The effect of continuous infestation with the sheep body louse (*Bovicola ovis*) on live weight and wool traits of Merino and SA Mutton Merino sheep

A.J. Scholtz[1], J.J.E. Cloete[2,3] and S.W.P. Cloete[1,3]

[2]Directorate: Animal Sciences, Department of Agriculture, Western Cape Government, Private Bag X1, Elsenburg, 7607, South Africa. [2]Elsenburg Agricultural Training Institute, Private Bag X1, Elsenburg 7607, South Africa. [3]Department of Animal Sciences, University of Stellenbosch, Matieland 7602, South Africa

Abstract

The study investigated the effects of infestation with the sheep body louse (*Bovicola ovis*) on wool traits and live weights of non-reproducing Merino and SA Mutton Merino (SAMM) ewes over a two-year period. The performance of infested sheep used as experimental animals was compared to that of comparable louse-free sheep in the same quarantine facility. Experimental sheep were maintained with five infester sheep to ensure an adequate challenge throughout. Total square root transformed lice numbers (as assessed on 10 cm parts opened on the neck, shoulder, midrib and rump of each sheep) showed a marked decline after shearing both in infester (shorn in December) and experimental sheep (shorn in July). Total square root transformed lice numbers of initially louse-free sheep gradually increased with time to reach a mean (±SE) of 3.51±0.18 in Merinos and 0.65±0.27 in SAMM ewes 12 months after infestation commenced. There was some evidence that the mean live weight of infested sheep was impaired by 7.5 to 8.9% just before shearing compared to control sheep (respectively 54.5±1.3 vs. 58.9±2.1 kg in 2011 and 68.9±1.4 vs. 75.8±2.2 kg in 2012). Clean fleece weight was impaired by 12.7% in infested sheep relative to the control group (3.51±0.14 vs 4.02±0.22 kg respectively). Clean yield were accordingly impaired by 3.4% (65.5±0.1 vs. 67.8±1.3 % respectively). None of the other wool traits were affected significantly. The study suggested that SAMM ewes carried lower louse burdens than Merinos when maintained in the same flock under comparable challenge conditions. The infestation of sheep with the sheep body louse resulted in slightly lower live weights than in comparable control sheep, while clean fleece weight and clean yield were also compromised.

Corresponding author: ansies@elsenburg.com

Introduction

The sheep louse, *Bovicola ovis* (previously *Damalinia ovis*; Howell *et al*., 1978; Zumpt, 1970), is regarded as an important ectoparasite of the wool industry. *Bovicola ovis* is an obligate parasite of sheep with no off host stage, and exceedingly poor survival away from the host (James & Crawford, 2001). Up to about two decades ago, lice were satisfactorily controlled by dipping for sheep scab (*Psoroptes communis ovis*) in South Africa. This practice led to a decline in sheep scab in the early 1980's, but the incidence of infestation with sheep lice increased towards the end of the 1980's (De Wet & Bath, 1994), after compulsory dipping was abolished.

Chemical control of lice was so effective for many years that few alternative strategies to dipping have been considered (James, 2002). The continued use of synthetic pyrethroid (SP) backline products resulted in resistance of sheep lice as early as 1987 in Australia (Levot & Hughes, 1990). Resistance to insecticides subsequently continued to spread and 90 % of the western Queensland lice populations were resistant to SP compounds by 1998 (Ward & Armstrong, 1999, as cited by James, 2002). Harmful chemicals in primary products such as meat and wool is strictly legalised by the European Union, thus impacting on the export of these products (Madden, 2001). The quantity of chemicals used for the control of lice exceeded that used for blowfly control by threefold in Australia during the early 1990's (McLeod, 1995). The total chemical load of the Australian wool clip is thus markedly influenced by the pesticides used to control sheep lice (James, 2002).

It unsure what the situation is in South Africa, but it is unlikely to be vastly different from that in Australia in terms of pesticide usage. In fact, anecdotal evidence suggests that a high frequency of local sheep flocks is similarly infested with lice. However, there is a paucity of information on the impact of lice infestation upon production traits of sheep under local conditions, whereas no information exists on the possibility of breed differences pertaining to the severity of lice infestation.

Against this background, the present study investigates the spread of infestation by *B ovis* in previously uninfested non-reproducing ewes of divergent South African breeds. The influence of lice infestation upon live weight and wool traits is investigated simultaneously.

Material and Methods

Experimental animals

Lousy Merino ewes (n=5) of unknown age, but presumably 2 years or older, were purchased from industry sources in the Malmesbury district during February 2010. These sheep were maintained in an approved quarantine facility at the Langgewens Research Farm between Moorreesburg and Malmesbury in the Swartland region of South Africa. The quarantine facility was developed from 8 paddocks of approximately one ha each that were previously used in a study on the provision of shade to pregnant and lactating ewes (Cloete *et al*., 2000).

