Article — Artikel

A survey of the prevalence of blowfly strike and the control measures used in the Rûens area of the Western Cape Province of South Africa

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ABSTRACT

Blowfly strike and the methods used to combat blowfly strike were recorded on 33 properties in the Rûens area of South Africa during 2003/2004. Data were recorded on Merino and Dohne Merino hoggets (n = 4951) with at least 3 months' wool growth. The following data were captured: presence or absence of strike, site of the strike (body or breech), presence or absence of dermatophilosis as well as subjective scores for wool quality and wool colour. Control measures recorded include: chemical treatment (preventative and spot treatment), crutching, mulesing and the use of the Lucitrap® system. Blowfly strike was not significantly influenced by gender or breed. Hoggets suffering from dermatophilosis were more likely to be struck, compared with contemporaries not suffering from the skin disorder (0.057 *vs* 0.027; $P < 0.05$). Merino hoggets generally had higher scores than their Dohne Merino contemporaries for wool quality (32.6 *vs* 27.4; $P < 0.05$) and wool colour (29.0 *vs* 27.2; $P < 0.05$). There was an indication that the Lucitrap® system may have reduced flystrike, but the effect was not statistically significant ($P = 0.19$ for overall strikes and $P = 0.12$ for body strike). The Mules operation benefited overall flystrike (0.013 *vs* 0.110; $P < 0.05$); mainly through an effect on breech strike (0.010 *vs* 0.109; $P < 0.05$). The proportion of fly strikes increased with wool length, and declined with an increase in farm size in wool colour score. None of the ethically acceptable control measures assessed could substantially reduce blowfly strike on their own, and an integrated pest management programme was proposed.

Keywords: blowfly strike, control methods.

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INTRODUCTION

The blowfly *Lucilia cuprina* (Diptera: Calliphoridae) is almost exclusively responsible for primary strikes in South Africa[11,26]. Blowfly strike on sheep has been well researched in Australia, New Zealand and England but research on the sheep blowfly in South Africa is limited to a relatively small number of publications over the last century[8,11,14,26,37,63]. A survey of blowfly strike in the 1990s suggested that blowfly strike results in an annual estimated loss of R19.8 million to the South African small stock industry[38].

Until recently blowfly control relied largely on insecticides as the 1st line of defence in most of the major wool producing countries[26,27], including South Africa. However, certain strains of *Lucilia cuprina* have demonstrated an ability to develop resistance to these chemicals[19,28,69,70]. Resistance of blowflies to certain organic phosphorous compounds in South Africa was reported as early as the mid 1950s[14].

Growing worldwide concern about the impact of chemicals on the environment and their potential human health risk has resulted in strict international trade agreements such as the Integrated Pollution Prevention and Control (IPPC) Directive (1996) imposed by the European Union (EU). As a result the United Kingdom and EU countries that import raw wool have imposed strict regulations concerning chemical residues in wool. The South African Wool Industry as a primarily grease wool exporter cannot afford to ignore this trend, since pesticide residues in wool are likely to negatively impact the future marketing and price of South African raw wool.

Other control measures against flystrike in use in South Africa include crutching, tail docking, shearing and, until recently, the Mules operation[11,37,38]. Changes in social attitudes towards improving animal welfare have led to the targeting of the Mules operation by animal welfare campaigners[45,52,53]. Welfare concerns about the pain and stress associated with the procedure led to the Australian Wool Industry agreeing in November 2004 that mulesing will be phased out by 2010[9,36]. International pressure has resulted in all wool producing countries that make use of mulesing stopping this practice. The South African National Wool Grower's Association (NWGA) in collaboration with the National Society for the Prevention of Cruelty to Animals (NSPCA) also responded to this pressure and they announced the following: 'The practice of mulesing is cruel and causes pain and stress to the animal and is a contravention of the Animal Protection Act no. 71 of 1962'[49].

Other management practices that are currently in use in South Africa, when used on their own, are usually not sufficient for efficient blowfly control. With limitations on the use of chemicals, restrictions on the Mules operation and limited success with management practices when used on their own, the control of blowfly in South Africa needs to be reassessed. Against this background it was decided to conduct a survey in the Rûens area (Western Cape Province of South Africa) to assess control methods used to combat blowfly strike.

MATERIALS AND METHODS

Animals, the environment and recordings

The survey was done during 2003 and 2004 on 33 farms in the Caledon district (34°16'S, 19°42'E) and the Riviersonderend district (34°08'S, 21°11'E) (Fig. 1). This area is otherwise known as the Rûens area of the Western Cape Province of South Africa and is situated in the foothills of the Swartberg and Langeberg

