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WORM BURDENS AND EGG COUNTS IN SOUTH AUSTRALIAN PRIME LAMBS

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Abstract

Research from 2004-2007 on 15 prime lamb producing properties in South east Australia provided original data on worm egg counts (WEC), total worm counts, individual and flock production and environmental factors potentially influencing these. Linear regression of weight gain on worm burden for 82 prime lambs confirmed that there was no linear relationship between the two variables. Despite imprecision in predicting both individual performance and total worm burdens we found flock average WECs useful in the context of overall assessment of prime lamb flock health, but interpretation benefits from repeated measures and consideration of complex influencing factors. Caution needs to be exercised in assuming that some high individual WECs in a flock confirm an impact of parasites in that flock. Average WEC approximately doubled in samples collected at slaughter after transport compared with those from the same lambs on-farm, with some individual values increased several fold. In general, a flock WEC greater than 400 epg is cause for attention, but not when growth is uncompromised by other factors. When flock growth rate is greater than 200 g/day effective management of other important productivity parameters is such that internal parasites are unlikely to be present in sufficient numbers to seriously impair flock productivity. As parasites accumulate over the course of a lamb grow out their penalty on growth increases with time.

Introduction

For nearly 80 years Australian veterinarians and researchers have used a limited arsenal of relatively simple techniques or subjective observations to assist in interpretation of immediate or potential effects of gastrointestinal nematodes (GIN) in sheep flocks. Chief among these are faecal worm egg counts (WEC) and total worm counts (TWC) supported by observations on body condition and the prevalence and severity of scouring.

Among other applications WEC is used for measuring drench efficacy and in selection for genetically resistant sires, but its overwhelming use in Australia is to underpin decisions on whether to drench or not, within an overall control strategy including management interventions to provide safe pastures and high quality nutrition. It is generally accepted that as a diagnostic tool WEC, is at best, a rude guide to the levels of worms across the flock as a whole, with arguably more value in young rather than older immune or partially immune sheep. Nevertheless, it remains a useful, and currently the only option for field evaluation of the worm status of a flock. There are no fixed rules for interpretation of results. Over the years each laboratory or veterinary practitioner has developed their own interpretation of critical values and threats to production based on local experience, taking into consideration factors such as age and composition of the flock, seasonal conditions, and nutrition.

Although this has proved to be a workable process overall, there are probably many ongoing unseen losses to the prime lamb industry because the basic principles of worm control and interpretation of diagnostic information in Australia have been almost exclusively derived from huge research inputs into wool sheep. Indeed, an exhaustive review of literature relevant to internal parasitism in Australian meat sheep prior to 2006 (1,2) found that only 2.4% of 894 publications dealt directly with meat sheep, the remainder with wool sheep. There are, however, large differences between management and expectations in the two production systems. Apart from the fundamental difference of breed composition between prime lamb and wool flocks, the overriding imperative in prime lamb enterprises is to avoid severe penalties by achieving the maximum possible growth rate through careful attention to all factors which might hinder it. There have been many valuable scientific contributions concerning genetics and nutrition which are certainly the main factors driving production in prime lamb enterprises, but only one thorough field study addressing GIN, which can be a significant impediment (3, 4).

The above 4-year study on the impact of GIN on the prime lamb industry of south-eastern Australia included controlled measurements of levels and overall production penalties associated with GIN in prime lamb flocks, and aspects of epidemiology.

This paper presents findings from the research of flock weight gains in relation to WEC over time, individual weight gains in relation to TWC, WEC in finished lambs on farm and at slaughter, and factors influencing WEC, TWC and growth performance of lambs in South-eastern Australia.

Materials and methods

Sites, animals and trial design

Experimental sites were established from 2004-2007 on 15 farms in South Australia and Victoria, with prime lamb production as the sole or an important component of the enterprise. All key production systems, namely dry land, flood irrigation, pivot (spray) irrigation and cropping were represented. A range of finishing systems was studied, as well as lambs marketed for slaughter directly from their dams. Nutrition and worm effects were separated in 28 growth studies in prime lambs in which the performance of lambs with worm levels suppressed by sustained release anthelmintic capsules or repeated injections of moxidectin (Cydectin Injection™) was compared with that of lambs subject to the normal drenching program on the property. An average of 95 lambs managed as a single flock or as part of a larger flock was included in each trial. Lamb growth and factors potentially affecting it were measured regularly and form the basis of the data presented in this paper.