The lousy sheep bought in were maintained for the sole purpose to act as reservoirs for lice in the project, and will be referred to as infester sheep further on. The experimental protocol required that these ewes were joined in the quarantine facility with twelve ewes each of Merino lines selected for reproduction at Elsenburg Research Farm (Cloete *et al*., 2004b; 2009) or maintained as an unselected control line at Tygerhoek Research Farm (Cloete *et al*., 1998), as well as SA Mutton Merino ewes from Elsenburg (Cloete *et al*., 2004c). The Merino lines represented woolled sheep, while the SA Mutton Merino ewes representing dual-purpose sheep. Twelve Dorper ewes, representing meat sheep, were also initially obtained from the Nortier Research Farm (Cloete *et al*., 2007) to be included in the experiment as well. Although some data were recorded on the Dorper ewes, they were excluded from the experiment after July 2011 for reasons reported below.

The SA Mutton Merino ewes as well as the Tygerhoek Merino ewes were about 14 months of age while the Elsenburg Merino and Nortier Dorper ewes were approximately 11 months. The experimental animals were transported to Langgewens, shorn (except for the Dorpers) to standardise their wool growth, spray-dipped with a registered organophosphate insecticide and allowed for a month to adapt to the conditions. The experiment commenced during May 2010, when the experimental animals were joined with the infester sheep. No louse control was practiced in the flock thus created, and it was assumed that all ewes introduced to the infester ewes were naturally infested with lice.

Four contemporary animals of each breed were kept separately to act as a control treatment without lice. These animals were sprayed with a registered organophosphate dip annually to keep them louse free. These sheep were maintained to collect data that would indicate the impact of lice infestation upon wool and live weight traits in the experimental animals. In the absence of any other suitable criteria, all ewes brought in were stratified according to live weight within genetic groups and allocated within weight groups to either the experimental or control groups.

Experimental protocol and recordings

The experimental animals were subjected to the monthly counting of all lice on four locations on each sheep from June 2010. To enable this, the wool of all experimental subjects were parted for 10 cm at each of four body locations along the midside (neck, shoulder, midrib and hind leg), and all the observed lice were counted. The choice of site was based on the assertions of Kettle & Pearce (1974) and James & Moon (1999) that lice were more likely to be found on the sides and the back of sheep than on the underlines. All animals were also weighed monthly when the lice were counted.

This procedure was followed for a period of two years, from June 2010 to May 2012. All animals were shorn annually. To ensure that an adequate lice challenge is present throughout the year, the infester ewes were shorn in summer during December, while the experimental animals were shorn during winter (June-July). Year-old wool were shorn from all the experimental animals, and weighed to obtain a greasy fleece weight (GFW). Wool samples taken from the fleece were analysed for clean yield (CY), fibre diameter (FD), the coefficient of variation of fibre diameter (CVFD), staple strength (SS) and the position of the break. The live weight and fleece data so recorded were used to assess the impact of lice infestation on these production traits in the experimental sheep.

All sheep were provided with lucerne hay three times a week (Monday, Wednesday and Friday), and had access to potable drinking water. Lucerne hay was supplied on an *ad libitum* basis throughout the experiment, except for the first month, when the experimental group, consisting of 53 animals (12 ewes each of the Tygerhoek Merinos, Elsenburg Merinos, Elsenburg SA Mutton Merinos and Nortier Dorpers, as well as the five infester ewes) were supplied with the same number of lucerne bales as the control group consisting of 16 ewes (4 ewes of each genotype). Feeding space was also initially confined in the former group as the number of self-feeders supplied was only double that in the control group. However, this oversight was realised when it became evident that the experimental group did not gain weight while the control group gained weight. The number of self feeders as well as the number of bales provided were then adapted to the number of animals in the group. The paddocks utilised produced rain

fed material during winter, which was allowed to supplement the lucerne hay provided. The two groups of sheep (experimental plus infesters and the control group) were rotated through the eight paddocks that were available to minimise the possible effect of individual paddocks. However, care was taken that the control group of sheep were always separated from the infested group by at least one paddock, to prevent cross-contamination. The experiment was conducted under the auspices of ethical clearance by the Departmental Ethics Committee for Research on Animals (DECRA) under the number R12/25.

Statistical analysis

Monthly live weight and lice counts data were subjected to least square analysis to account for uneven subclasses. Repeated records on the same animals were accommodated by fitting a random animal effect to account for the intraclass correlation thus arising. ASREML software (Gilmour *et al*., 2006) was used for this purpose. Month of recording was included as a sole fixed effect in the analysis of data from the infester sheep. Breed (Merino or SA Mutton Merino) and treatment (infested or control) were interacted with month of recording in analysis involving the experimental animals.