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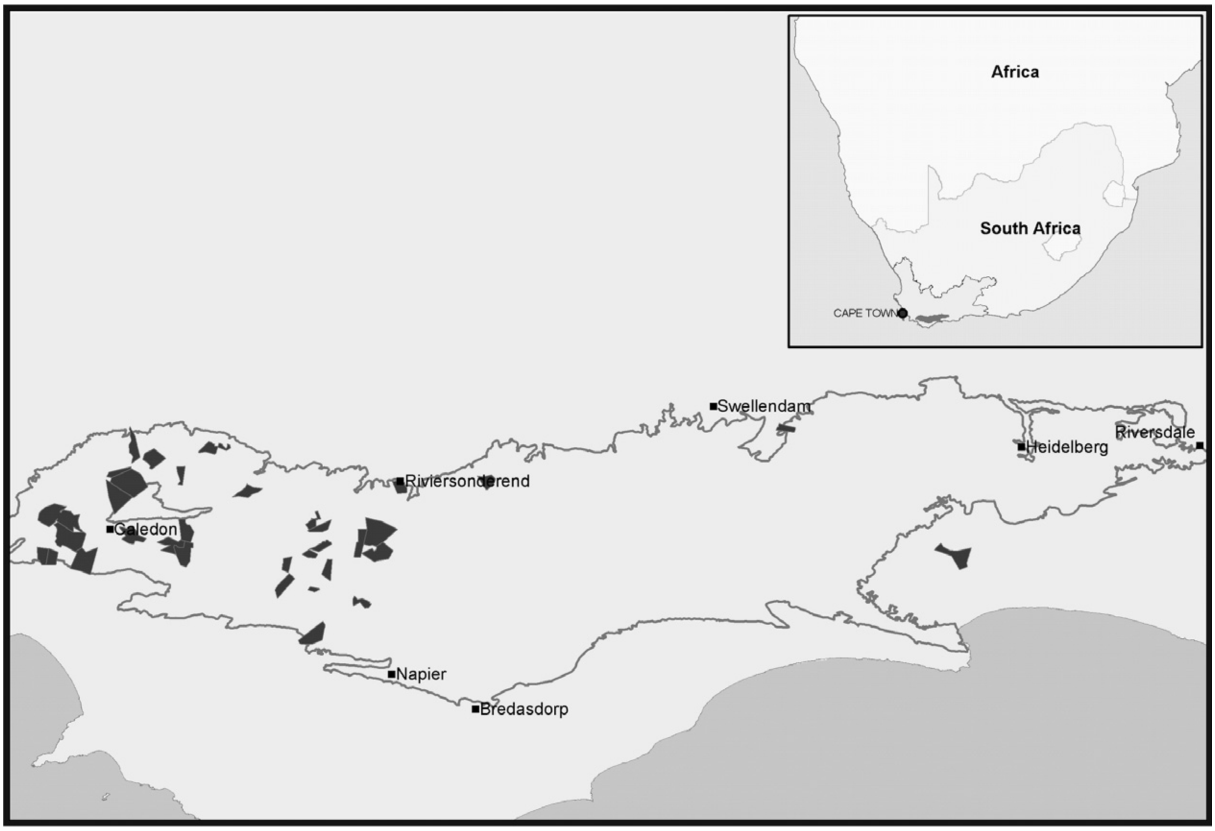

Fig. 1: **A chart of the Rûens area depicting the location of the farms where the survey was conducted**.

mountains. The topography of the area is sloping, with valleys draining in a south-westerly direction. The climate in this area is Mediterranean with an average annual precipitation of 420 and 429 mm for the Caledon and Riviersonderend areas respectively. Approximately 60 % (Riviersonderend) to 70 % (Caledon) of the annual rainfall in the Rûens area is recorded between April and September[1]. Small grain cropping, usually associated with sheep farming for meat and wool, is the dominant farming enterprise of the area.

The majority of farms were visited only once, but a number of visits were followed up, resulting in 50 farm visits altogether. During a visit young ewe hoggets intended for replacement and in rare cases young wether hoggets (used for wool production) were inspected. On farms where replacement flock sizes exceeded 100 animals, 100 animals were counted off at random and inspected. In smaller flocks all the available hoggets were inspected. Data were recorded for 4951 Merino and Dohne Merino hoggets with at least 3 months' wool growth. The following data were recorded: presence or absence of strike, site of the strike (body, breech or elsewhere), severity of the strike (1=mild to 5 = severe: see published definition[59]) as well as the presence or absence of dermatophilosis. Strikes were recorded if observed on the sheep inspected. Presence of strike was defined as any sign that an observed animal had been struck at any time since the previous shearing, the latter indicated by shorter wool at the position of the strike. Dermatophilosis was subjectively defined as present if, on opening of the fleece, any dermo' scabs as previously described[48] were noticed on the skin or in the fleece. The fleece was opened at 3 sites: behind the neck, on the backline and down the side. A linear type scoring system was used for wool quality and wool colour[50]. Quality was defined as sharpness/definition of crimp as well as variation of crimp frequency between fibres and along the staple from 1 (indistinct evenness of crimp) to 50 (very well defined crimp). Wool colour was also scored on a scale from 1–50, where 1 equated with canary yellow wool and 50 equated with bright white wool. All the animals were subjectively scored for wool quality and colour by the same qualified wool classer.

Management strategies and control measures were recorded by interviewing the owner or manager of the farm. Information on crutching and the use of the Lucitrap® system was recorded for the flocks under observation. Shearing and tail-docking were practised as routine management practices on all the farms, and were therefore not recorded. Other control measures that were used to combat flystrike that were recorded included details of chemical treatment (preventative treatment, spot treatment, chemical and method used) and mulesing. The exact time of chemical treatment and crutching was not recorded.

Statistical analyses

Preliminary chi-square analyses indicated that frequencies differed ($P < 0.05$) between levels of some of the effects that were considered. However, it was decided to assess all relevant effects in a single analysis on each of the dependent variables (overall frequencies of dermatophilosis, flystrike, breech strike and body strike, as well as wool colour and quality). Least squares procedures were used for this purpose, to account for uneven subclasses (Table 1). The mixed model that was fitted included the concatenated random effect of farm and year, as well as the fixed effects specified in Table 1. Spot treatment of existing strikes had a 100 % incidence and the effect was not considered in any analysis. In analyses on the various measures of blowfly strike the occurrence of dermatophilosis was added as an additional fixed effect. Wool length, wool colour, farm size (in hectare). and wool quality were added to the model as linear covariates where appropriate. Random deviations from linearity were also considered but did not result in models with a better fit and were not considered further after preliminary analyses. Preliminary analyses included all effects listed, as well as interactions of breed with the absence or presence of the Mules operation, breed with wool length and breed with wool colour. In the case of the 3 flystrike traits, the interaction of breed with the occurrence of dermatophilosis was also initially considered.

