The effect of application of the FAMACHA© system on selected production parameters in sheep

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ABSTRACT

Much research has gone into developing a sustainable management tool for haemonchosis, namely the FAMACHA© system, which has been validated by numerous studies worldwide. However, the financial implications on production of implementing this system have not been fully investigated in sheep previously. A trial was conducted on a farm comprising a flock of approximately 300 Mutton Merinos on which the FAMACHA© system was in use. Seventy five maiden and multiparous ewes were randomly

allocated to the following three trial groups: (i) FAMACHA© in which ewes judged to be incategories 4 or 5 were dosed with levamisole HCl 2,5% (Nemasol NF, Intervet); (ii) Conventionally dosed in which all ewes were dosed every six weeks with levamisole HCl 2,5% (Nemasol NF, Intervet); (iii) Suppressively dosed in which all ewes were injected every six weeks with moxydectin 1% m/v (Cydectin, Bayer AH).

There were no significant differences in body weight gains, FAMACHA© and body condition scores amongst the three treatment regimens for ewes that did not conceive. For those that became pregnant during the trial there was a significant difference when analysed by calendar date but not when analysed by reproductive stage. There were also no significant differences between trial groups in lamb birth weight and, after slow growers had been sold, the average daily gain of the lambs born to ewes in the trial. The cost of anthelmintics was considerably lower for the FAMACHA© group. In conclusion there were no significant differences in selected production parameters when using the FAMACHA© system as opposed to other methods of anthelmintic use in a Mutton Merino flock in a semi-intensive farming system and that the gestation status should be taken into account when measuring these parameters in future studies.

Key words: Sheep, ovine, FAMACHA©, targeted selective treatment, helminth management, *Haemonchus contortus*, animal production

INTRODUCTION

The role of helminths in small stock production, and hence the optimal use of anthelmintics to manage helminth infections, has received much attention (Van Wyk *et al.*, 1990; 1997; 1998; Van Wyk and Bath, 2002; Van Wyk, 2001; 2005; 2006; 2008; Besier and Love, 2003; Waller, 2003; Kaplan *et al.*, 2004; Jackson *et al*., 2009; Kenyon *et al.*, 2009). Over time, newer and more effective anthelmintics have been produced that controlled worms effectively for decades, but almost total reliance on treatment was not sustainable and ultimately has been to the detriment of good farming practices and farm management. The indiscriminate use of these drugs has in turn led to the development of widespread anthelmintic resistance in the helminth population (Kenyon *et al.*, 2009). A growing number of farmers are thus forced to use additional or alternative methods to control the parasites in their stock.

The most important helminth of sheep in South Africa is *Haemonchus contortus* which has the distinctive clinical effect of anaemia as a result of haematophagia. This can be used as an index of infection and ability of sheep to cope unaided with the current worm challenge, culminating in the development of the FAMACHA© system (Bath *et al*., 1996; Van Wyk and Bath, 2002). A full investigation of the system's effects on animal production is however required to evaluate its economic impact on sheep farming.

Work in New Zealand on Romney sheep has shown an unfavourable genetic correlation between faecal egg count (FEC) and some production traits (Morris *et al.,* 2000). This study was conducted where *Trichostrongylus* and *Teladorsagia* were predominant. However, in Australia it was not found to be the case with merinos with *H. contortus* burdens (Kahn *et al*., 2003). Eady *et al.* (1998) found that parasite-resistant merinos had relatively lower wool growth rate, but not body weight (BW) gain.

The FAMACHA© system of clinical evaluation of anaemia associated with haemonchosis has been used with success in a number of countries (Malan *et al*., 2001; Kaplan *et al*., 2004; Mahieu *et al*., 2007; Kenyon *et al*., 2009). Studies showing a reduction in live weight gain from infection with other worm species (Coop *et al*., 1977, 1988; Hubert *et al*., 1979; Kenyon *et al*., 2009) have led to some unsubstantiated criticism by uninformed drug purveyors of the FAMACHA© system, based on the inference that it would lead to a decrease in production particularly with chronic haemonchosus. To some extent this has been rebutted in previous investigations (Bisset et al., 2001; Mahieu et al., 2007; Burke and Miller, 2008; Van Wyk, 2008; Greer et al. 2009) but few have included production of pregnant and lactating animals as done in the study in goats (Maheiu *et al*., 2007).

The necessity of maintaining effective refugia to ensure prolonged anthelmintic efficacy is well recognized (Kenyon *et al*., 2009). Frequent blanket treatment to reduce worm burden is not a sustainable practice since it leads to anthelmintic resistance (AR) (Van Wyk, 2001) especially with *H. contortus*.

The objective of this study was to investigate the effect of application of the FAMACHA© system in sheep on selected production parameters. The parameters measured were body weight gain, body condition scores, FAMACHA© scores and lambing data.

MATERIALS AND METHOD

The investigation was carried out on a farm near Delmas (26°2'35" S, 28°32'53" E), at an approximate altitude of 1570m, in the Mpumalanga Province, South Africa. The farm is situated in a summer rainfall region and received 347mm rain for the year 2007, with minimum and maximum temperatures of -5.6°C and 32.2°C respectively measured at the Delmas weather station (South African Weather Service, 2009).

