

## Seasonal occurrence and production effects of the biting louse *Damalinia limbata* on Angora goats and 2 treatment options

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### ABSTRACT

Adult biting lice *Damalinia limbata* (Gervais 1844) were most numerous on Angora goats in southwestern Free State Province from November to May with the smallest numbers present during August. Nymphs were most numerous from January to March with the smallest numbers present during July. The largest proportion of adult lice was present on the ventral surface of goats during winter, when population numbers were lowest, and the largest proportion of nymphs during summer, when population numbers were highest. Infestation did not affect the body weight of goats, but adversely affected both the quantity and quality of mohair produced. A single treatment with deltamethrin, applied as a pour-on along the mid-line of the backs of the goats, effectively controlled infestation and resulted in a significant increase in mohair production compared with untreated goats. Deltamethrin sprayed along the sides of the animals was equally effective in controlling infestation.

**Key words:** Angora goats, biting lice, *Damalinia limbata*, deltamethrin, production effects, seasonality, treatment.

Brown L, Van der Linde T C de K, Fourie L J, Horak I G **Seasonal occurrence and production effects of the biting louse *Damalinia limbata* on Angora goats and 2 treatment options.** *Journal of the South African Veterinary Association* (2005) 76(2): 74–78 (En.). Department of Zoology and Entomology, University of the Free State, PO Box 339, Bloemfontein, 9301 South Africa.

### INTRODUCTION

*Damalinia limbata* (Gervais, 1844), colloquially known as the biting louse or red louse of Angora goats, is an obligate, host-specific ectoparasite of these animals<sup>12,15</sup>. Although a number of surveys on the occurrence of *D. limbata* on Angora goats have been conducted in South Africa, no clear pattern of seasonality has emerged, largely because of the marked effect that regular shearing has upon louse numbers<sup>11</sup>. It has, however, been suggested that biting lice are most numerous on goats during the cooler months of the year<sup>5,14</sup>. Angora goat kids on irrigated Kikuyu grass pastures in the Eastern Cape Province acquired infestation within 2 days of birth and their mean burden of 13 lice increased to 3994 by the time they were 5 months old<sup>6</sup>. Thirty-seven yearling goats on the same farm examined in sets of 3–4 animals at monthly intervals over a period of 10 months harboured mean

burdens of 1686 nymphs and 1609 adult lice. Fifty Angora goat kids and 48 adult goats examined in pairs at monthly intervals over a period of 44 months on a farm in the Valley Bushveld of the Eastern Cape Province, had mean burdens of 4320 and 2743 *D. limbata*, respectively<sup>10</sup>. All the adult goats and 49 of the kids were infested and no seasonal pattern of infestation could be determined<sup>10</sup>. All but 1 of 160 Angora goat kids and yearlings examined at monthly intervals in sets of 3–6 goats over a period of 26 months on a farm in Noorsveld in the southern Karoo region of the Eastern Cape Province were infested and their mean burdens consisted of 4455 nymphs and 2727 adult lice<sup>11</sup>. The mean burden of 295 *D. limbata* on 1-week-old kids in the latter study had increased to 3392 a month later, and peak numbers of lice were recorded during March when the goats were 18 months old<sup>11</sup>.

Various authors have studied the effect of the biting louse, *Damalinia ovis*, on the body weight and wool production and fleece quality of infested sheep<sup>4,13,19,22</sup>. Although it is assumed that infestation with *D. limbata* adversely affects mohair production, no data in support of this could be found.

Mohair producers in South Africa have expressed concern at the apparent increase in the prevalence of biting lice on their goats, and it has been suggested that this could be due to the development of resistance to insecticides<sup>8,12</sup>. However, it would seem that in the majority of cases in which a perceived breakdown in product performance has been reported, the main problem resided in incorrect usage<sup>14</sup>.

The present study was aimed at determining the seasonal occurrence and distribution of *D. limbata* on Angora goats and the effect of infestation on their body weight and quantity and quality of mohair produced. In addition, 2 methods of insecticide application were compared to assess both the efficacy and the most effective method of administering the synthetic pyrethroid, deltamethrin.