The software used was ASREML[18], which is suitable for the analysis of a wide range of mixed models in agricultural studies. In the case of the binary response variables (the occurrence of flystrike or dermatophilosis), the normal distribution was linked to the binomial distribution by the logit link function[18]. The analyses were structured according to type of trait, *i.e.* of subjective wool traits (the presence of dermatophilosis, wool colour score, wool quality score) and of blowfly strike traits (overall flystrike, breech strike and body strike). From initial analyses, the final runs for the respective trait types only included effects and covariates that approached significance ($P = 0.10$) in preliminary runs for at least 1 trait in a group. None of the interactions that were considered initially were thus included for flystrike traits. Significant interactions for subjective wool traits are reported in the text. Only those effects, interactions and covariates included in the final runs were tabulated or illustrated graphically and discussed. Logit transformed means are provided with an appropriate standard error of the difference (SED) and the applicable back transformations to proportions on the underlying normal scale. Means for the 3 flystrike measures and the presence of dermatophilosis were predicted at a wool length of 10 months. Significance at $P = 0.10$ was accepted for flystrike, given the low frequencies of struck animals (Table 1).

RESULTS

General

The number of animals recorded for each effect is listed in Table 1, along with unadjusted flystrike frequencies assessed over all animals that were evaluated during the study. Overall strike rates as well as respective frequencies for breech strike and body strike are presented. Poll strike and pizzle strike were also recorded in 1 animal each but these frequencies were too low for meaningful analyses. These cases were, however, included in the overall strike rate. It is notable that wethers as well as animals that were crutched were represented by only small proportions of the overall number of observations.

It is evident that breech strike was by far the most important type of blowfly strike (Table 1). Slight discrepancies in the observed frequencies can be attributed to 6 animals that had both body strike and breech strike that cancelled out the 2 strikes on other body locations mentioned previously. Furthermore, fairly large absolute differences in flystrike prevalence were observed between ewe and wether hoggets. The prevalence of flystrike in crutched hoggets was also much higher in absolute terms than in their contemporaries that were not crutched. Preventative chemical treatment did not have the beneficial effect on blowfly strike that was expected. The effects of crutching, preventative treatment and sex did not approach statistical significance at $P < 0.10$ in the overall analyses and were excluded in final statistical analyses. Recorded cases of body strike were more likely to have strike severity scores of 3 or higher (21/27 = 0.778) than recorded cases of breech strike (80/162 = 0.494) ($\chi^2 = 6.40$, $P < 0.05$).

Table 1: **Simple tabulation of effects for animal numbers, as well as the overall frequencies of overall flystrike, breech strike and body strike.**

Effect and level	Number of observations	Overall flystrike	Breech strike	Body strike
Year				
2003	3151	0.039	0.033	0.006
2004	1800	0.034	0.032	0.004
Sex				
Ewe	4351	0.034	0.029	0.005
Wether	600	0.063	0.060	0.005
Preventative treatment				
No	1500	0.033	0.028	0.006
Yes	3451	0.039	0.035	0.005
Use of crutching				
No	4644	0.033	0.029	0.004
Yes	307	0.101	0.085	0.019
Use of Lucitraps®				
Yes	1200	0.023	0.023	0.001
No	3751	0.042	0.036	0.007
Use of the Mules operation				
No	3556	0.050	0.045	0.006
Yes	1395	0.004	0.002	0.003
Breed				
Merino	2538	0.033	0.030	0.004
Dohne Merino	2413	0.041	0.035	0.007

Subjective wool traits

Dermatophilosis was more prevalent in wether than in ewe hoggets (Table 2).

Table 2: **Subjective wool characteristics of hoggets evaluated according to, sex, breed, the use of crutching and of mulesing.**

Effect and level	Presence of dermatophilosis		Wool colour	Wool quality
	Logit value	Mean		
Sex				
Ewe	–2.53	0.074[a]	28.1	29.6
Wether	–1.73	0.151[b]	28.1	30.3
SED*	0.23		0.49	0.6
Breed				
Merino	–2.02	0.117	29.0[b]	32.6[b]
Dohne Merino	–2.23	0.097	27.2[a]	27.4[a]
SED*	0.19		0.5	0.5
Use of crutching				
No	–1.60	0.167	28.3	28.5
Yes	–2.65	0.066	27.9	31.5
SED*	0.73		2.5	1.9
Use of mulesing				
No	–1.93	0.126	27.7	29.1
Yes	–2.32	0.089	28.4	30.9
SED*	0.42		1.5	1.1

*Standard error of the difference.
[a,b]Denote significant differences ($P < 0.05$).