The trial started in November 2006 and ended on 1 July 2007, and thus spanned the period during which haemonchosis is most likely to occur in the region.

This flock comprised approximately 300 Mutton Merino ewes where the FAMACHA© system had already been in use for a decade. Rams were introduced into the ewe flock including trial ewes between November and December 2006 and again between March and April 2007 for a period of six weeks for each breeding season. Lambing occurred from 15 April to 1 May and 7 August to 1 September.

The sheep grazed on oats pastures during the winter months and a mixture of lucerne (*Medicago sativa*) and Smuts finger grass (*Digitaria eriantha*) during the summer months. Due to poor rains and pasture growth, and later inaccessibility to the pastures, the ewes were supplemented with Ewe and Lamb pellets (Afgri Animal Feeds, Table 1) at approximately 250-500g per ewe per day from 7 May 2007 to 21 May 2007 when this was replaced by similar amounts of chocolate maize (70kg yellow maize, 5ℓ water, 7kg sheep lick concentrate (Voermol Maxiwol), 1.5kg slaked lime) for financial reasons. Chocolate maize was supplemented until September 2007.

Table 1 Composition of Ewe and Lamb pellets[a]

Ingredient	Amount (g/kg)
protein	130 (min)
crude protein (CP) from NPN	30% (max)
urea	13,69 (max)
moisture	120 (max)
fat	25 (min); 70 (max)
fibre	150 (max)
calcium	15 (max)
phosphorus	3 (min)

[a] (Afgri Animal Feeds, registration number V8173)

Differential larval counts during the trial showed *H. contortus* to be the predominant parasite on the farm (97%) followed by *Oesophagostomum* spp. (2%) and *Trichostrongylus* spp. (1%). A faecal egg count reduction test (FECRT) using faecal worm egg counts (FECs) according to the modified McMaster method (Reineke, 1973) was performed on the farm prior to the trial at a test sensitivity level of one egg representing a count of 100 eggs per gram (epg). Both levamisole HCl 2.5% (Nemasol NF, Intervet) and injectable moxidectin 1% m/v (Cydectin, Bayer AH) were found to be >95% effective. Faecal egg counts (FECs) were performed on all groups on 28 February 2007 when data collection commenced to ensure that there was sufficient worm challenge to expect development of haemonchosis in some of the animals. A final FEC was done on 1 July to determine what the worm burden was at the end of the trial period. Low FEC's at this time showed that data collection could cease as *H. contortus* was no longer producing sufficient numbers of eggs and thus were no longer a severe challenge for the sheep.

Three groups were used namely the FAMACHA© (FMCH), Conventional (CONV) and Suppressive (SUPPR) groups. A total of 75 ewes was selected for the trial from ewes born in August 2005, April 2006 and August 2006 as these age groups included pregnant ewes, ewes being mated for the first time and ewes that were still too young to be mated. Each age group was ranked by weight and then allocated randomly in equal numbers to each group using block randomization. The same numbers of multiparous and maiden ewes were allocated to each treatment group. Ewes with BCS less than 2 were excluded from the trial. Trial ewes ran with the rest of the flock to simulate "on farm" conditions as far as possible and also to ensure that worm challenge was sufficient for all treatment groups.

Lambs born to ewes from the trial groups were weighed at birth and again at weaning. The number of days to weaning for each lamb was also recorded and average daily gains calculated.

Anthelmintics were administered by individual body weight according to manufacturers' recommendations as follows:

a) FAMACHA© (FMCH) group dosed with levamisole HCl 2.5% (Nemasol NF, Intervet) if judged to be in FAMACHA© categories 4 or 5 according to the FAMACHA© chart (Bath *et al*., 2001). However, all animals with submandibular oedema were dosed regardless of the FAMACHA© score;

b) Conventional (CONV) group treated strategically every 6 weeks using levamisole HCl 2.5% (Nemasol NF, Intervet);

c) Suppressive (SUPPR) group which was treated every 6 weeks with injectable moxidectin 1% m/v (Cydectin, Bayer AH) and served as the "worm free" control group.

FAMACHA© anaemia scores (on a scale of 1 to 5, with 1 being healthy optimum and 5 being extremely anaemic) and BCS (on a scale of 1 to 5, with 1 being emaciated and 5 being obese) (Bath and Van Wyk, 2009) as well as BW were recorded weekly by the farmer who had been thoroughly trained in all the subjective measurement methods. The data from pregnant and non-pregnant ewes were analysed together according to calendar date. However, because gestation status significantly affects parameters like body weight and resilience or resistance to nematodes (Russel, 1984), ewes that were pregnant during the trial were also evaluated in relation to gestation status from week -21 to week -1. For each of the trial ewes that lambed, the lamb birth weights, weaning weights and days to weaning were recorded and average daily gain (ADG) was calculated. Lambs were weaned at approximately 25kg.

