) than that of the long-term rainfall (778 mm) of the study area as described by Magawana *et al*. (2021) (Table 2). On the other hand, YR ewes might have selected grass species of nutritional quality to counteract limited or no access to pasture supplementation compared to the other treatment groups in the study. Furthermore, the findings in our study are supported by previous reports on low quality diets Moreover, there were no significant ($P>0.05$) differences observed in the CFY percentages. The AL and SL lambing ewes clean fleece weights (CFW) were 0.1 and 0.4 kg heavier than those in the YR ewes. These results are possibly explained by the availability of oats pasture offered to the AL and SL treatments as previously reported by Magawana *et al*. (2021). Several studies indicated that fleece weight can be directly linked with feed on offer (Ferguson *et al*., 2011). Furthermore, there were no significant ($P>0.05$) treatment differences observed in the fibre diameter and comfort factor traits (Table 1). The mean fibre diameter and comfort factor were not influenced by lambing season. These results indicate that the price paid for the wool would be the same irrespective of the treatment, since fibre diameter accounts for 75-80 percent of the monetary values (Botha & Hunter, 2010, Schlink, 2009; Schlink, 2013). The Standard deviation of fibre diameter (SDFD) of the SL ewes was 0.2 µm higher ($P<0.001$) than those of the AL and YR lambing ewes. The increase in the standard deviation of fibre diameter could be ascribed to the stage of lactation, nutrition and post-lambing stress, since SL ewes were shorn a week after they completed their lambing period. The results of our study are supported by those of Saywer *et al*. (2021) who investigated pre- and post-partum variation in wool cortisol and wool micron in Australian Merino ewes. The SL ewes were 0.7 µm higher ($P<0.001$) Coefficient of variance of fibre diameter (CVFD) than those of the AL and YR lambing ewes. Furthermore, it may also be noted that an increase in FD can be positively correlated with CVFD and SDFD in Merino wool. The comfort factor was not affected ($P>0.05$) by lambing season in the current study, as a result of the positive correlation between FD and the SDFD. The SL ewes recorded 2 and 3.6 mm lower ($P<0.001$) crimp lengths (CL) compared to the AL and YR ewes respectively. This could be attributed to the fact that SL ewes had a higher fibre diameter, which has negative relationship with crimp length as previously reported in literature (Malau-Aduli *et al*., 2012).

Table 1 Effect of lambing season on wool production traits (± S.E) of Merino ewes over the 3-year trial period (n =107)

Lambing season	No of ewes	GFW kg	CFY %	CFW kg	FD µm	SDFD µm	CVFD µm	CF %	CL mm
AL	30	5.0^{b}±0.1	68.6^{a}±0.5	3.4^{b}±0.1	19.6^{a}±0.2	3.4^{a}±0.1	17.5^{a}±0.2	98.9^{a}±0.1	10.9^{b}±0.2
SL	30	4.9^{b}±0.1	67.1^{a}±0.5	3.3^{b}±0.1	19.8^{a}±0.2	3.6^{b}±0.1	18.2^{b}±0.2	99.2^{a}±0.1	8.9^{a}±0.2
YR	47	4.5^{a}±0.1	67.5^{a}±0.5	3.0^{a}±0.1	19.6^{a}±0.2	3.4^{a}±0.1	17.5^{a}±0.2	99.2^{a}±0.1	12.5^{c}±0.2

Values in the same column with different superscript (a, b, c) differ significantly ($P<0.05$). GFW - greasy fleece weight, FD - fibre diameter, CFY- clean fleece yield, CVFD - coefficient of variance of fibre diameter, SDFD - standard deviation of fibre diameter, CF - comfort factor, CL - crimp length

Table 2 Rainfall and average monthly temperatures over 3 years (2017-2019)

Months	Rainfall (mm) 2017	Rainfall (mm) 2018	Rainfall (mm) 2019	Long-term rainfall (mm)
January	130.8	220.7	74.4	129
February	289.6	70.1	237.7	125
March	80.5	159.8	109.2	101
April	46.0	16.8	145.5	49
May	44.7	13.2	9.91	25
June	0.25	0	0.76	15
July	0	12.7	0	13
August	1.20	42.4	0	19
September	11.7	39.1	0	41
October	143.8	40.4	1.52	63
November	110.5	47.0	3.81	95
December	122.2	85.6	10.9	103
	981.3	**747.8**	**593.7**	**778**