### MATERIALS AND METHODS

#### Study site

The study was conducted on the farm Preezfontein (29°50'S, 25°19'E), approximately 10 km from the town of Fauresmith in southwestern Free State province. The veld type in this region is defined as 'False Upper Karoo' and lies within the Karoo biome<sup>1</sup>. The long-term (20 year) average rainfall for the area is approximately 480 mm, and although most rain falls during autumn and spring, it can be very erratic, and mild to severe droughts are periodically experienced.

#### Study animals

Ten adult Angora goats, 2–3 years of age, naturally infested with *D. limbata*, were selected from a herd of approximately 200 goats on this farm. These goats, consisting of wethers and non-gravid ewes, were held in a field approximately 2 ha in size and containing sufficient vegetation for their needs. At monthly intervals the lice on one side of the body of each goat were counted *in situ* within measured 10 cm<sup>2</sup> squares in the following regions: (1) shoulder, (2) brisket, (3) neck, (4) flank, (5) thigh, (6) groin and (7) abdomen. As all developmental stages are visible to the naked eye it was possible to class the lice within these sites as adults or nymphs, and all

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Received: January 2005. Accepted: May 2005.

adult lice in each of the sites were counted. Estimates of the numbers of nymphs were made at the same time and values of 0, 10, and then up to the next 50 in multiples of 50, to a maximum value of 250, were assigned to these estimates. The counts of adult lice and estimates of nymphs were separately summed for the 7 body regions of each goat, and monthly mean values calculated. Multiplying the total count obtained from adding the counts for the seven 10 cm<sup>2</sup> squares by a factor of 100 should give a rough estimate of the total number of lice present on each goat.

#### Effect on body weight

On 13 February 1995, a separate group of 20 Angora ewes, approximately 16 months of age, with moderate to heavy lice burdens, were selected from a herd of about 200 animals on the farm, shorn and weighed to the nearest 0.1 kg. The goats were ranked according to their body weights and allocated to 2 groups of 10 goats each, starting with the heaviest animals. All the goats in 1 group were treated for lice with the synthetic pyrethroid, deltamethrin (WipeOut<sup>®</sup>, Afrivet, South Africa), administered along the mid-lines of their backs. Goats in the other group were not treated and served as controls. After treatment the 2 groups were kept on irrigated pastures in separate camps to minimise the possibility of cross-infestation. The goats were inspected every 2 weeks to establish their infestation status and to check that those in the treated group had not become infested. Two goats, 1 from each group, died from undetermined causes before the end of the study and the results are therefore based on observations made on the remaining 18 goats. On 24 August 1995, 6 months after treatment the goats in the 2 groups were again shorn and weighed. A 1-way analysis of variance was done on the initial body weights and on the body weight gains of the treated and untreated goats to test for differences.

#### Effect on mohair quantity and quality

The same 2 groups of goats ( $n = 18$ ) that were used in the body weight study, were used in this study. All goats were shorn before treatment and the mohair of each goat was kept in a separate bag and transported to the laboratory where it was weighed and a 1-way analysis of variance done to determine whether the weight of mohair of the 2 groups differed significantly. All the goats in 1 group were treated for lice with the synthetic pyrethroid, deltamethrin (WipeOut<sup>®</sup>), administered along the mid-lines of their backs. Goats in the other group were not treated and served as controls. After 6 months the goats were again

shorn and the mohair weighed and subjectively classed by the goats' owner. The cuts were classed according to hair length, fineness and style. The weights of the initial mohair cuts were subtracted from those of the final cuts and a 1-way analysis of variance was done on the final weights of the mohair cuts of the 2 groups of goats.

#### Treatment

Twenty-four between-shears goats, considered heavily infested with *D. limbata*, were selected from a herd of approximately 250 goats on the same farm. These 24 animals were allocated to a group comprising 4 goats and 2 groups of 10 goats each according to their louse burdens so that each group harboured approximately the same mean level of infestation. The group of 4 goats served as untreated controls, while the goats in 1 group of 10 were each treated with 20 ml of a pour-on formulation of the synthetic pyrethroid, deltamethrin (WipeOut<sup>®</sup>) administered along the dorsal mid-line from the neck to the tail, and the goats in the 2nd group of 10 were each treated with 20 ml of deltamethrin applied laterally via a high pressure spray system (Tickspray<sup>®</sup>, J L Viviers & L J Fourie, South Africa, 1995). To prevent cross-infestation the 3 groups were kept on irrigated pastures in separate enclosures, and were examined separately for lice on each inspection date.