All statistical analyses were done using Stata 10.1 (StataCorp, College Station, Texas, USA). A significance level of $\alpha = 0.05$ was used throughout.

The effect of dosing according to set intervals versus targeted selective treatment (TST) on ewe BW gain, lamb birth weight and lamb ADG was estimated using multiple regression analysis adjusted for age group and sire. Means and standard deviations were calculated for BW, lamb birth weight and ADG for ewes that lambed and different age groups. For the pregnant ewes that lambed during the trial period, the effect of treatment system on weight gain from conception to eight weeks before lambing was estimated using multiple regression analysis adjusted for age group. In addition, ewe BW, BCS and FAMACHA© scores were compared between groups using linear mixed models with repeated measures.

Correlations between BW gain, BCS and FAMACHA© scores were estimated using partial correlation analysis, adjusting for ewe number, and separately for the pregnant ewes, adjusting for days to lambing.

Table 2 Body weight (kg) outcomes in ewes and their lambs: descriptive statistics

Outcome	Treatment group					
	FAMACHA©		Conventional		Suppressive	
	n	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD
Total BW gain over entire trial period	18[b]	12.25 ± 5.87	21[b]	15.62 ± 4.74	21[b]	16.33 ± 5.51
BW gain from 21 w to 8 w prior to lambing						
2005 ewes	9	6.44 ± 7.00	9	6.78 ± 5.59	9	6.00 ± 4.63
2006 ewes	6	2.00 ± 0.84	6	5.17 ± 2.11	7	4.86 ± 1.41
Total	15	4.67 ± 5.78	15	6.13 ± 4.48	16	5.50 ± 3.55
Weight of lambs born per ewe						
2005 ewes	9	6.22 ± 1.92	9	6.95 ± 1.63	9	6.06 ± 1.65
2006 ewes	7	5.36 ± 0.48	6	5.75 ± 0.76	7	5.57 ± 0.54
Total	16	5.84 ± 1.50	15	6.47 ± 1.45	16	5.84 ± 1.27
Average daily gain of lambs						
2005 ewes	7	0.31 ± 0.07	9	0.32 ± 0.12	7	0.31 ± 0.02
2006 ewes	5	0.24 ± 0.04	6	0.25 ± 0.04	7	0.25 ± 0.04
Total	12	0.28 ± 0.07	15	0.30 ± 0.10	14	0.28 ± 0.04

[b] Ewes that lambed down before the end of the trial were excluded from the analysis as they were removed from the flock upon lambing in order to allow the ewes and lambs to bond. Thus no further weights, BCS or

FAMACHA© scores were collected which accounts for the discrepancy in the number of ewes in each category: only 18 ewes in FMCH group, 21 ewes in STRAT group and 21 ewes in SUPPR (control) group.

Of the ewes born in August 2005 all those allocated to the FMCH group lambed, one of the ewes allocated to the STRAT group did not lamb and one of the ewes allocated to the SUPPR group did not lamb. Of the ewes born in April 2006, four of those allocated to the STRAT group did not lamb and three allocated to the SUPPR group did not lamb.

RESULTS

Changes in BW, BCS and FAMACHA© score over time are shown for the three treatment groups in Figures 1 to 4. Body weight gain, mean lamb mass and lamb ADG are shown by treatment group and age group in Table 2 and the results of the multiple regression models in Table 3.

Ewe data

Although the linear mixed model showed no significant overall difference in BW between the three groups (P=0.06), when the data of all the ewes from day 0 to end of trial were analysed together, the results indicated that the FMCH group had gained significantly less BW than both