The GFW of ewes lambing in 2018 was 0.6 and 0.3 kg higher ($P<0.001$) than those lambing in 2019 and 2017 respectively (Table 3). This could be explained by good grazing conditions ensuing from good rainfall in those years (2017-18) and lower pasture yield associated with crown rust infection of pasture in 2019 (Magawana *et al*., 2021). On the other hand, the results of this study confirmed earlier findings that AL and SL lambing ewes were heavier in terms of live weight when feed availability improves (Magawana *et al*., 2021). Similar findings were confirmed by Ferguson *et al*. (2011) when using live weight change during pregnancy and lactation to predict wool and reproduction performance of Merino ewes. The CFY of ewes lambing in 2017 were 1.2 and 5.9% higher ($P<0.001$) than those lambing in 2018 and 2019 respectively. The results of the study on clean yield seems to suggest a linear relationship exists between rainfall, veld/ pasture availability and CFY with years (2017-18). Year effects are also apparent for GFW, CFW, FD, SDFD and CL as indicated in Table 2. The results of this study could be attributed to the changes in non-genetic factors such rainfall while on the other hand, the rainfall declined by 233.5 and 387.6 mm in 2018 and 2019 lambing year when compared to 2017 (Table 2). Similar trends were also observed in respect of SDFD. This could be ascribed to the fact that FD is positively correlated with CVFD (Table 3). Moreover, there were significant ($P>0.05$) differences in coefficient of variance of fibre diameter and the comfort factor. The crimp length in 2019 of lambing ewes were 4.2 mm and 4.4 mm lower than those lambing in 2017 and 2018 respectively.

Table 3 Effect of lambing year on wool production traits (± S.E) of Merino ewes (n = 107)

Year of lambing	No of ewes	GFW kg	CFY %	CFW kg	FD µm	SDFD µm	CVFD µm	CF %	CL mm
2017	107	4.8^b±0.1	70.1^b±0.5	2.9^a±0.1	19.0^a±0.2	3.3^a±0.2	17.5^a±0.2	98.7^a±0.1	12.1^b±0.2
2018	107	5.1^c±0.1	68.9^b±0.5	3.4^b±0.1	20.3^c±0.2	3.6^c±0.2	17.8^a±0.2	99.2^a±0.1	12.3^b±0.2
2019	107	4.5^a±0.1	64.2^a±0.5	3.5^b±0.1	19.8^b±0.2	3.4^b±0.2	17.6^a±0.2	99.4^a±0.1	7.9^a±0.2

Values in the same column with different superscript (a, b) differ significantly (*P<0.05*).
FD - fibre diameter, CFY- clean fleece yield, CVFD - coefficient of variance of fibre diameter, SDFD - standard deviation of fibre diameter, CF - comfort factor, CL - crimp length.

The wool CF was moderately negatively correlated with CVFD (-39), FD (-0.44) and FSD (-0.59). The results of this study are in agreement with earlier studies in the Australian Merino sheep industry with highly negative correlations between CF and FD (Malau-Aduli *et al*., 2010). Lower to moderate correlations (*P<0.001*) between CVFD and FD (0.18) and FSD (0.62) were observed. The FD was moderately positively correlated with FSD (0.42). The CFW was positively correlated (*P<0.001*) with CL (0.13), GFW (0.91) and CFY (0.58). The CL was negatively correlated with FSD (-0.15) and CFY (-0.15). The GFW was positively correlated with CFY.

Table 4 Pearson's residual correlation coefficients between ewe wool quality traits

Traits	CF	CVFD	FD	CFW	CL	GFW	FSD	CFY
CVFD	-0.39***	-						
FD	-0.44***	0.18**	-					
CFW	-0.05	-0.10	0.04	-				
CL	0.06	-0.08	-0.09	0.13**	-			
GFW	-0.06	-0.11	0.07	0.91***	0.03	-		
FSD	-0.59***	0.62***	0.42***	-0.02	-0.15**	0.03	-	
CFY	-0.02	-0.03	-0.05	0.58***	-0.15***	0.21***	-0.11	-

Level significant: * significant (P<0.05), ** highly significant (P<0.01), *** very highly significant (0.001). Greasy fleece weight (GFW), Clean fleece yield (CFY), Clean fleece weight (CFW), Comfort factor (CF), Coefficient of variation of fibre diameter (CVFD), Crimp length (CL), Fibre diameter (FD), standard deviation of fibre diameter (SDFD)

The greasy fleece weight (GFW) of lambs born to SL ewes were 0.3 kg lighter (*P<0.001*) than those born in the AL and YR respectively (Table 5). This could be attributed to the fact that SL born lambs were shorn in partial wet –cool conditions (autumn season) (April) every year when they were six months old. On the other hand, seasonal differences in the veld with the decline in sour veld grasses in terms of quantity and quality could also have contributed to the lighter GFW in the SL lambs. Similarly, the CFW of lambs born in SL were 0.2 kg lighter (*P<0.001*) than those born in AL and YR. The fibre diameter (FD) of SL and YR born lambs did not differ , while the FD of SL born lambs were 0.6 µm lower (*P<0.001*) than the AL born lambs. Therefore, SL lambs had the finest wool compared to the other lambing seasons. The crimp length (CL) of lambs born in SL were 24.7 and 20.4 mm longer than those born in AL and YR respectively. There was no differences in CFY, SDFD, CVFD and CF across lambing seasons. Gender and birth status had no influence on the wool production traits.