Wool traits of the year-old fleeces were similarly assessed by repeated records least-squares analyses of variation (Gilmour *et al*., 1999). The fixed effects in this analysis included treatment (infested or control), breed (Merino or SA Mutton Merino) and year (2011 or 2012). Three-factor interactions were not significant ($P>0.28$) in any of the analyses and were not considered. Significant two-factor interactions were either reported in the text or depicted in graphs where they occurred.

Results

Infester sheep

Live weight: The live weight of the infester Merino sheep inclined ($P<0.05$) from the commencement of the trial to reach 64.2 kg in December 2010, just prior to shearing (Figure 1). The live weights of the animals plateaued between 55.6 and 59.8 kg after shearing before again increasing to 67.9 kg ($P<0.05$) in December 2011 before being shorn for the second time in the experiment. Live weights again hovered between 57.9 and 63.4 kg up to the cessation of the experiment.

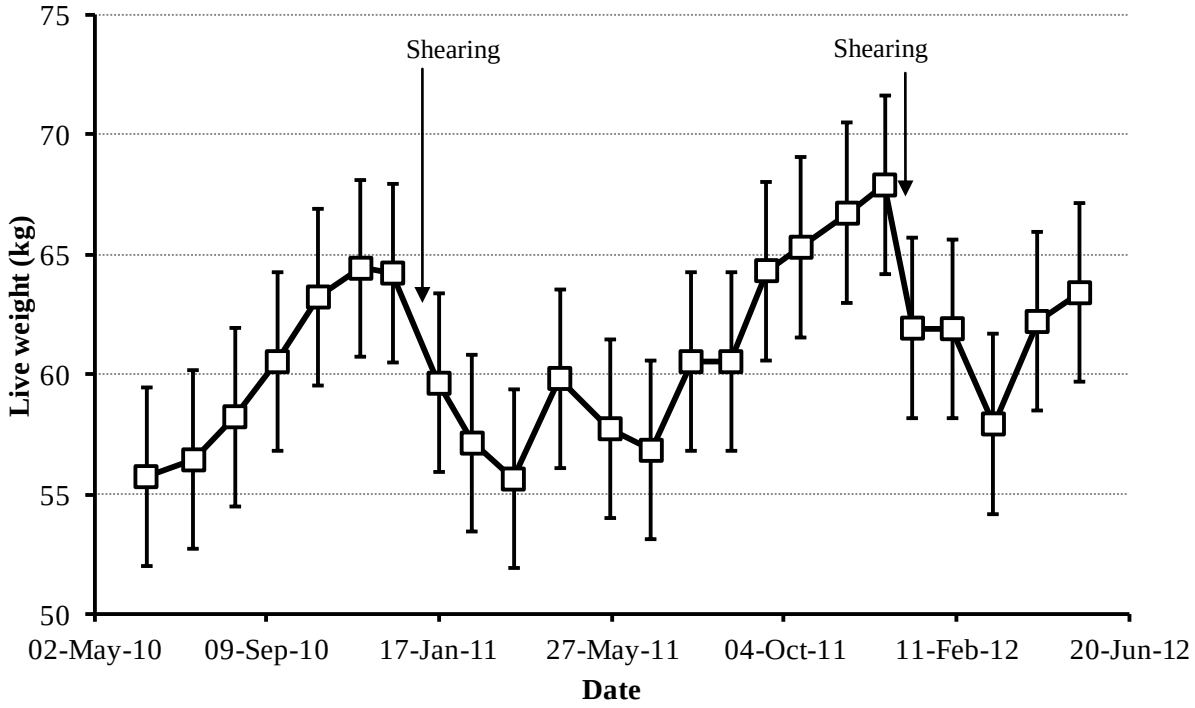

Figure 1. Approximately monthly live weights (±SE) of the five infester ewes that were used as source of infestation for the other ewes

Lice counts: The repeatability of square root transformed lice counts amounted to 0.35±0.18 in the five ewes that were used as infesters. The month of recording affected square root transformed total lice counts of the infester Merino sheep ($P<0.01$). Means (geometric means in parentheses) fluctuated between 3.4 and 4.2 (11.4 and 18.0) from the commencement of the experiment to December 2010, just prior to shearing (Figure 2). Shearing was marked by a substantial drop ($P<0.05$) in square root transformed total lice counts to 1.7 (2.8) in January 2011. Square root transformed total lice counts subsequently inclined to 4.0 (16.1) in December 2011. Shearing again resulted in a reduction ($P<0.05$) in square root transformed total lice counts during January 2012, to reach the same levels observed in January 2011.