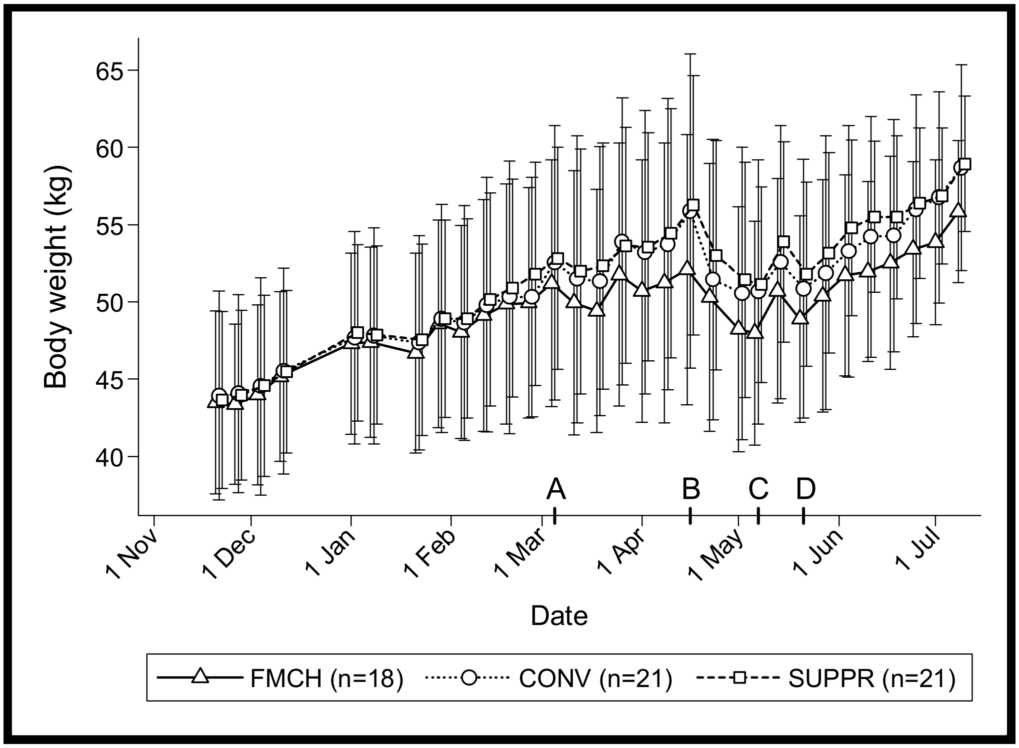

Figure 1 Body weight (mean ± SD) over an eight-month period of ewes dosed according to the FAMACHA© system (FMCH), conventionally (CONV) and suppressively (SUPPR). A: Rams in (5 March); B: Rams out (16 April); C: Supplementation with ewe and lamb pellets starts (7 May); D: Supplementation with chocolate maize starts (21 May).

the SUPPR (P = 0.007) and CONV groups (P = 0.001) (Tables 2 and 3, and Fig 1). However, when pregnant ewes that lambed were analysed separately according to gestation status, the differences between the groups in BW gain from 21 weeks to eight weeks prior to lambing were not statistically significant (Tables 2 and 3, and Fig 2).

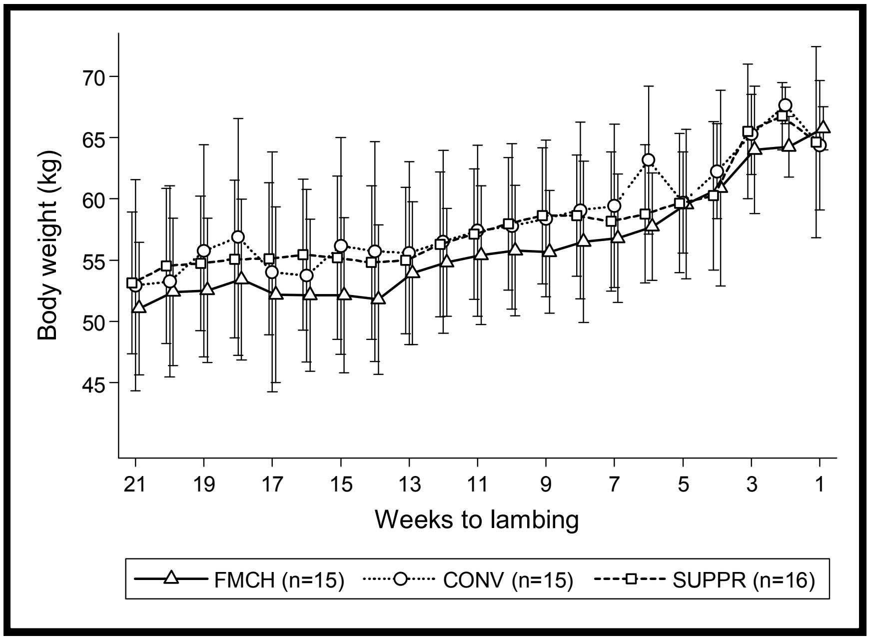

Figure 2 Body weight (mean ± SD) of ewes dosed according to the FAMACHA© system (FMCH), conventionally (CONV) and suppressively (SUPPR) from 21 weeks to 1 week prior to lambing

Low rainfall throughout summer was followed by heavy, late rains in June 2007 (South African Weather Service, 2009). This prevented access to the pastures due to extremely muddy conditions when the farmer wanted to utilize these pastures at this time and thus lowered intake, and is assumed to have caused a marked drop in BCS (Fig 3). The mixed model indicated a higher BCS overall for the SUPPR group versus the FMCH group (P=0.002) and for the

CONV group versus the FMCH group (P=0.03. However, the differences in BCS between the three groups at specific time points were significant only on 19 and 26 March (Fig 3).

A partial correlation analysis between BCS and BW from day 0 to the end of the trial, adjusted for days to lambing (i.e. stage of gestation) showed a significant positive correlation (r = -0.51; P<0.001).