Table 5 Effect of lambing season on wool production traits (± S.E) of Merino lambs over the 3-year trial period (n =226)

Lambing season	No of ewes	GFW kg	CFY %	CFW kg	FD µm	SDFD µm	CVFD µm	CF %	CL mm
AL	86	1.8^{b}±0.1	71.4^{a}±0.7	1.3^{b}±0.1	17.8^{b}±0.2	3.3^{a}±0.2	18.6^{a}±0.3	99.4^{a}±0.1	58.3^{a}±1.3
SL	71	1.5^{a}±0.1	71.1^{a}±0.9	1.1^{a}±0.1	17.2^{a}±0.2	3.3^{a}±0.2	19.0^{a}±0.3	99.4^{a}±0.1	83.0^{c}±1.6
YR	69	1.8^{b}±0.1	72.5^{a}±0.7	1.3^{b}±0.1	17.6^{b}±0.2	3.4^{a}±0.2	19.4^{a}±0.3	99.6^{a}±0.1	62.6^{b}±1.3
Gender of lambs									
Male	108	2.1^{a}±0.1	71.1^{a}± 0.4	1.5^{a}±0.1	17.7^{a}±0.2	3.3^{a}±0.2	19.0^{a}±0.3	99.4^{a}±0.1	65.9^{a}±1.1
Female	118	2.1^{a}±0.1	70.8^{a}± 0.5	1.5^{a}±0.1	17.4^{a}±0.2	3.4^{a}±0.2	18.9^{a}±0.3	99.5^{a}±0.1	65.5^{a}±1.2
Birth status									
Single	154	2.2^{a}±0.1	71.1^{a}± 0.2	1.5^{a}±0.1	17.5^{a}±0.2	3.3^{a}±0.2	19.0^{a}±0.3	99.5^{a}±0.1	65.9^{a}±0.9
Twins	72	2.0^{a}±0.2	70.6^{a}± 0.9	1.4^{a}±0.1	17.8^{a}±0.2	3.3^{a}±0.2	18.8^{a}±0.3	99.4^{a}±0.1	65.2^{a}±1.6

Values in the same column with different superscript (a, b) differ significantly (*P<0.05*).
Greasy fleece weight (GFW), Clean fleece yield (CFY), Clean fleece weight (CFW), Comfort factor (CF), Coefficient of variation of fibre diameter (CVFD), Crimp length (CL), Fibre diameter (FD), standard deviation of fibre diameter (SDFD

In terms of the wool production traits (Table 6), CFW was highly positively correlated with GFW (0.98), CL (0.29) and CFY (0.17). CF was positive correlated with CFY (0.22). CVFD was highly negatively correlated with CFY (-0.18) and CF (-0.47). CL was highly correlated to CVFD, while GFW (0.29), CFY (0.21), CFW (0.32), CF (0.13) were negatively correlated with CVFD (-0.23). FD was highly negatively correlated with CFY (-0.26), CF (-0.65). FSD was highly negatively correlated with CFY (-0.29), CF (-0.77), CL (-0.26) but positively correlated with CVFD (0.80) and FD (0.62).

Table 6 Pearson's residual correlation coefficients between lamb wool quality traits

	GFW	CFY	CFW	CF	CVFD	CL	FD	FSD
CFY	-0.04	-						
CFW	0.98***	0.17*	-					
CF	-0.01	0.22**	0.03	-				
CVFD	0.04	-0.18**	0.01	-0.47***	-			
CL	0.29***	0.21**	0.32***	0.13***	-0.23**	-		
FD	0.04	-0.26***	-0.01	-0.65***	0.06	-0.15	_	
FSD	0.06	-0.29***	0.01	-0.77***	0.80***	-0.26***	0.62***	_

Level significant: * significant (P<0.05), ** highly significant (P<0.01), *** very highly significant (0.001). Greasy fleece weight (GFW), Clean fleece yield (CFY), Clean fleece weight (CFW), Comfort factor (CF), Coefficient of variation of fibre diameter (CVFD), Crimp length (CL), Fibre diameter (FD), standard deviation of fibre diameter (SDFD)