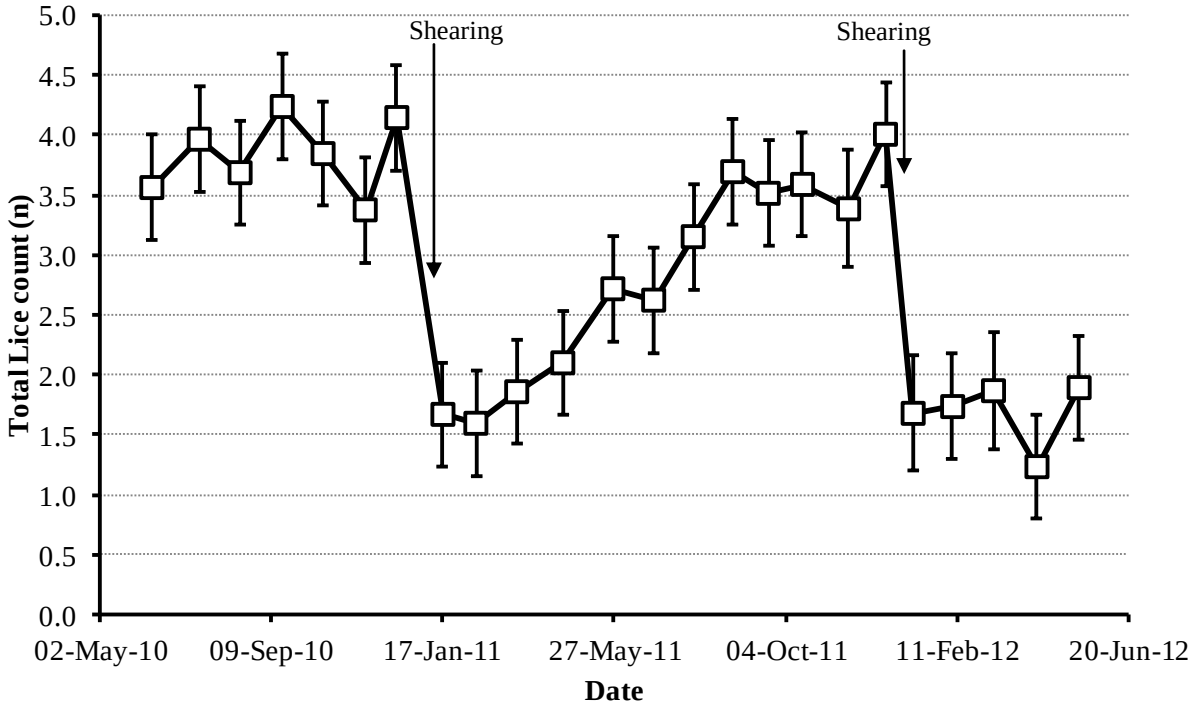

Figure 2. Square root transformed monthly total lice counts (±SE) of the five infester ewes that were used as source of infestation for the other ewes

Experimental sheep infested with lice

Live weight: SA Mutton Merino experimental ewes were generally heavier than Merinos, with respective least squares means being respectively 40.4±2.0 vs. 37.8±1.4 kg at the commencement of the experiment, 49.0±1.4 vs. 64.5±2.0 kg during May 2011 and 63.1±1.5 vs. 81.6±2.1 kg during May 2012. It was expected that the dual-purpose breed would be heavier than the pure wool breed and these results will not be elaborated upon. Across breeds, infested sheep failed to gain weight during the first month of the experiment, while there was evidence of a gain in control sheep (Figure 3). However, both groups subsequently gained weight and the live weights of infested sheep did not differ from those of the control group from September 2010 to February 2011 ($P>0.05$). Subsequently control ewes were generally heavier than infested ewes. During June 2011, before being shorn for the first time in the experiment, the live weight of infested sheep was 7.6% below that of control sheep (54.5±1.3 vs. 59.0±2.1 kg respectively). The infested ewes briefly caught up with the control group again during the summer of 2011-2012, but control group ewes were consistently heavier ($P<0.05$) than infested ewes from February 2012 (Figure 3). At the cessation of the experiment in May 2012 the difference between infested and control ewes amounted to 9.1% (68.9±1.4 vs. 75.8±2.2 kg respectively).