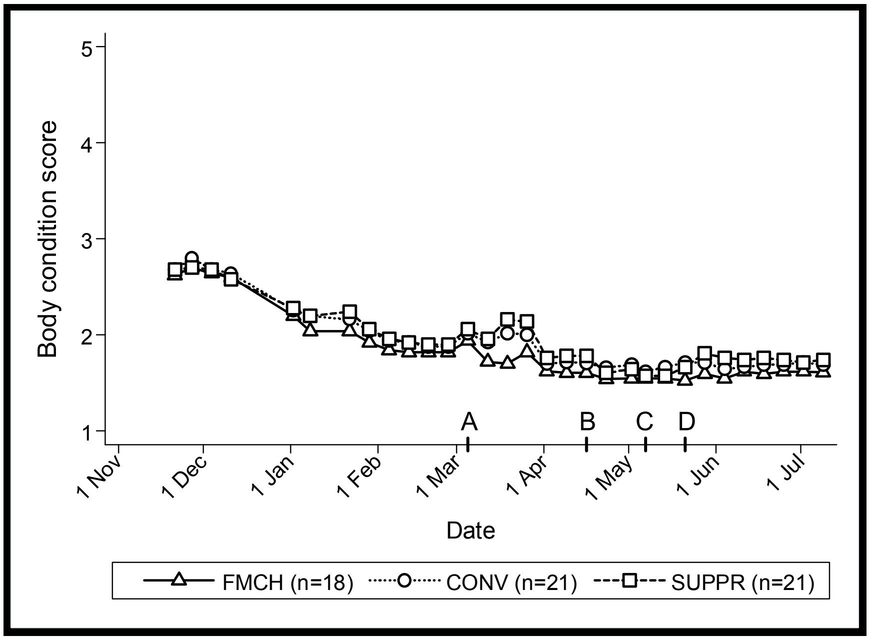

Figure 3 Body condition scores (mean ± SD) over an eight-month period of ewes dosed according to the FAMACHA© system (FMCH), conventionally (CONV) and suppressively (SUPPR). A: Rams in (5 March); B: Rams out (16 April); C: Supplementation with ewe and lamb pellets starts (7 May); D: Supplementation with chocolate maize starts (21 May).

A highly significant (P<0.001) negative correlation (r = -0.28) was found between BCS and FAMACHA© scores translating into a highly significant positive correlation due to

Table 3 Effect of dosing strategy on body weight (kg) outcomes in ewes: results of multiple regression models adjusting for age (and sire for lamb outcomes).

Outcome	Treatment group	*n*	Coef.	95% CI	*P*-value
Total BW gain over entire trial period	FMCH	18	0[c]	–	–
	CONV	21	3.23	0.93, 5.52	0.007
	SUPPR	21	3.94	1.65, 6.23	0.001
BW gain from 21 w to 8 w prior to lambing	FMCH	15	0[c]	–	–
	CONV	15	1.47	-1.90, 4.83	0.384
	SUPPR	16	0.92	-2.39, 4.23	0.577
Weight of lambs born per ewe	FMCH	16	0[c]	–	–
	CONV	15	0.54	-0.42, 1.51	0.263
	SUPPR	16	0.06	-0.89, 1.01	0.900
Average daily gain of lambs	FMCH	12	0[c]	–	–
	CONV	15	0.01	-0.04, 0.06	0.661
	SUPPR	14	0.01	-0.06, 0.04	0.606

[c] Reference group

the inverse scales of BCS (1 being thin a 5 being fat) and FAMACHA© scores (1 being good and 5 being poor).

Although mean FAMACHA© scores for all groups increased (deteriorated) reciprocally with a decrease in BCS over the trial period when the ewes were lambing (15 April to 01 May 2007), the mean scores did remain acceptable (≤3) throughout the trial period (Figs 3 and 4). The mixed model for FAMACHA© scores showed that overall scores were significantly higher in the FMCH group that in the other two groups (P<0.001).

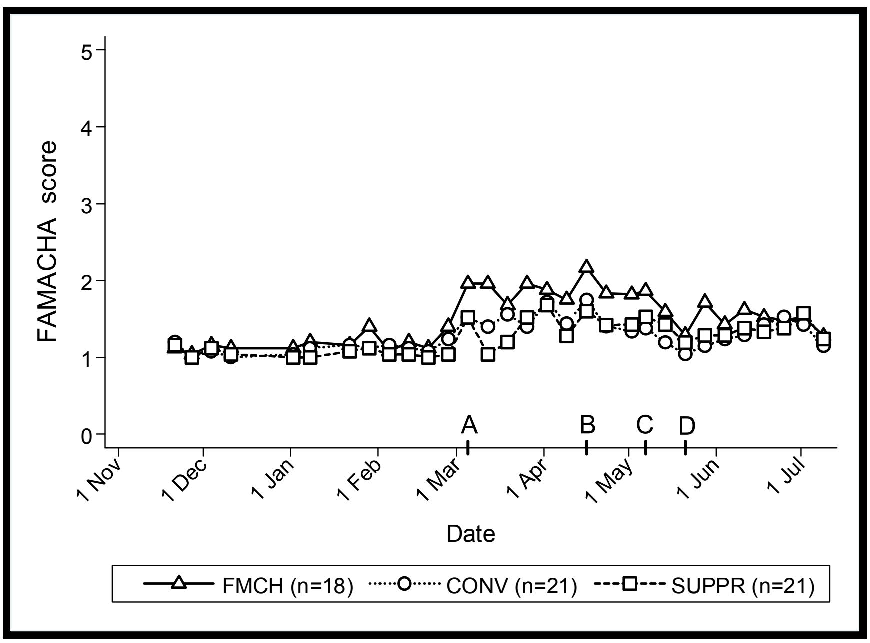

Figure 4 FAMACHA© scores (mean ± SD) over an eight-month period of ewes dosed according to the FAMACHA© system (FMCH), conventionally (CONV) and suppressively (SUPPR). A: Rams in (5 March); B: Rams out (16 April); C: Supplementation with ewe and lamb pellets starts (7 May); D: Supplementation with chocolate maize starts (21 May).