Lice counts were done on all the goats before treatment and at 4-week intervals for a period of 8 weeks after treatment. A 1-way analysis of variance was carried out on the initial counts of adult lice and on the estimations of nymph numbers and a factorial analysis of variance was done on the post-treatment counts to determine the significance of differences between groups and over time.

#### Climate

Daily, from May 1994 until April 1995, atmospheric minimum, maximum and average temperatures and relative humidity (RH) were measured with a data-logger (MCM systems, Cape Town) at the study site.

## RESULTS AND DISCUSSION

### Seasonality

Seasonal variations in the numbers of *D. limbata* on the goats and the average monthly temperatures and RH are illustrated in Fig. 1. The numbers of adult lice decreased from May to June as well as after shearing in July 1994. The adult louse population increased during September and October 1994 and despite shearing in February 1995, remained high from November 1994 to April 1995 (Fig. 1a).

The numbers of nymphs decreased from May to July 1994 (when the goats were shorn) and then increased steadily over the next 6 months to reach a peak in February 1995. The number of nymphs decreased after shearing in February and continued to decline until April 1995 (Fig. 1a).

The increase in the number of nymphs in August preceded that of the adults by 1 month, matching the 32 days it takes for the life cycle to progress from eggs through nymphs to adults<sup>9</sup>. The initial peak in adult numbers in November was followed by a large increase in nymphs, which peaked in January and February. These nymphs presumably moulted to adults in autumn, and, judging by the decline in the population of nymphs thereafter, the latter adults did not reproduce at the same rate or as effectively as the summer population of adult lice. This resulted in a decline in the number of nymphs during autumn followed by a decline in adults, as recorded in the winter of 1994. In contrast to earlier observations<sup>5,14</sup>, this study shows that *D. limbata* reached maximum levels of infestation on Angora goats during summer and not during winter. This finding corresponds in some respects to those made on Angora goat kids on irrigated pastures and on 18-month-old Angora goats in the southern Karoo in which peak numbers of *D. limbata* were recorded during March on 3 occasions<sup>6,11</sup>. It also agrees with the peak numbers of *D. ovis* recorded on Merino sheep in Australia during summer or late summer<sup>19,22</sup>. However, other authors in the same country found that *D. ovis* populations decrease in late spring, remain low during summer and increase in winter<sup>18</sup>. In the present study *D. limbata* numbers increased in spring after a winter shearing, and peaked during summer and late summer as adults or nymphs, respectively (Fig. 1a). However, large numbers of lice have also been recovered from yearling goats on irrigated pastures during May and August<sup>6</sup>, and it therefore seems as if the pattern of seasonality of *D. limbata* on Angora goats has still not been resolved satisfactorily.

The lowest mean atmospheric temperature was recorded during July 1994, and the absolute lowest minimum of -10 °C on 8 June 1994. The highest mean temperature was recorded during February 1995 and the highest absolute maximum of 35.9 °C on 6 January 1995. Mean monthly RH varied inversely with that of temperature (Fig. 1b). There appears to be a positive correlation between average monthly atmospheric temperature and the estimated numbers of nymphs on the goats and a negative correlation with average monthly RH. With the exception of

newly-shorn goats, it seems unlikely that temperature or RH can have a direct effect on the numbers of nymphs. Their effects are more likely to be exerted on the fecundity of female lice, and this would subsequently result in an increase or reduction in the number of eggs produced and hence in the number of nymphs. Most eggs are laid by *D. ovis* at 37.5 °C, with a decrease occurring at both higher and lower temperatures<sup>16</sup>. A RH of 95 % compared with 1 of 60 % may also result in a decrease in the number of eggs laid<sup>16</sup>. The present results seem to indicate that the fecundity of female *D. limbata* is also directly related to atmospheric temperature and inversely related to RH (Fig. 1a and b). This would account for the decline in the numbers of nymphs in autumn while adult lice remain at high levels before their numbers are depleted by age.