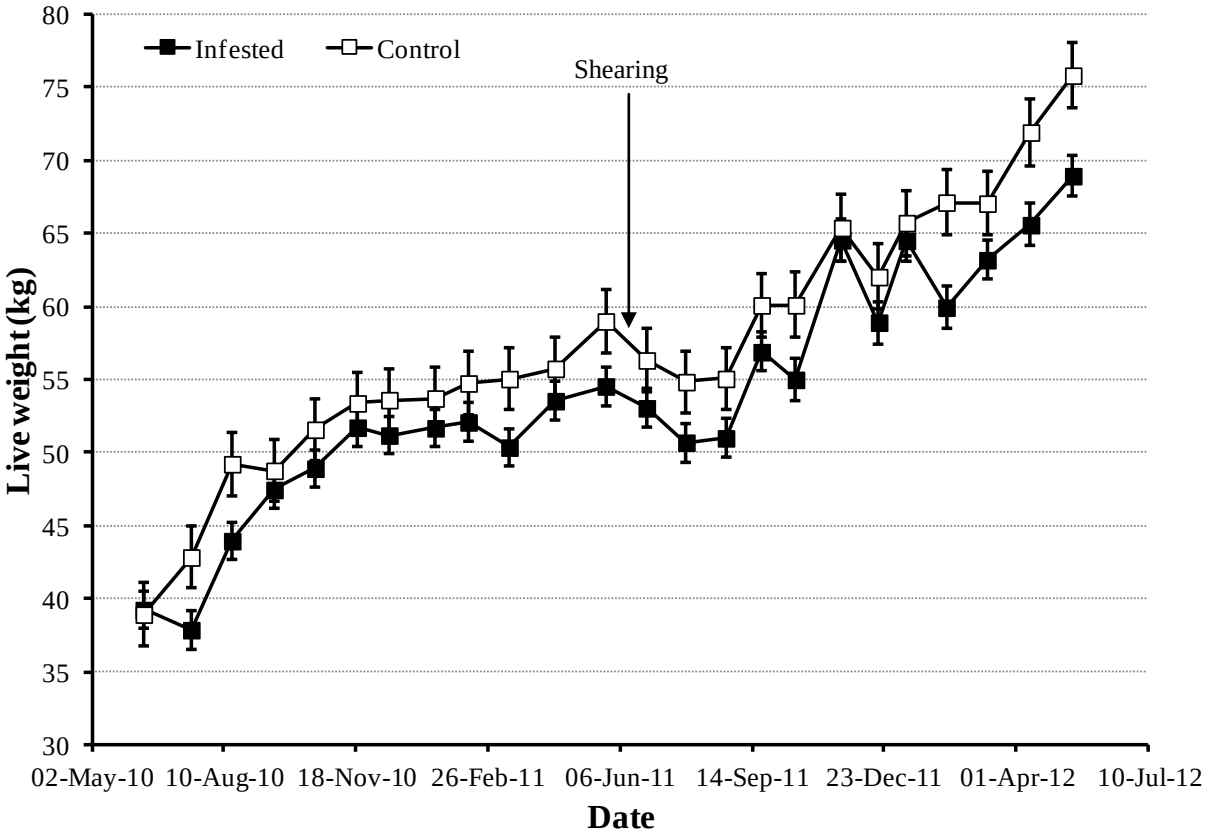

Figure 1. Approximately monthly live weights (±SE) of 35 lice infested Merino and SA Mutton Merino ewes and 12 control ewes for the duration of the experiment

Lice counts: Infestation picked up slowly in the experimental ewes, and by November 2010 lice were detected on 11 of 24 Merino ewes (45.8%) and 2 of 11 SA Mutton Merino ewes (18.2%). It proved to be difficult to achieve a sustainable lice infestation on Dorper ewes. During the summer months, when the undercoat of the Dorper ewes was shed, lice were occasionally observed on only one of 12 ewes (8.3%). During autumn and winter a total of one to three lice were occasionally counted on up to five of 12 ewes (41.7%). After a year on the experiment, the live weight of Dorper ewes also appeared to be unaffected by lice infestation (54.4±1.7 kg for infested sheep vs. 56.7±3.9 kg for control sheep; P>0.05). These results are in contrast to those for Merinos (respectively 44.5±1.9 vs. 53.5±2.3 kg) and SA Mutton Merinos (respectively 61.3±2.3 vs. 68.4±2.2 kg) recorded at the same age. These results formed the basis for the decision to exclude the Dorper breed from the rest of the experiment.

The repeatability of square root transformed lice counts of Merino and SA Mutton Merino ewes amounted to 0.29±0.06 in the repeated records analysis. Square root transformed lice counts (geometric means in parentheses) continued to rise in Merinos to reach 3.5 (12.3) in June just prior to shearing (Figure 4). In contrast, square root transformed lice counts of SA Mutton Merinos stabilized at levels between roughly 0.5 and 1.0 for the last five months prior to shearing in 2011. Shearing was marked by an abrupt drop in lice counts to just over 2.0 in Merinos and 0.1 in SA Mutton Merinos. After

shearing, square root transformed lice counts again increased to 2.5 to 2.8 (6.4 to 7.9) in Merinos and 0.05 to 1.0 in SA Mutton Merinos.