Merino hoggets generally had higher scores than their Dohne Merino contemporaries for wool quality and colour on a subjectively scored scale. Hoggets subjected to the Mules operation generally had higher scores for quality (P = 0.05). Results pertaining to dermatophilosis and wool quality were complicated by significant (P < 0.05) interactions between breed and the presence of the Mules operation. The presence of dermatophilosis was independent of mulesing treatment in Merinos (logit transformed means for animals subjected to mulesing or not: –2.09 *vs* –1.96; SED = 0.41; P > 0.10; back transformed means, respectively 0.110 *vs* 0.124). In Dohne Merinos, animals that were subjected to the Mules operation generally had higher levels of dermatophilosis than those that were not (logit transformed means for animals subjected to mulesing or not: –1.77 *vs* –2.69; SED = 0.41; P < 0.05; back-transformed means: 0.145 *vs* 0.064). In contrast, quality score was independent of mulesing treatment in Dohne Merinos (means for animals subjected to mulesing or not: 27.6 *vs* 27.1; SED = 1.1; P > 0.10). Merino hoggets subjected to the Mules operation had higher quality scores than those that were not (means for animals subjected to mulesing or not: 34.2 *vs* 31.0; SED = 1.1; P < 0.05). There was a tendency for crutched hoggets to have better quality scores than hoggets that were not crutched (P = 0.12). A similar tendency was found for sex, where wethers tended to outperform ewes (P = 0.19).

The incidence of dermatophilosis was associated with subjective scores for wool quality and wool colour (Fig. 2a,b). Predictions on the normal scale suggested that the occurrence of dermatophilosis may be above 60 % in sheep with very yellow wool (a wool colour score of 10; Fig. 2b). This percentage declines to below 5 % for sheep with wool colour scores of 40 and higher. In contrast, sheep with higher scores for quality were more likely to suffer from dermatophilosis.

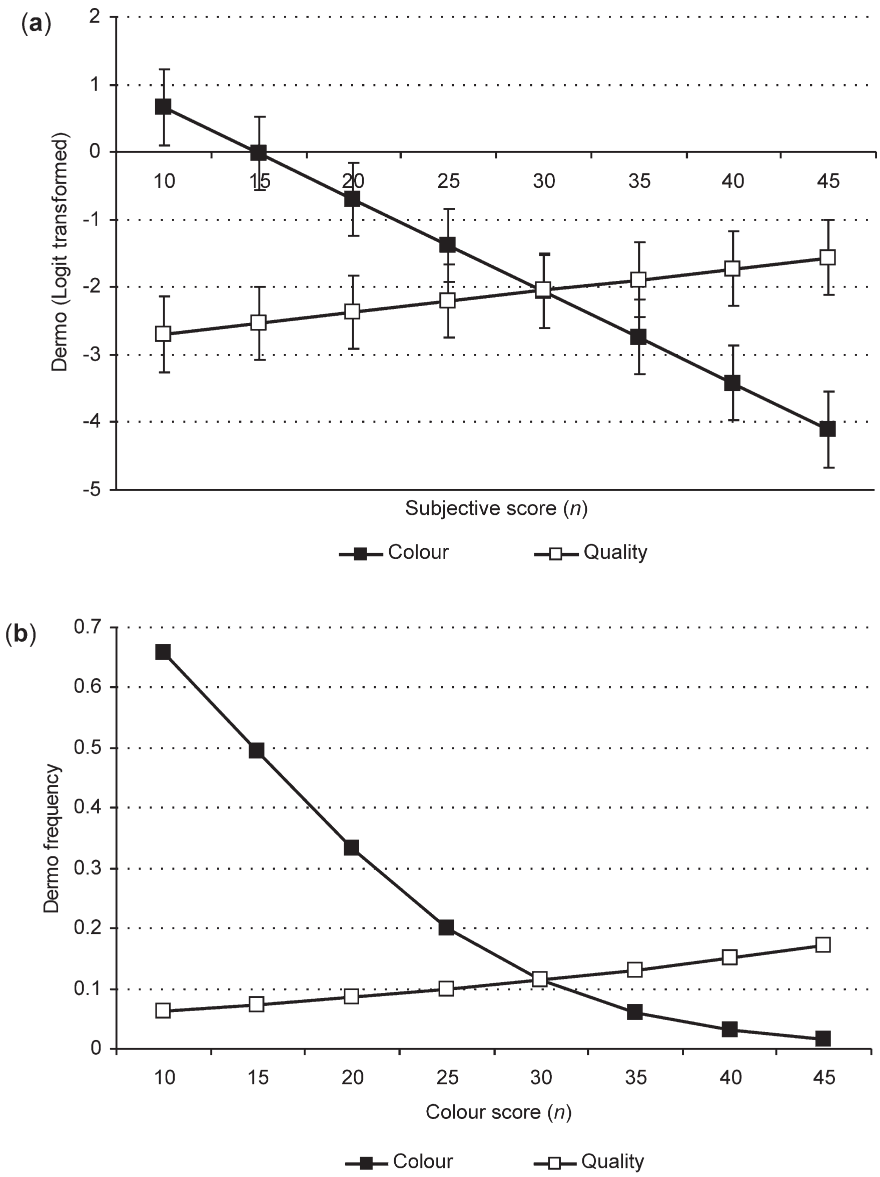

Fig. 2: **Predicted means depicting the effects of wool colour and wool quality on the prevalence of dermatophilosis on the logit scale** (a)**, with corresponding back transformed values on the observed normal scale** (b)**. Vertical lines about the mean denote standard errors** (a)**.**

Overall flystrike, breech strike and body strike

The prevalence of blowfly strike was independent of breed (Table 3). Absolute values favoured the Dohne Merino breed, approaching statistical significance (P = 0.13) for overall strike rate. It is noteworthy that the absolute difference between breeds in Table 3 (0.053 for Merinos *vs* 0.029 for Dohne Merinos) is reversed in comparison with the uncorrected values in Table 1 (respectively 0.033 *vs* 0.041). It is important to note that Merino hoggets were much more likely to be subjected to the Mules operation than their Dohne Merino contemporaries (1095/2538 = 0.431 *vs* 300/2413 = 0.124; χ^2 = 574.9, P < 0.01). There was an indication that the use of the Lucitrap® system may reduce flystrike (P = 0.19 for overall flystrike and P = 0.12 for body strike). Overall flystrike was reduced (P < 0.01) in animals subjected to the Mules operation, mainly through a marked effect on breech strike (P < 0.01), while body strike was unaffected by the Mules operation (Table 3). The direction and magnitude of means for animals subjected to the Mules operation and grazing on properties where the Lucitrap® system was employed were fairly consistent between Tables 1 and 3. All forms of flystrike (overall, breech and body) were more prevalent (P < 0.01) in hoggets suffering from dermatophilosis compared with their unaffected contemporaries (P < 0.01).