A partial correlation analysis of FAMACHA© scores with BW showed a highly significant (P<0.001) positive correlation (r = 0.27); this correlation became weaker (r = 0.10) when adjusting for stage of gestation, due to the fact that FAMACHA© scores increased as days to lambing decreased (r = -0.29; P < 0.001).

Lamb data

Lamb birth weights, weaning weights and number of days to weaning (at approximately 25kg) were recorded and ADG was calculated. Birth weight and ADG were analysed (Tables 2 and 3). Lambs were weaned at approximately 25kg liveweight.

Lambing percentages were 71% for the FMCH group, 76% for the STRAT group and 64% for the SUPPR group. The total trial group had a lambing percentage of 70%. Of the five ewes that gave birth to twins, one was from each of the FMCH and SUPPR groups and three from the CONV group.

Unfortunately the farmer sold six lambs before weaning as they were subjectively considered to be “slow growers”, of which four lambs (all singletons) were from the FMCH group and the remaining two (both one of a twin) were from the CONV and SUPPR groups. Therefore weaning percentages could not be assessed.

In comparison with the FMCH group no significant differences were found for lambs born to the CONV (P=0.263) or SUPPR groups (P=0.900) or in the ADGs of the lambs of the CONV (P=0.661) or SUPPR groups (P=0.606). ADGs were analysed excluding the “slow growers”.

Worm data

FEC of the SUPPR group was 0 epg for all ewes with two exceptions of 100 epg by the end of the trial (Table 4) thus confirming the high efficacy of moxidectin against *H. contortus* on this farm. Similarly the efficacy of LEV was confirmed by the arithmetic mean FECs in the low hundreds in the CONV group.

A total of 11 ewes from the FMCH group were dosed during the trial. Three of these ewes were from the August 2005 age group, five from the April 2006 age group and 3 from the August 2006 age group. None of the ewes dosed needed to be dosed more than once. The time during the trial in which the ewes in the FMCH group needed dosing according to FAMACHA© scores was mid-March to mid-April which corresponds to high haemonchosis challenge times in this area.

Table 4 Faecal egg counts (epg) of all trial ewes during the months of February and July.

	Group	Sum	Mean	Median
February	FMCH	167100	6684	6300
	CONV	6300	252	100
	SUPPR	2600	104	0
July	FMCH	15100	629	100
	CONV	500	21	0
	SUPPR	200	8	0

DISCUSSION

The importance of the FAMACHA© system has been comprehensively reviewed (Van Wyk and Bath, 2002; Kaplan *et al*., 2004; Bath *et al*., 2005; Van Wyk 2005, 2008; Kenyon *et al*, 2009) and has not only been tested in Southern Africa (Bath *et al*., 2001; Malan *et al*., 2001; Vatta *et al*, 2002) but also in many countries including North America and St Croix (Kaplan *et al*., 2004), Brazil (Sotomaior *et al*., 2003, Molento *et al*., 2004; Vieira *et al*., 2008), the

Caribbean (Mahieu *et al*., 2007), and Europe (Cabaret, 2004; Scheuerle *et al*., 2010). Time and again it has proven to be an effective way of assessing whether or not animals are able to cope unaided with high levels of *Haemonchus* challenge and thus the need for treatment, as well as the usefulness of this form of TST (Maheiu *et al.*, 2007; Riley and van Wyk, 2009, Reynecke *et al.,* 2011 a,b,c). However, there have been concerns or criticisms raised that implementation of the FAMACHA© system may result in unacceptable losses in production. In one of the earliest evaluations this did not seem to be the case, judged by the responses of farmers to questionnaires on their opinions of the acceptability of the FAMACHA© system (Bath *et al.,* 2001). While these impressions were not backed by objective measurements, the trials of Mahieu *et al.* (2007) in goats supported these observations, based on measured effects. An important consideration is that by treating only ewes with FAMACHA© values of 4 and 5 in this current study, the ewes were stressed at an unnecessarily high level of worm challenge, as Van Wyk and Bath (2002) recommended routine treatment of animals in FAMACHA© categories 3-5, i.e. at a much earlier stage of anaemia.

The FMCH group showed both resistance and resilience as FECs were usually in the low thousands with the exception of two ewes which did not need dosing during the trial according to the FAMACHA© scores, despite having had FECs of 16 400 and 18 800epg. From this it can be assumed that other sheep in the flock that were not involved in the trial but which were also evaluated according to the FAMACHA© system would have exhibited similar results. Thus sufficient parasites were being excreted onto the pasture in order for the groups to have a significant challenge and for the trial to be a good study of the effects of deworming schedules.