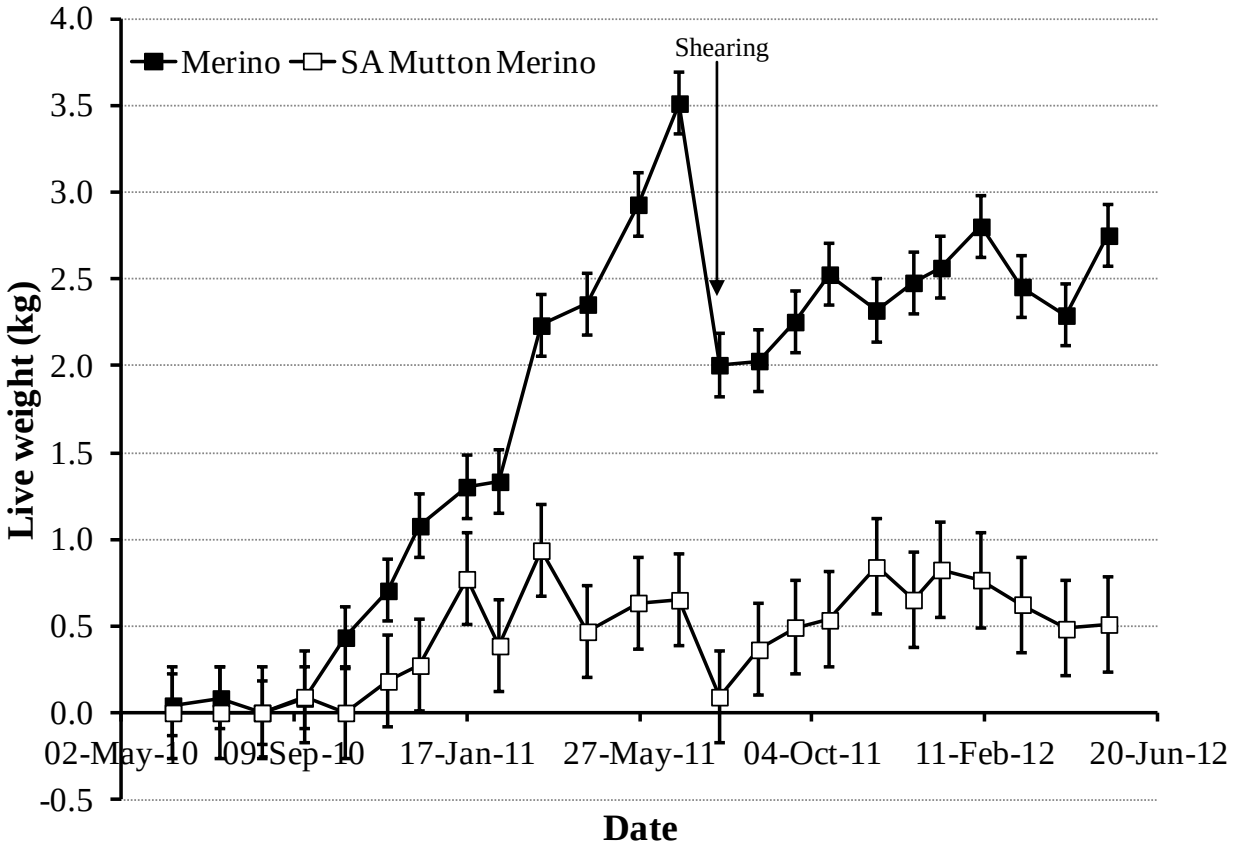

Figure 4. Approximately monthly square root transformed lice counts (±SE) of 24 lice infested Merino ewes and 11 infested SA Mutton Merino ewes for the duration of the experiment

Wool traits of experimental sheep

Overall, Merino ewes produced heavier fleeces, with a better CY and SS but with a lower FD than SA Mutton Merino ewes (all P<0.01; Table 1). Fleece weights and CY were lower in 2011 than in 2012 (P<0.01). In contrast, FD and SS were higher in 2011 than in 2012. The interaction of breed with year were significant for most traits (P<0.05), with the exception of CY. CFW of SA Mutton Merino ewes did not differ between years (2.87±0.02 kg in 2011 vs. 2.84±0.02 kg in 2012). In contrast, the CFW of Merino sheep was increased by 24.8% in 2012 compared to 2011 (respectively 4.16±0.02 vs. 5.19±0.02; P>0.05). SS was not affected by year in SA Mutton Merino ewes (30.8±2.4 N/ktex in 2011 vs. 28.5±2.4 N/ktex in 2012), while the wool of Merino ewes had a higher SS in 2011 than in 2012 (respectively 44.9±1.7 vs. 28.0±1.7; P>0.05).

CFW was reduced by 12.7% in lice infested sheep when expressed relative to the control group (P<0.05; Table 1). Overall, CY was reduced by 3.4% in lice infested sheep relative to the control group. However, CY was subject to a significant interaction of breed with treatment (P<0.01). CY in SA Mutton Merino

ewes was largely independent of treatment (64.5±1.3% in lice infested sheep vs. 63.4±2.1% in control sheep; P>0.05). The CY of Merinos infested with lice, in contrast, was reduced by 8.0% relative to control sheep (respectively 66.5±0.9 vs. 72.3±1.5; P>0.05).