In the overall analysis involving all effects it was clear that the prevalence of overall flystrike and breech strike increased with wool length (*i.e.* smaller negative values) (Fig. 3a). Body strike (which was observed at a reduced prevalence) was not affected to the same extent. Back-transformed values in Fig. 3b clearly indicated that the risk of overall flystrike and breech strike were minimal in short-woolled sheep, increasing to 5.5 to 6.0 % in hoggets with a wool growth of 11 months.

Wool colour remained an important source of variation in the prevalence of overall flystrike and breech strike (Fig. 4a,b). Back-transformed values suggested that overall flystrike was reduced from ~7 % in very yellow wool to below 3 % in very white wool.

The effect of wool colour on the fre-

Table 3: **Overall blowfly strike, breech strike and body strike of hoggets evaluated according to breed, the presence of Lucitrap®, the use of the Mules operation, and the presence of dermatophilosis. Wool length, farm size and wool colour were included as linear covariates. Means were adjusted to a wool growth period of 10 months, and an average wool colour score**

Effect	Overall blowfly strike		Breech strike		Body strike	
	Logit value	Mean	Logit value	Mean	Logit value	Mean
Breed						
Merino	–2.89	0.053	–3.04	0.046	–5.72	0.004
Dohne Merino	–3.51	0.029	–3.63	0.026	–5.86	0.003
SED*	0.41		0.48		0.57	
Presence of Lucitrap®						
No	–2.80	0.058	–3.05	0.045	–4.91	0.007
Yes	–3.60	0.027	–3.63	0.026	–6.66	0.001
SED*	0.61		0.66		1.1	
Use of Mules operation						
No	–2.09	0.110[b]	–2.10	0.109[b]	–5.39	0.003
Yes	–4.31	0.013[a]	–4.58	0.010[a]	–6.19	0.001
SED*	0.70		0.84		0.86	
Presence of dermatophilosis						
No	–3.59	0.027[a]	–3.69	0.024[a]	–6.35	0.001[a]
Yes	–2.81	0.057[b]	–2.99	0.049[b]	–5.22	0.005[b]
SED*	0.19		0.20		0.43	

*Standard error of the difference.
[a,b]Denote significant differences ($P < 0.05$).

quency of both breech and body strike was appreciably smaller than the effect of wool length. When the standard errors (Fig. 4) were studied there did not appear to be any conclusive differences between the high and lower wool colour scores, although the overall regression coefficient was significant.

DISCUSSION

Breech strike appeared to be the dominant form of flystrike in the Rûens area of the Western Cape Province as also reported for Merino sheep at the Tygerhoek Research Farm (which falls within the region of interest)[8] Similar results were also reported in other parts of the world[2,3,54,62]. The lack of response of flystrike to preventative chemical treatment was unexpected. It may be related to the timing of preventative treatment relative to shearing, since it is less likely to be implemented in short-woolled sheep, which showed lower susceptibility to flystrike. Data pertaining to sex and the use of crutching were very unevenly distributed and, as they were not statistically significant, were not retained in the final analyses. It is accepted that crutching of sheep has a role to play in blowfly strike control[15,61], but this was not evident in the present study. Crutching may have been performed in response to flystrike in the 307 animals that were crutched, as their liability to flystrike in absolute terms appeared to be much higher than their cohorts that were not crutched. In accordance with previous observations, body strike appeared to be more severe than breech strike[59]. It is suggested on the basis of the present results that body strike may be more difficult to detect during routine inspections than breech strike. It is conceded that date of shearing could have influenced flystrike but this effect was confounded by wool length in the present study and therefore not assessed.

It is conceivable that fixed effects based on the treatment of entire mobs at properties (crutching, preventative treatment, mulesing, etc.) could have been based on knowledge of flystrike risk on those properties. This could potentially influence results of this study, as such considerations were not known to the surveyor. If this reasoning is founded, it would support the effectiveness of mulesing in the alleviation of breech strike and it would also explain the tendency towards lower levels of flystrike on those properties where the Lucitrap® system is employed.

The ideal would be to classify properties prior to the survey according to their flystrike risk, but since no historic information on the respective properties was available, this was not possible. It is, however, conceivable that properties with high flystrike risk could rely on preventative practices such as crutching, mulesing and trapping. However, given the relative homogeneity of the experimental area in terms of climate, topography and farming practices, this does not seem likely. Of course, the effects measured on individual sheep do not suffer from this complication.

Subjective wool traits

Dermatophilosis appeared to be more prevalent in wether than in ewe hoggets in the present study (Table 1). In contrast, an average prevalence of, respectively, 0.2 % *vs* 0.6 % for wether and ewe lambs was reported in a survey on ovine dermatophilosis in Western Australia[12]. The study further reported that the prevalence of dermatophilosis and its relationship to various environmental and management factors varied with the age and sex of sheep in their study[12]. Wethers are valued for their meat, since meat typically contributes largely to the income of wool farmers in South Africa[51]. This result can probably also be attributed to management factors, with ewe flocks generally well looked after, while little effort and money is spent on wether lambs before they are sold for slaughter. However, this is pure speculation since management practices for the control of dermatophilosis were not recorded. It has to be taken into consideration that the number of wethers in the survey was small compared with the ewes, and coincidence may have played a role.