The decrease in numbers of *D. limbata* after shearing agrees with findings on Angora goats in the southern Karoo, on which on 3 occasions mean burdens decreased from between 12 000 and 30 000 to below 1000 lice after shearing<sup>11</sup>. It also agrees with a marked reduction in the *D. ovis* population recorded on sheep in Australia after shearing<sup>17</sup>. However, peak numbers of *D. limbata* on 18-month-old Angora goats in the Karoo during March of 2 successive years were followed by spontaneous declines, one of which was accelerated by shearing<sup>11</sup>. In the present study the populations of both adults and nymphs were declining even before shearing as the temperature decreased towards winter 1994 (Fig. 1a,b). Consequently the decrease in the lice population in this study, as well as that in the Karoo, cannot be attributed to shearing alone.

Three known causes of mortality of lice on sheep during summer are shearing, solar radiation and thunderstorms<sup>18</sup>. The conclusions concerning solar radiation were, however, based on findings derived from sheep with a fleece length of 2.5–5 cm<sup>17,18,22</sup>. The goats in the current study were carrying mohair 6–7 cm in length when 1st exposed to high levels of solar radiation in late spring and their hair was up to 13 cm long just before shearing in late summer. This long hair would presumably have given greater protection to the lice against high levels of solar radiation, thus ensuring greater stability in their population size. The latter view is supported by observations that the numbers of *D. ovis* on sheep with long wool did not decline during summer<sup>19,22</sup>. Heavy rainfall was very rare during the current study and could therefore not have had a marked influence on the lice populations.