Table 1. Least squares means (±SE) depicting the effects of breed (Merino or SA Mutton Merino), production year (2011 or 2012) and lice infestation (infested or control) on fleece traits of the experimental animals

Effect	Trait					
	GFW	CFW	CY	FD	CVFD	SS
Breed	**	**	**	**	**	**
Merino	6.71±0.02	4.68±0.02	69.4±0.9	20.8±0.4	19.9±0.4	36.5±1.3
SA Mutton Merino	4.45±0.03	2.85±0.02	63.9±1.2	25.3±0.5	17.4±0.5	29.6±1.7
Year	**	**	**	**	**	**
2011	5.46±0.02	3.51±0.02	63.8±1.0	24.2±0.3	17.6±0.4	37.8±1.5
2012	5.71±0.02	4.02±0.02	69.6±1.0	21.9±0.3	19.6±0.4	28.3±1.4
Treatment	0.13	*	*	0.63	0.72	0.18
Infested	5.33±0.02	3.51±0.01	65.5±0.8	22.8±0.3	18.9±0.3	32.2±1.1
Control	5.84±0.03	4.02±0.02	67.8±1.4	23.3±0.5	18.4±0.6	33.9±1.8

* (P<0.05); ** (P<0.01); real significance level otherwise

Traits: greasy fleece weight (GFM), clean fleece weight (CFM), clean yield (CY), fibre diameter (FD), coefficient of variation of FD (CVFD), staple strength (SS)

Discussion

Repeatability of lice counts

Lice counts were moderately repeatable at 0.28 to 0.35. These within-year estimates are on the lower end of the range of 0.34 to 0.80 reported for across-year estimates by James *et al*. (2002). Repeatability is often considered as the upper level for heritability (Turner & Young, 1969). It is thus appropriate to mention that Pfeffer *et al*. (2007) reported heritability estimates of 0.22 in winter and 0.34 in summer for log transformed lice counts in Romney lambs. It thus seems that lice counts may be repeatable and heritable in sheep.

Influence of shearing on lice counts

Lice numbers seemed to incline as the period of wool growth increased irrespective of the season the ewes were shorn in. Lice numbers were often reported to rise during the winter and spring, to decline in summer (Kettle & Pearce, 1974; Scott, 1952). Shearing both the infester ewes during summer (December) and the experimental ewes of both breeds during winter (July) resulted in a marked reduction of lice counts. The reduction so derived thus seems to be fairly robust across seasons and genotypes. Data presented in Figure 1 of Kettle & Lukies (1982) accordingly suggested a marked reduction in the mean louse rating of reproducing Border Leicester-Romney cross ewes after shearing. In an intensive study involving sheep recorded at 69 body positions, James & Moon (1999) reported a change in the spatial distribution of lice from the back and sides to the neck, belly and lower legs. This finding could not be verified in the present study, since the sheep were nor inspected on the latter body positions. The effect of shearing was not consistent in adult Angora goats infested with *Damilinia limbata* (Brown *et al*., 2005). During winter (July) shearing appeared to aid an already present decline in lice numbers, but no clear evidence of a reduction was evident in summer (February). James *et al*. (1998) also reported a reduction in louse counts after shearing, but also reported an independent marked seasonal variation in lice counts, peak lice counts recorded in spring and minima during summer.

The impact of lice infestation on production traits

When comparing the live weights of the infester ewes in Figure 1 with those of the experimental ewes in Figure 3 it is evident that the infester ewes did not grow as much during the two years of the experiment than the experimental ewes. This result was expected when it was considered that the infester sheep were older than the experimental group at the commencement of the study. There was evidence of sustained growth in the latter group, suggesting that the nutrients in the lucerne hay provided *ad libitum* (supplemented with the material available on the paddocks) exceeded maintenance requirements for non-reproducing ewes aged approximately one year.

The initial divergence in live weight between the experimental and control animals during June-July 2010 in Figure 3 was prompted by the lower nutrient supply per head in the former group. Once this was rectified, growth in the experimental group was comparable with that in the control group allowing the experimental animals to catch up in the summer of 2010. However, the experimental group subsequently started to lag behind and was 7.6% lighter than the control group after a year in the experiment. This pattern seemed to be repeated in the second year, with the experimental group catching up with the control group in the summer and lagging behind subsequently. The accrued deficit in live weight at the end of the experiment in May 2012 amounted to 9.1% relative to the control group. These results are in contrast to those of Kettle & Pearce (1974), suggesting that body weight gain of lambs were independent of lice infestation over a 10-month period. A follow-up long-term study on reproducing Border Leicester cross ewes over two production seasons failed to produce conclusive evidence of live weight or reproduction being impaired by lice infestation (Kettle & Lukies, 1982). Brown *et al*. (2005) accordingly reported that infestation of Angora goats with *Damilinia limbata* did not result in any changes in live weight.