Merino hoggets generally had higher scores for wool quality and colour than the Dohne Merino hoggets when scored subjectively (Table 1). Merino is valued for its fine quality wool[5,31]. The Dohne Merino, developed from the Merino and South African Mutton Merino (formerly the German Merino), was originally intended for semi-intensive farming in the Eastern Cape grassland regions[35]. The Dohne Merino has proved adaptable under widely divergent conditions and is considered to be one of the main dual-purpose breeds of South Africa. In a comparative study between Merino and Dohne Merino yearlings, average fibre diameters of 21.8 μm *vs* 22.0 μm for rams and 21.9 μm *vs* 21.8 μm for ewes were recorded for the respective breeds[7]. In a recent study fibre diameter was reported to be 18.0 μm for Merinos and 19.7 μm for Dohne Merinos[24]. Even though Dohne Merino wool can be considered to be of the same fibre diameter as medium to fine Merino wool when measured objectively, a significant difference ($P < 0.05$) of 32.6 (Merinos) *vs* 27.4 (Dohne Merinos) in terms of quality (evenness and boldness of crimp, softness of handle and the absence of strong and hairy fibres) of the wool was observed. A significant difference of 27.2 (Dohne Merino) *vs* 29.0 (Merino) ($P < 0.05$) for wool colour was found. No comparative study in terms of wool colour or wool quality between the Merinos and Dohne Merino breeds to support or refute the present findings could be found. Wool from German Merinos (one parent breed of the Dohne Merino) was considered to have a yellowish appearance initially. It is noteworthy to mention that Belschner[4] was of the following opinion 'I regard yellow colouration of the yolk as an important factor in rendering sheep susceptible to fleece rot, but I regard character and 'handle' (softness of the wool) as more important factors than colour'.

The interactions between breed and mulesing status for the presence of dermatophilosis could be considered to be spurious, as the interaction seems to be driven mostly by a low incidence of dermatophilosis in the numerically small group of Dohne Merinos that were subjected to the Mules operation. However, in the case of quality, the interaction seemed to be driven by better scores in mulesed Merino hoggets, which were numerically very similar to those Merino hoggets not subjected to mulesing. As the Mules operation was at that time considered a routine managerial intervention on well-managed farms, it may be argued that those Merino farmers that practised mulesing may actually have been more committed sheep farmers, hence the better wool quality in their stock.

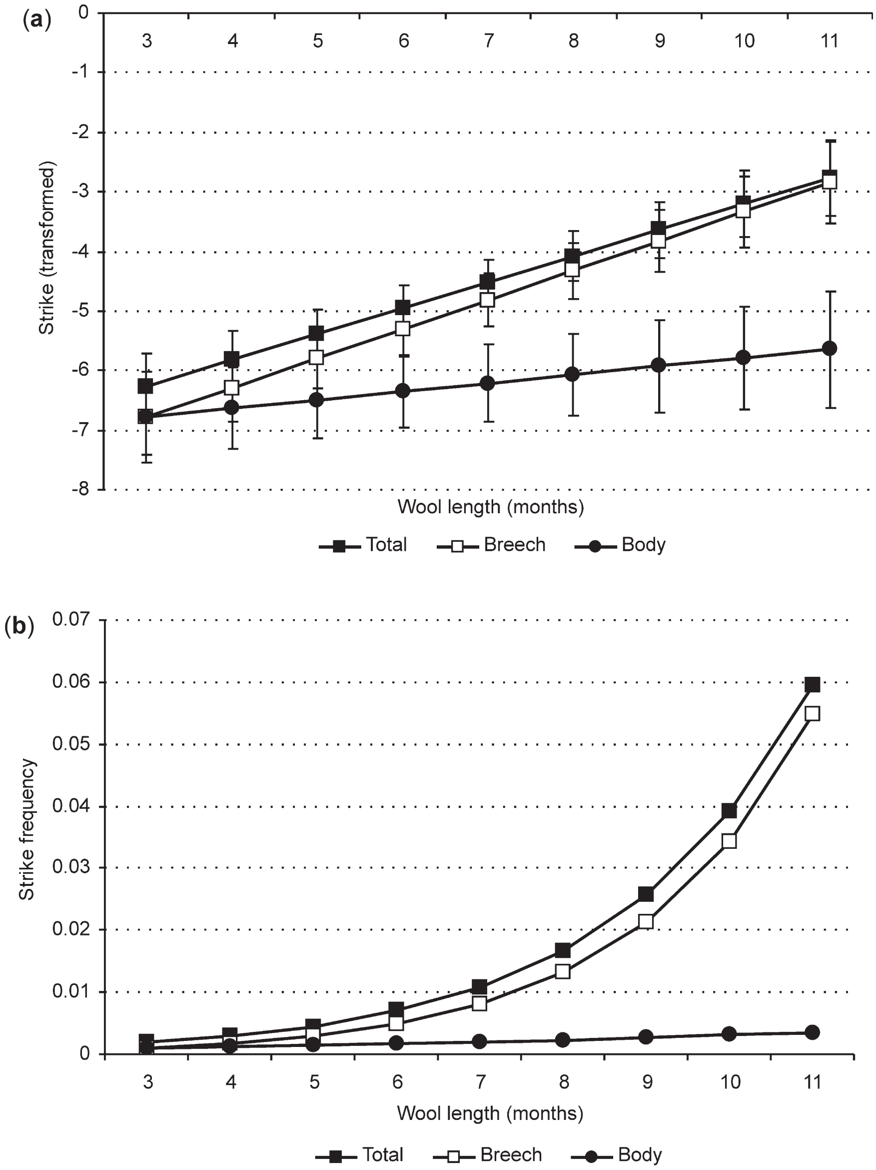

Fig. 3: **Predicted means depicting the effect of wool length on the prevalence of total flystrike, breech strike and body strike on the logit scale** (a)**, with corresponding back transformed values on the observed normal scale** (b)**. Vertical lines about the mean denote standard errors** (a)**.**