Body weights

Lambs were weighed at the beginning of each experiment and as close as possible before marketing or removal from grazing for finishing. Usually an additional 2-3 measures of weight were also taken during the growing period. Lambs were individually identified enabling comparison of weight with other measurements such as total worm counts.

Worm egg counts and species present

Flock WEC was determined as the mean count of 15-30 individually processed samples collected *per rectum* at each weighing interval. Standard laboratory technique was used to process samples at a sensitivity level of 25 epg. Trichostrongylid-type eggs (*Teladorsagia*, *Trichostrongylus* and *Haemonchus*) were differentiated from other worm egg types and are the only WEC values considered in this paper. *Haemonchus* was rarely found in differential larval cultures and then only in low numbers, so WEC values apply to the important regional scourworm species.

Total worm counts

At the end of each grow out 4 or 5 lambs were slaughtered for estimation of TWC and species of worms present. *Trichostrongylus* spp. were differentiated but are not reported here. Immature (fourth stage larvae) worms were counted but are not reported here because they make no contribution to WEC. TWC therefore refers to the combined adult burdens of the 2 scourworm genera.

Nutrition

Pasture nutritive value (FEEDTEST®) and to a lesser extent Feed on Offer (kg DM/ha) were assessed regularly on most properties.

Pasture contamination

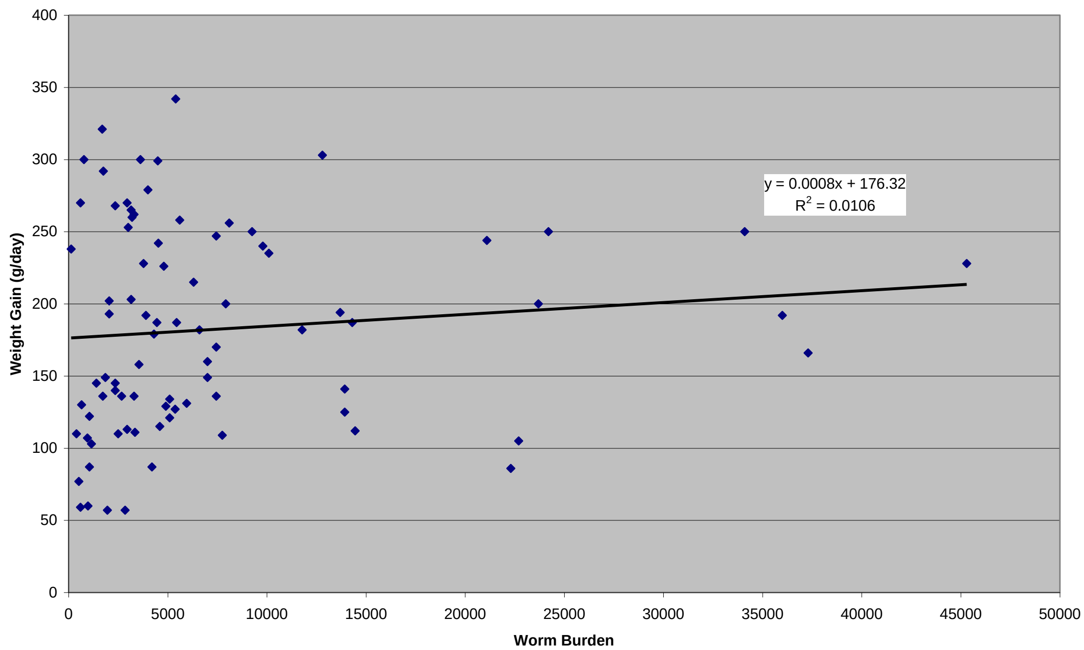
The number of nematode (worm) larvae on pasture (larvae/kg DM) was measured regularly and served as a guide to the levels of worms to which lambs were exposed at various points during the growout

Results and Discussion

<u>Individual weight gains and total worm counts</u>

Total worm counts were available for 82 lambs with matching individual average daily growth rates. Linear regression of weight gain on worm burden (Fig 1) confirmed that there was no linear relationship between the two variables (R^2 = 0.0106). Although another component of this work (3,4) showed that worm infections were responsible for significant loss in 38% of prime lamb grow outs, individual TWC is clearly not the main determinant of the level of production loss.