CFW was accordingly impaired by 12.7% in lice infested sheep relative to the control group. An Australian study on Merino wethers indicated that clean wool production was boosted by 14 to 31% by lice control based on different chemicals (at varying success rates) compared to a comparable group of lice infested sheep (Niven & Pritchard, 1985). James *et al*. (2011) reported that lice infestation reduced clean fleece weight of Merino wethers by 0.12 to 0.22 kg per year in an experiment that was conducted over three years. Wool classing scores were correspondingly reduced in infested sheep. The reduction in CFW of experimental sheep in the present study partly resulted from a reduction in CY. However, this reduction in CY was only observed in Merinos, CY being independent of treatment group in the SA Mutton Merino breed. In correspondence with the results obtained for Merinos, Niven & Pritchard (1985) reported that the CY of Merino wethers were improved by 3.5 to 7.9% in animals subjected to various methods of lice control when compared to lice-infested contemporaries. In contrast, Kettle & Pearce (1974) reported no difference in fleece weight of lambs infested with lice relative to control lambs, but reported that fleece grade was impaired in infested lambs. Angora goats infested with *Damilinia limbata*, however, showed a marked production in fleece weight, as well as in mohair quality. The finding pertaining to the quantity of mohair produced is consistent with the results of the present study.

A number of studies suggested that lice counts are associated with pelt defects in sheep (Heath *et al*., 1995) and cattle (Coles *et al*., 2003). The study by Pfeffer *et al*. (2007) suggested that lice counts were genetically very similar to cockle, a pelt defect, as reflected by genetic correlations between these traits that exceeded 0.90. These results suggest that these traits may be determined by largely the same genes. Although the impact of lice on the skins of experimental animals was not explicitly studied in the present investigation, it is clear that the effect of lice infestation stretches beyond effects on body weight and wool traits.

Moreover, the impact on production is not the only concern pertaining to external parasites and their hosts. Plant (2006) stressed the importance of host welfare in sheep infested with the most important ovine ectoparasites, namely sheep lice, sheep scab and blowflies. No detailed welfare indicators were recorded in the present study, but pruritic behaviour was frequently seen in the infested animals. In contrast, such behaviour was not observed in the control group. These observations suggested that the welfare of lice infested sheep in the present study may have been compromised.

Impact of breed on lice infestation and derived production parameters

Dorper sheep seemed to be fairly resistant to infestation by the sheep body louse, as reflefcted by a failure to establish populations consistently detectable by visual inspection. Means for square root transformed total lice counts for this breed never differed from zero and the Dorper breed were therefore excluded from the final analysis. Live weight of experimental Dorpers use also did not differ from those of control ewes after one year in the experiment.

Although viable lice populations seemed to establish on SA Mutton Merino sheep, square root transformed total lice counts were markedly lower than in Merinos. James *et al*. (1998) and James & Moon (1999) accordingly reported an approximately tenfold higher lice count in Polypay ewes compared

to Columbia ewes over a two-year period under housed conditions. Moreover, James *et al*. (2002) reported strain differences within the Merino breed in total lice counts, suggesting that strains within the higher susceptible Merino breed may also differ for their ability to withstand lice challenge. Also, CY of SAMM ewes appeared to be unaffected by infestation by lice, whereas the opposite applied in Merinos. Kettle & Lukies (1982) accordingly reported that the CY of lice infested reproducing Border Leicester-Romney cross ewes were impaired by 2.6% relative to louse-free control animals.

Non-reproducing SA Mutton Merino ewes were between 29 and 32% heavier than Merinos in the present study. Comparable values in the literature were 23 to 25% for reproducing ewes (Cloete *et al*., 2004a) and 33% for yearling replacements (Cloete *et al*., 1999). The CFW of SA Mutton Merino ewes amounted to 31 to 45% below that of Merinos, which seemed to be on the lower end of a range of literature values amounting to 43 to 48% (Greeff, 1990; Cloete *et al*., 1999; 2003). It should be remembered that the Merino ewes in the present study were not intentionally subjected to selection for CFW, while those in the other studies probably were. The CY of SA Mutton Merino ewes was 8% below those of Merinos, compared to literature estimates of 12 to 14% (Greeff, 1990; Cloete *et al*., 1999; Brand *et al*., 1999). During 2011, the SS of SA Mutton Merinos was 31% below that of Merinos. Although this value compares very well with a corresponding value reported by Cloete *et al*. (2003), it should be remembered that no breed difference was evident in SS in 2012. The wool of SA Mutton Merino ewes was generally stronger than that of Merinos, as was also reported in the literature (Brand *et al*, 1999; Cloete *et al*., 1999; 2003).

Conclusions

This study reaffirms the impact shearing has on the resident lice population upon woolled sheep. The penalties imposed by lice infestation on live weight and CFW, albeit not severe at 8 to 13%, were nonetheless real in economic terms. However, the impact of lice on the welfare of sheep was not considered in the present study. Breed differences in lice infestation, moderate repeatability estimates for lice counts, as well as literature results suggest that lice counts may be controlled genetically. Breeding may thus form part of a sustainable integrated lice control programme that may be devised in future. Further research upon the impact of lice on the welfare of sheep, as well as breeding for reduced lice susceptibility should be considered.

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