Overall flystrike, breech strike and body strike.

Blowfly strike was independent of breed (Table 3), although absolute values favoured the Dohne Merino and approached statistical significance for overall flystrike ($P = 0.13$). The discrepancy between raw means for overall flystrike in Table 1 and adjusted means in Table 3 stems from the adjustment of flystrike data of Merinos for the difference in wool colour, as well as for a much higher prevalence of the Mules operation in the latter breed. This survey was done on young animals and young animals are known to be very susceptible to blowfly strike. Young sheep, regardless of sex, with 3–6 months' fleece growth have been reported to be the most susceptible to body strike[55]. With an overall raw blowfly strike rate of below 4 %, and with a body strike prevalence of below 0.5 %, the challenge might have been too low to demonstrate any difference in blowfly strike susceptibility that may exist between these breeds. The blowfly strike rate reported in this study is in accordance with strike rates ranging from 1.6 % to 15 % reported elsewhere[15,23,38,67].

With regard to the Lucitrap® system, absolute values for flystrike favoured properties where trapping was employed as a component of integrated pest management (Tables 1 and 3). In the case of body strike, this difference approached statistical significance ($P = 0.12$), although it must be conceded that body strike occurred at a very low prevalence. The effectiveness of the Lucitrap® system in reducing blowfly populations was demonstrated in Australia[65] and South Africa[56,57,58]. A 46 % reduction in strike rate in a trial conducted in southern Queensland by using the Lucitrap® system was reported[66]. The absolute value for overall flystrike in trapped areas (2.7 %) amounted to 46.6 % of that in areas where no traps were placed (5.8 %) in the present study (Table 3). Clearly, this result agrees closely with the study in southern Queensland[66]. However, an important factor to consider in monitoring fly populations is the correlation between the numbers of flies caught and the incidence of flystrike[10]. It has been reported that the incidence of flystrike was related to the logarithm of the density of gravid females in the area during the previous week[67]. As a result of the logarithmic relationship, a reduction