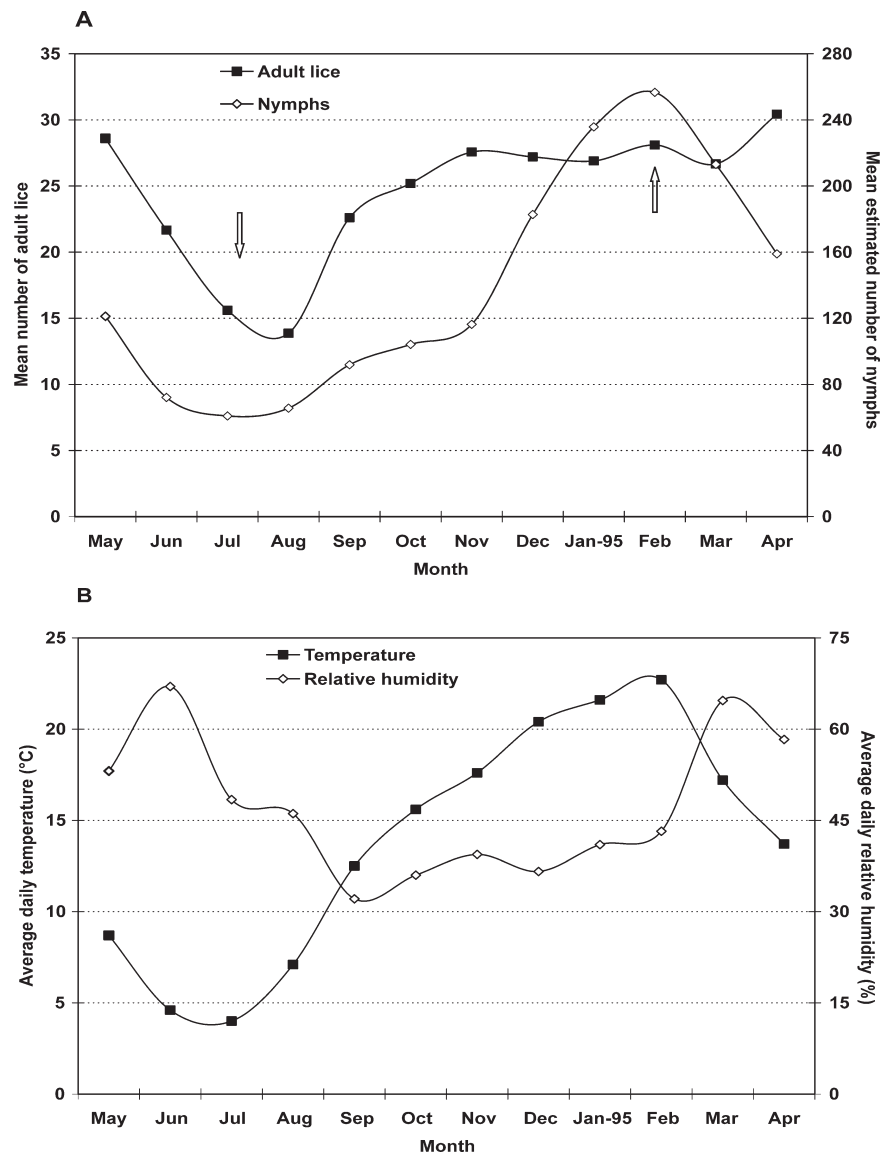


Fig. 1: A: Seasonal occurrence of *Damalinia limbata* adults and nymphs on Angora goats (3-month running averages),  $\uparrow$  = shearing; B: mean monthly atmospheric temperature and relative humidity on the farm Preezfontein in southwestern Free State province.

During July 1994 the extremes in minimum and maximum temperatures varied between -9.5 and 19.2 °C. These large temperature fluctuations to which lice on the newly-shorn goats were exposed could have killed many of them because of the absence of the insulating effect of the hair. This supports the view that a major after-effect of shearing on sheep is an alteration in the body surface habitat resulting in a more variable microclimate for those lice that survive after shearing<sup>18</sup>.

#### Site predilection

The lice counts on the ventral surface of the goats, namely brisket, abdomen and groin, and on the lateral surface, namely neck, shoulder, flank and thigh, were separately pooled as were the data for the seasons, and the averages calculated. For this purpose winter was assumed to last from June–August, spring from

September–November, summer from December–February and autumn from March–May. The number of adult lice on the ventral surface of the goats always exceeded 50 % of the adult population during any particular season, and that of nymphs on the ventral surfaces 20 % of the nymph population.

The ventral surface of goats has the highest average temperature during winter compared with other body regions<sup>3</sup>, and the largest proportion of adult lice was present here during this season when their populations were at their lowest (Fig. 2a). It has been reported that *D. ovis* are attracted to warmth prior to oviposition<sup>16</sup>, and that this attraction might also be an initial feature of a behaviour pattern when they need to feed<sup>17</sup>. Very low temperatures prevailed during July 1994, when the goats were shorn, and could have caused the adult lice to move to the warmer and more sheltered ventral



surface of the body.

The nymphs of *D. limbata* were most numerous on the lateral surfaces of the goats' bodies throughout the year. The population on the ventral surface did, however, increase as atmospheric temperatures rose and then regularly exceeded 30 °C during summer (Fig. 2b). In mid-summer the temperature at the tip of the hair can be as high as 48 °C<sup>3</sup>. When exposed to a similar temperature for 60 minutes, adults and nymphs of *D. ovis* died<sup>17</sup>. Because of potentially lethal temperatures in the mohair during summer it is probable that *D. limbata* tends to move away from them. The ventral surface is not densely covered with hair and is mostly shaded and would therefore be a suitable habitat for the nymphs, which are unsclerotised, during summer.

### Effect on body weight

The initial body weights of the control and treated groups did not differ significantly ( $F_{1,16} = 1.66, P = 0.22$ ), nor did the mean difference of 0.57 kg in weight gained after treatment ( $F_{1,16} = 0.82, P = 0.38$ ). These results support those obtained for sheep in which infestation with *D. ovis* had no significant influence on their body weights ( $P > 0.1$ )<sup>13</sup>. The absence of effect on body weight can probably be ascribed to the fact that biting lice feed on sebaceous secretions, loose scurf and superficial *stratum corneum*<sup>20</sup> and not on living tissue, and would therefore be unlikely to have a direct effect on the weight of a host animal. The assertion that *D. ovis* causes ill-thrift in sheep is probably based on the presence of heavy louse burdens on animals already suffering from some other condition, such as malnutrition, and lice may therefore be an indicator, rather than a cause of ill-thrift<sup>13</sup>.

### Mohair production

At the commencement of the study the average weight of mohair produced by goats in the 2 groups differed by only 5 g. During the 6 months after treatment the goats in the treated group produced an average of 271 g more mohair per animal than those in the untreated group. These differences were significant ( $F_{1,16} = 105.33, P < 0.001$ ) (Table 1). When the mohair clips of the 2 groups were classed it was found that the treated goats produced better quality cuts with less damage to the hair than the untreated animals (Table 2).