There were a number of constraints and complications which arose from the nature of this investigation, because it was a farm trial that had to fit in with normal farm practices and farmer decisions. Some of these decisions were made without prior consultations or in conflict with agreed procedures to be followed. A number of factors need to be considered in relation to the results of this trial:

1) *FAMACHA© categories treated:* As in the Maheiu et al. (2007) trial the farmer treated only FAMACHA© categories 4 and 5 thus constituting a very severe *Haemonchus*

challenge on the sheep and a severe test of the FAMACHA© system.

2) Intervals between FAMACHA© evaluations: For many farmers it is not practical or even necessary to make FAMACHA© decisions on a weekly basis as was done in this trial. This is especially true when large numbers of livestock are to be assessed, or on extensive systems with no handling facilities conveniently situated close to grazing paddocks. However there are practical ways of monitoring sheep or goats at short intervals, for example only examining a sample (aliquot) of animals and only examining all stock if the screening examination indicates this is necessary. Still better is to examine the "tail" of a flock, i.e. the last sheep that come into a holding pen after being herded from their pasture. These animals are likely to be the non-coping, anaemic sheep needing treatment and will alert the farmer at an early stage of an emerging problem. If epidemiological data can be evaluated by computer, as is currently under investigation, this will further sharpen the accuracy of intervals and intensity of monitoring.

3) Common pasture for trial groups: The three trial groups (75 ewes), as well as the balance of the flock (225 ewes), ran together on the same pastures and therefore were exposed to the same parasite challenge. Since only 50 of the 300 ewes were treated regularly (CONV) or suppressively (SUPPR) it can be concluded that this challenge was substantial, as the other 250 ewes were treated according to TST. This could have disadvantaged the CONV and SUPPR groups since they were exposed to worm challenges higher than that which would be expected if they had run separately. This effect was to a certain extent counteracted by the regular anthelmintic treatments although this method is not recommended in farming practice as explained below.

4) The cost of resistance: The emergence and importance of AR is difficult to quantify in terms of costs. For the purpose of measuring the effect on production parameters of applying TST (FAMACHA©) versus a conventional system (blanket treatments every six weeks) and a control (suppressive treatment with a long-acting remedy), the long term results, either on production, or development of AR, or the ultimate financial costs of any of these treatment options, cannot be measured. However, both conventional and suppressive treatments are likely to promote AR in the longer term since neither promotes the significant survival of worm populations in refugia (Van Wyk, 2001; Van Wyk *et al*., 2001). In turn, this implies a long-term cost as drug group treatment options dwindle. The cost of developing a truly new anthelmintic unrelated to existing groups (and therefore not affected by pre-existing AR) is almost astronomical (McKellar, 1994). These drugs are therefore more costly than established products, but can soon be ruined by injudicious use or misuse. This factor, although not quantifiable, must be considered when comparing the treatment options investigated in the current study.

5) Nutrition: Changes in the nutritional status had a definite, unplanned effect on this investigation. Poor nutrition, especially protein, is known to reduce the animal's ability to mount an effective immune response. Thus low summer rainfall, followed by above average winter rains and subsequent inaccessibility to the muddy pasture is probably responsible for the lower BCS values and indirectly, resilience or resistance to helminths.

6) Selecting animals for resistance/resilience: A potential advantage in using FAMACHA© for TST is that when consistently applied, the heritability of the system is in the region of that of FEC (Riley and Van Wyk, 2009; 2011), but has the added benefit of on-farm evaluation by farmers.

Because it is relatively inexpensive to apply, FAMACHA© can be used for routine selection of ewes and not only the rams.

The significant differences between the trial groups when not divided according to reproductive status is misleading since it resulted from the differences in gestation status. There was a lack of significance in difference between groups when the BW gains were compared in relation to stage of gestation (Tables 2 and 3, and Fig 2). The highly significant negative correlation between BCS and BW was most likely owing to development of the conceptus, as normally a positive correlation would be expected (Russel, 1984).

The youngest group of ewes was the worst affected by drops in body condition score and were fed additional concentrates which lead to a small improvement in BCS (Fig 5).