The year of lambing had a significant (*P<0.001*) effect on GFW, CFY, FD, SDFD, CVFD and CL traits (Table 7). The GFW of lambs born in 2017 were 0.4kg heavier (*P<0.001*) than those born in 2018 and 2019 respectively. This results are in conformity of the earlier findings that lambs born in 2017, which had a higher live weight which can could be attributed to the fact that the non-genetic environmental factors such as good rainfall and feed availability might have contributed to heavier GFW in 2017 (Magawana *et al*., 2021). The CFY of lambs born in 2019 was 3.6, 2.6% higher than those born in 2018 and 2017 respectively. The CFW of lambs born in 2017 were 0.3 kg heavier than those in 2018 and 2019 respectively (Table 7). This finding was expected due to the fact that there is a highly positive correlation between CFY and GFW (Table 5). The FD of lambs born in 2017 were 1.1 µm higher than those born 2018 and 2019. The reduction in FD over three years (2017-2019) could be as result of overall intensive selection of Merino flocks with lower FD. In studies conducted in Uruguay, similar trends were reported in a long-term trial with the aim of reducing FD while increases GFW and live weight (Wuliji *et al*., 1999; Ramos *et al*., 2021). The SDFD of lambs born in 2017, 2018 were 0.3 µm higher compared to those born 2019 (Table 7).

This could be ascribed to the fact that SDFD is highly positively correlated with CVFD (Table 6) and as previously reported by Safari *et al*. (2007) to be moderately correlated with FD. However, in this study, there were no significant correlation between FD and CVFD (Table 6). The year of lambing had ($P>0.05$) no effect on CF. The CL of lambs born in 2019 were 34, 29.3 mm longer than those born 2017 and 2018 respectively (Table 7). Interestingly in this study, CL was positively correlated with CFY and negatively correlated with CVFD (Table 6; Gelaye *et al*., 2021) and this different from what was reported in the study by Van Wyk (1946) where there was negative correlation between CL and CFY.

Table 7 Effect of lambing year on wool production traits (± S.E) of Merino lambs (n = 226)

Year of lambing	No of ewes	GFW kg	CFY %	CFW kg	FD µm	SDFD µm	CVFD µm	CF %	CL mm
2017	86	2.4^b±0.1	70.6^a±0.8	1.7^b±0.1	18.3^b±0.2	3.4^b±0.2	18.7^a±0.2	99.4^a±0.1	54.9^a±1.3
2018	71	2.0^a±0.1	69.6^a±0.8	1.4^a±0.1	17.2^a±0.2	3.4^b±0.2	20.1^b±0.2	99.4^a±0.1	59.6^a±1.4
2019	69	2.0^a±0.1	73.2^b±0.8	1.4^a±0.1	17.2^a±0.2	3.1^a±0.2	17.2^a±0.2	99.6^a±0.1	88.9^b±1.5

Values in the same column with different superscript (a, b, c) differ significantly ($P<0.05$)
Greasy fleece weight (GFW), Clean fleece yield (CFY), Clean fleece weight (CFW), Comfort factor (CF), Coefficient of variation of fibre diameter (CVFD), Crimp length (CL), Fibre diameter (FD), standard deviation of fibre diameter (SDFD)

Conclusion

These results suggest that AL and SL ewes tend to produce heavier GFW and CFW than those lambing throughout the year, resulting in increased wool yields. FD, CFY and CF were not affected by the lambing season. This means that the economic returns per kg from wool remained unaffected irrespective of lambing season. However, it is worth noting that FD is a price determinant of wool. The moderate to high (0.13- 0.91) positive correlations in ewe's wool traits were more pronounced between FSD, CVFD, FD, CFW, GFW and CL. This study showed that lambs in SL had lighter GFW, CFW and had longer crimps length. Furthermore, SL born lambs had a finer wool compared to those born in AL and YR. It is further noted that the correlation in the wool traits (CFW, GFW, CFY, CF, FSD, CVFD, FD) of lambs varied from moderate to high (0.13 – 0.98). This study also showed that the year of lambing could have a significant effect on wool production traits. From these results, it is recommended that for farmers practising year round lambing, serious consideration should be taken to implement specific breeding and lambing seasons to improve wool income. This is of particular relevance to communal farming systems, which run their sheep at higher stocking rates than applied in the trial and do not have a specified breeding season.

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Authors contributions

MM was involved in conducting the research, statistical analysis, interpretation and write up. TJD was involved in the initial design of the trial and editing of the manuscript. JFdV was involved in organising statistical consultant, manuscript design structure, editing of the manuscript and supervise the researcher.

Conflict of interest declaration

No conflict of interest. Authors are employed by KZN Department of Agriculture & Rural Development, which funded this Research. Project number AS-S08/03K**.**

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