These results agree with those obtained for sheep infested with *D. ovis*, on which there was a decrease in both the weight and quality of wool produced<sup>4,19,22</sup>. It has been suggested that changes in wool quality are indirect and result from the irritation caused by lice, which elicit host responses such as rubbing, scratching

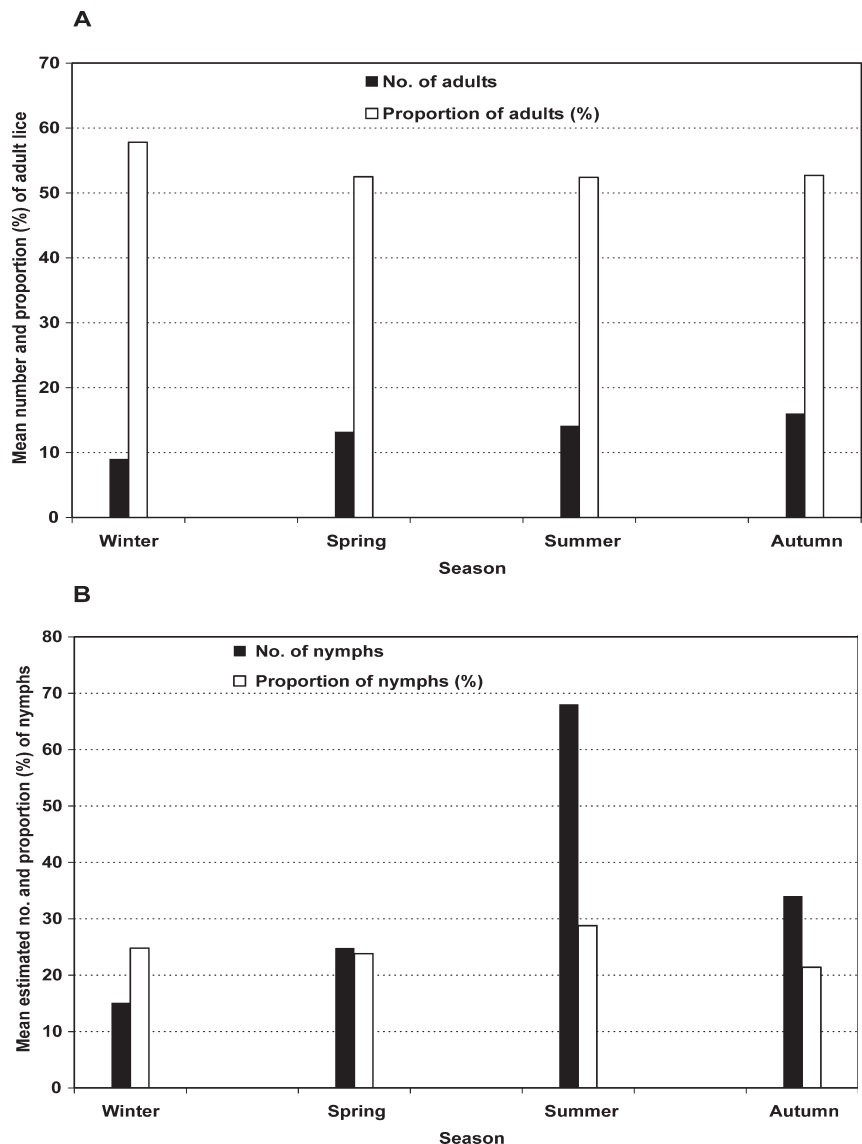


Fig. 2: The seasonal distribution of *Damalinia limbata* on the ventral surface of Angora goats; A: adult lice; B: nymphs.

and biting<sup>13</sup>. However, lice also cause the skin to thicken<sup>2</sup>, and a decrease in wool quality may thus also be due to alterations in the skin structure of infested sheep. The reduction in mohair quality and quantity in the present study is presumed to be due to excessive grooming in response to irritation caused by the lice.