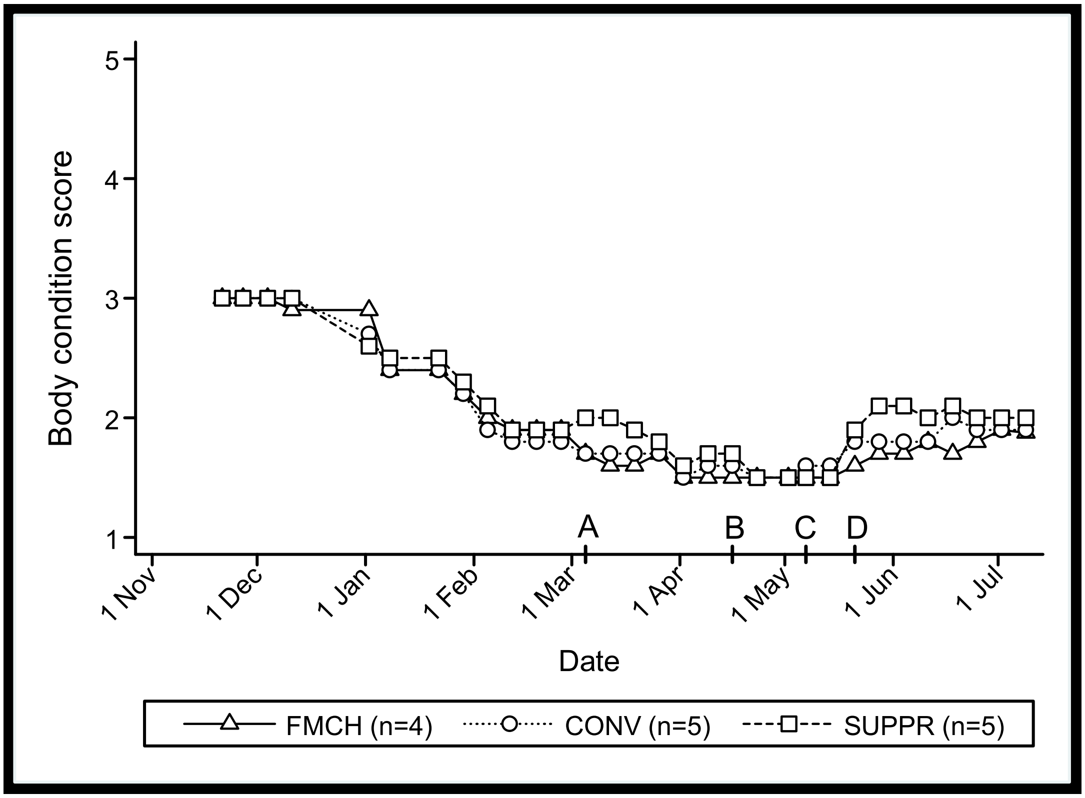

Figure 5 Body condition scores (mean ± SD) over an eight-month period of ewes born in August 2006 dosed according to the FAMACHA© system (FMCH), conventionally (CONV) and suppressively (SUPPR). A: Rams in (5 March); B: Rams out (16 April); C: Supplementation with ewe and lamb pellets starts (7 May); D: Supplementation with chocolate maize starts (21 May).

The highly significant negative correlation between BCS and FAMACHA© scores may indicate that the food shortage leading to the decline in BCS also had an impact on the FAMACHA© scores, either by a decrease in available protein for the ewes, or a decrease in resilience to the *H. contortus* burden. The deterioration of BCS and FAMACHA© scores around the time that the ewes were lambing (Figs 3 and 4) can probably be attributed to a combination of peri-parturient relaxation of immunity (PPR) and poor nutrition. Once supplementation was given (7-21 May 2007) the FAMACHA© scores improved.

Since mating only took place after the trial commenced, allocation to trial groups could not be made according to reproductive status. However, there were similar numbers of lambs born in the three groups, and also numbers of pregnant ewes. Thus it appears that the groups were similar from this point of view.

Although the FMCH group had the highest number (four) of lambs sold as “slow growers”, all of which were singletons, the ewe from the FMCH group that had twins was able to successfully raise both lambs, whereas the other two lambs that were sold as “slow growers” were one of a twin from both the STRAT and SUPPR groups.

There was no significant difference between groups in mean weight born per ewe including lambs that were later perceived to be “slow growers” by the farmer, and, when the “slow growers” are excluded from the data, there is no significant difference in the mean ADG of the lambs (Tables 2 and 3). However, had the slow growers been included in the data, the FMCH group of ewes would have had a higher mean birth weight for the lambs but would have had a poorer performance with regards to ADG than the SUPPR and STRAT groups, and there may have been a significant difference between the FMCH lambs and those in the strategic and suppressive groups.

CONCLUSION AND RECOMMENDATIONS

This study has demonstrated that there was no statistically significant difference when using the FAMACHA© system compared to blanket strategic (conventional) and suppressive deworming, in any of the production parameters measured. However, mean ADGs may have differed had slow growers not been sold.

Growth of the conceptus could be responsible for a perception that weight gains can be significantly affected by using the FAMACHA© system. Gestation status should therefore be considered in any similar research.

It is also evident from this trial that in the use of the FAMACHA© system, nutrition needs to be considered as it plays a vital role in resistance and resilience of individual animals. The importance of the effect of malnutrition on the ability of animals to withstand high levels of worm challenge is well illustrated in this trial.

By leaving the sheep that appear to be coping with the worm burden untreated under conditions as in the present trial, anthelmintic use is decreased and selection for resistance to the anthelmintics being used is reduced.

The ongoing rise of multiple AR populations in many nematode genera all over the world suggests that excessive reliance on anthelmintics and the lack of an integrated approach will progressively make the older, established drug groups less useful (Kenyon *et al.*, 2009). Even as new drug groups are brought into use, their effective life could well be severely curtailed by misuse.

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