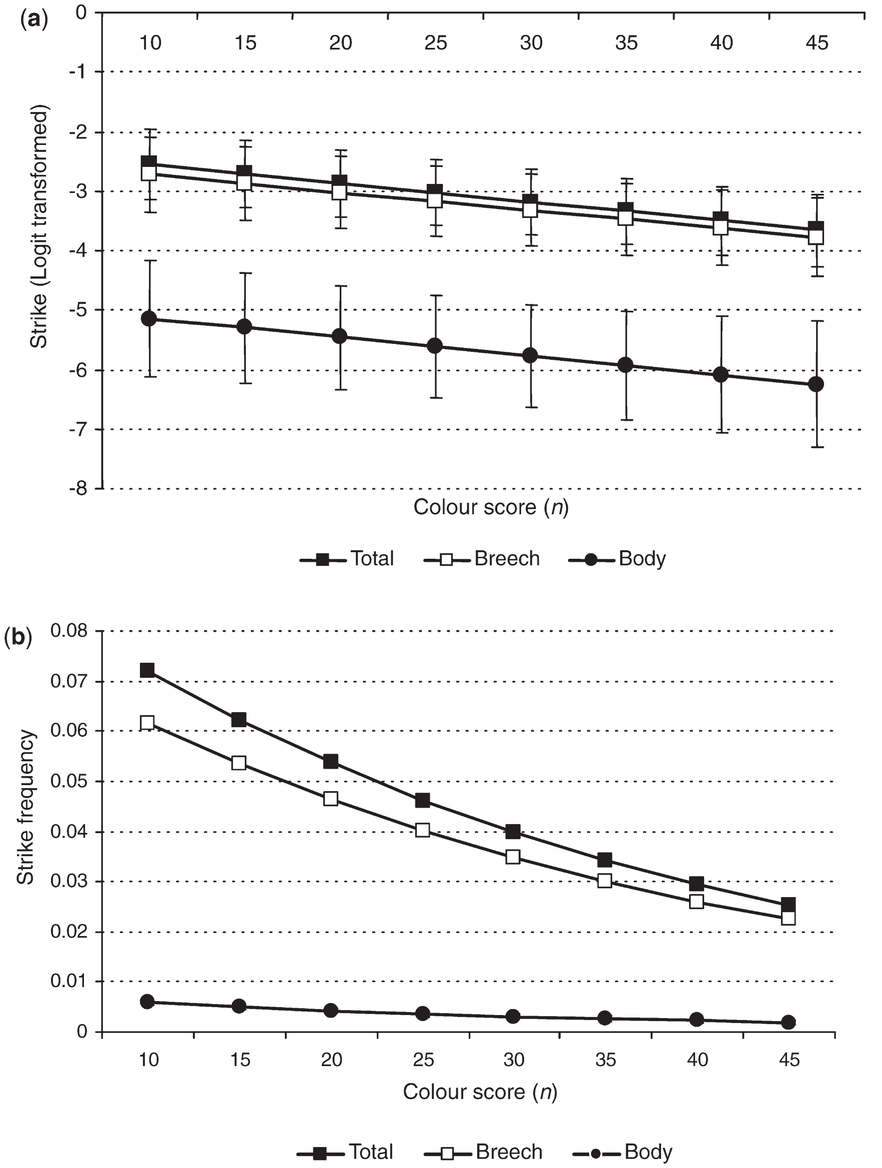

Fig. 4: **Predicted means depicting the effect of wool colour on the prevalence of total flystrike, breech strike and body strike on the logit scale** (a), **with corresponding back-transformed values on the observed normal scale** (b). **Vertical lines about the mean denote standard errors** (a).

of fly numbers by 70 % would be necessary to reduce flystrike by 50 %. Previous studies reported that intensive use of the Lucitrap® system and a high level of fly-trapping for several years may reduce the blowfly problem to more manageable levels[66] but are unlikely to prevent flystrike overall[13,22]. Furthermore the large numbers of adult females that need to be attracted by traps to achieve effective population management[6], thereby allowing a noteworthy reduction of pesticide treatment[25,67], is seldom achievable. It is interesting to note that Smit[63] was already of the opinion 'that the trapping of blowflies must be a supplementary measure, since even though substantial numbers of flies may be caught in traps the numbers caught in a trap does not always indicate the amount of good the trap is doing'. It is recommended that flytraps should be used in combination with other management systems to keep flystrike at low levels[13].

The Mules operation benefited overall flystrike (1.3 % *vs* 11.0 % for mulesed and unmulesed hoggets respectively, P 0.05). The Mules operation is known to be highly effective for reducing the incidence of strike in the breech[39,44,68]. This also held true for this study where incidence of breech strike was reduced more than 10-fold from ~11 % in unmulesed hoggets to ~1 % in mulesed hoggets. Mulesing is permanent and can reduce the prevalence of breech strike from 60–80 % in ewes to less than 1 % when combined with crutching[55]. However, in terms of animal welfare, it can no longer be considered a control option for breech strike. With the restriction on its use in South Africa alternative measures need to be considered for the control of breech strike. Body strike was independent of mulesing, as would be expected. The likelihood of hoggets suffering from dermatophilosis having flystrike was approximately double that of contemporaries not suffering from the skin condition (Table 3.). In the present study, this difference was evident both for breech strike and for body strike. The latter finding is in accordance with scientific reports indicating that dermatophilosis is 1 of the main predisposing conditions for body strike in particular[17,48,64]. Furthermore, immunologically 'naïve' sheep such as the locally-bred young sheep in this survey are expected to have a higher susceptibility during their 1st challenge period[33].

The proportion of fly strikes increased with wool length (Fig. 3) as was expected. Already in the early history of the wool industry, MacLeod[40] identified wool length as the factor dominating the susceptibility of sheep to blowfly strike. It is furthermore accepted that clipped sheep and young lambs with short fleeces (2–3 months' wool growth) are not usually struck, but as the length of the fleece increases, so does the risk of strike[16].

There was a decline in proportion of strikes as wool colour became whiter (Fig. 4). This is in accordance with published results stating that sheep with bright, white wool are generally more resistant to fleece rot and body strike than those with yellow wool[13,71]. Various researchers have looked for indirect selection criteria to identify sheep that are more resistant to fleece rot and therefore more resistant to flystrike[3,21,42]. Greasy wool colour (yellowness) has been reported to be the character most strongly associated with fleece rot in South Australian Merinos[29,30], while it was also consistently related to fleece rot in studies with other Merino strains[3,21,34]. Moderate to high heritability estimates (0.30–0.64) have also been reported for greasy colour score in Australia[30,42,43]. Wool colour score of South African Merino sheep was similarly reported to be highly heritable at 0.33[41]. Therefore, selective breeding for sheep with bright white wool may reduce the incidence of flystrike[46,47].

One of the aims of the wool sheep industry is to implement sustainable ectoparasite control[32]. The most efficient method to achieve this is through Integrated Pest Management (IPM) programmes. International trade agreements favour an IPM approach for the control of the sheep blowfly.

CONCLUSIONS

This study concludes that breech strike is the major form of strike in the Rûens area. Ironically, mulesing was once again demonstrated to be an effective control method for breech strike. With the termination of mulesing as an acceptable management practice, this study highlights the need for alternative methods to be used in blowfly IPM. It is notable that other initiatives that could add to blowfly IPM as recorded in the present study failed to have the same impact on blowfly strike than that of mulesing. In the present study, indicator traits associated with blowfly strike included the presence of dermatophilosis and a low wool colour score. Recent research in Australia identified more such indicator traits with potential to combat breech strike, namely: wrinkle-, dag-, urine stain-, breech cover- and crutch cover scores as well as wool characteristics as indirect selection criteria for the control of breech strike. This presents an opportunity for a genetic solution to the breech strike problem in the Rûens area. Although breeding is a long-term solution, it is attractive from an animal welfare, ethical, economic and sustainability perspective. Based on recent results, it seems feasible for selective breeding to contribute to blowfly IPM[20,60] and the topic clearly warrants further research.

Since none of the management practices in use on the farms surveyed were sufficient to guarantee complete blowfly control when evaluated on their own, an IPM approach should be considered. An IPM approach for the control of blowfly strike should include sheep husbandry, farm management, selective breeding and strategic insecticide use.

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