### Treatment

The pre-treatment burdens of adult lice on the 3 groups of goats did not differ significantly ( $F_{2,21} = 1, P = 0.385$ ) (Table 3). Treatment with deltamethrin resulted in a

significant decrease in the numbers of adult lice on the treated goats compared with those on the untreated animals ( $F_{2,42} = 58.16, P < 0.001$ ). Application of deltamethrin either along the mid-line of the back or along the sides of the goats did not affect its efficacy ( $F_{1,42} = 1.67, P = 0.203$ ).

A 1-way analysis of variance indicated that the initial burdens of nymphs on the 3 groups of goats did not differ significantly ( $F_{2,21} = 0.765, P = 0.478$ ). The numbers of nymphs on the 2 treated groups did not differ significantly during the 8

Table 1: The effect of treating goats for biting lice on the weight of mohair produced.

Item	Untreated control goats (n = 9)			Treated goats (n = 9)		
	Weight of mohair cuts (g)		Gain (g)	Weight of mohair cuts (g)		Gain (g)
	13 Feb 1995	24 Aug 1995		13 Feb 1995	24 Aug 1995	
Mean	1 743	1 848	105	1 748	2 124	376
SD	±0.193	±0.151	±0.047	±0.234	±0.209	±0.064

Table 2: The effect of treating goats for biting lice on the quality of mohair produced.

Item	Quality		
	Poor	Medium	Good
Mohair class	B	BF	BS
Mohair from treated goats	1	2	6
Mohair from untreated goats	7	1	1

B = fibre length between 125 and 150 mm; F = fibre diameter of less than 36 micron; S = mohair with a good to super style and character.

Table 3: The efficacy of deltamethrin against *Damalinea limbata* on Angora goats.

Group	No. of goats	Mean number of lice					
		Day 0		Day +28		Day +56	
		Nymphs <sup>a</sup>	Adults	Nymphs <sup>a</sup>	Adults	Nymphs <sup>a</sup>	Adults
Untreated controls	4	201.7 <sup>A</sup>	27.4 <sup>B</sup>	290.0 <sup>C</sup>	35.7 <sup>C</sup>	402.5 <sup>C</sup>	22.5 <sup>C</sup>
Treated along back	10	207.9 <sup>A</sup>	28.2 <sup>B</sup>	5 <sup>D</sup>	0.1 <sup>D</sup>	0 <sup>D</sup>	0 <sup>D</sup>
Treated along sides	10	162.6 <sup>A</sup>	20.1 <sup>B</sup>	5 <sup>D</sup>	0.8 <sup>D</sup>	1 <sup>D</sup>	0 <sup>D</sup>

<sup>a</sup>Estimated mean numbers of nymphs.

<sup>A</sup>Mean adult louse burdens did not differ significantly before treatment ( $P = 0.478$ ).

<sup>B</sup>Mean burdens of nymphs did not differ significantly before treatment ( $P = 0.385$ ).

<sup>C,D</sup>Treatments with different superscripts in the same column differ significantly ( $P < 0.01$ ).

weeks after treatment ( $F_{1,42} = 0.305$ ,  $P = 0.584$ ), but were significantly lower than those on the control group ( $F_{2,42} = 44.47$ ,  $P < 0.001$ ). The method of application of the insecticide did not affect its efficacy against nymphs ( $F_{1,42} = 0.0003$ ,  $P = 0.987$ ).

The incomplete efficacy of deltamethrin, administered as a pour-on, against *D. ovis* on sheep has been ascribed to a decline in insecticide residues to sub-lethal concentrations in the fleece furthest from the application site<sup>7</sup>. Long, dense wool might negatively influence the efficacy of jetting fluids on Merino sheep, as the fluid may not be able to penetrate to the skin surface<sup>21</sup>. Although long mohair is not as dense as wool and the penetration of jetting fluids is thus probably not affected to the same extent as on sheep, it would probably be preferable to treat goats immediately or soon after shearing. This would reduce the effect that the length or density of mohair may have on the dispersal of an insecticide applied along the back, or allow it to penetrate to the skin surface more readily when it is administered laterally, and also reduce the costs of treatment.

#### ACKNOWLEDGEMENTS

Mr Archie du Plessis is thanked for the use of his farm and goats during the field-work, and Dr K L Pringle for assistance and advice concerning the statistical analysis of the data.

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