Fig 1 Plot of weight gain (g/day) versus scourworm burden at slaughter for 82 prime lambs



<u>WEC in finished lambs on farm and at slaughter and its relationship with total worm count</u>

Of the 82 lambs for which TWCs were available there were 66 for which WEC means and ranges on farm and at slaughter were also available. WEC means and ranges on farm and at slaughter by ascending level of TWC are summarised in Table 1

Table 1 Mean worm egg counts (eggs/g faeces) on farm and at slaughter for 66 prime lambs in relation to increasing total Scourworm count

No. of lambs	16	19	14	11	6
Total worm count	<2500	2500-5000	5000-10000	10000-25000	>25000
Field WEC (range)	64 (0-250)	180 (0-625)	220 (0-675)	425 (100-975)	1119 (650-1550)
Slaughter WEC (range)	83 (0-250)	373 (75-675)	461 (75-925)	1005 (350-3450)	2250 (1175-4275)
Ratio of pre- and post WEC	1.3	2.1	2.1	2.4	2.0

In general, ranges of WEC increased with TWC although not linearly and with many individual exceptions. For example, on farm individuals had 0 epg with TWC in the ranges from <2500 to as high as 5000-10000 worms. Conversely, moderately high WEC was found in lambs with less than 5000 worms. Therefore, individual WECs have limited application unless they are at one or the other end of the spectrum. The relationship between WEC and TWC in young sheep has been carefully examined previously (7,8,9). In New Zealand, using data from 190 sheep McKenna (7) examined the probability of egg count class (eg. <100 epg, 100-500 epg, etc.) falling into various worm count classes (eg. 0-500 worms, 501-200 worms, etc) and derived a simple formula to estimate the proportions of a flock carrying various intensities of infection. Application of the formula to 10-15 WEC counts on randomly selected flock animals produced a good fit between egg count data and worm burdens in Romney and Perendale lambs on 4 farms (8). Reinecke and Groeneveld (9) using WEC and TWC data from >400 sheep in South Africa found no method of analysis to accurately estimate TWC from WEC values in respect of individual sheep. However, they found the mean natural log egg count to roughly predict the mean natural log nematode count in groups of sheep. Our limited data largely support the judgements and interpretations of the above authors. Despite their imprecision in predicting both individual performance and total worm burdens we find flock average WECs useful in the context of overall assessment of prime lamb flock health. However, it would be inadvisable to rely upon them as a diagnostic tool in isolation, except in overt clinical disease. Data in Table 2 provide some practical examples of this application.

Except for the lowest values average WEC approximately doubled in samples collected from lambs at slaughter after transport and a withholding period, compared with those from the same lambs on-farm. Some individual values were increased several fold. This confirms that results from abattoir surveys are likely to be inflated over field values from the same animals.

Flock weight gains in relation to WEC, management and other factors

Flock growth in 15 on-farm trials, growth penalties from worm infections, flock WEC values and factors associated with these are summarised in Table 2.

Table 2 Growth penalties from worm infections and environmental factors associated with faecal worm egg counts in prime lamb production enterprises in south-east Australia

No.[a]	**Start weight (kg)**	**Period (days)**	**WEC**[b] **(range)**		**Growth**[c] **(g/day)**	**Penalty**[c] **(g/day)**	**Comments (weather, management, pasture details**[d]**, worm burdens - TWC**[e]**)**
			Start	**End**			
1a	39	27	33	95 (0 – 600)	272	7	Placed on contaminated paddock with heavy challenge of 3000 l/kg falling to 300 l/kg. Minimal penalty initially, but serious damage done. Adverse effects of pasture decline (high NDF and low ME), hot weather, shearing. TWC only 5700 worms. Overall penalty 33 g/day.
1b	47	49	95	266 (0 – 700)	123	47	
2a	22	49	0	206 (0 - 700)	246	2	Lambs weaned after 39 days but not drenched. Initially exposed to 2000 l/kg then average of 500 l/kg. Early good quality pasture. Entered summer with rising worm burdens. Serious stress of shearing in hot weather. Pasture decline after 2 months. Overall penalty 29 g/d.
2b	34	28	206	498 (100 - 925)	130	62	
2c	38	36	498	717 (50 - 2025)	48	39	
3a	56	33	8	175 (25 -375)	164	8	Very heavy lambs. Good quality pasture. Increased growth penalty with increasing worm challenge to 2000 l/kg[f].
3b	62	43	175	410 (0 – 1425)	91	29	
4	25	97	116 (0 – 325)	582 (100 -2850)	113	25	Moderate pasture initially but NDF increasing to 60. Insufficient FOO (600) to drive growth. Challenge 1800 l/kg. TWC 11,600.
5	35	54	0	775 (50 – 1525)	150	18	Lambs had grown at 289 g/day over previous 51 days. Rapid senescence of pasture (P 13; Dig. 62; E 9.7; NDF 59). Moderate worm challenge (1000 l/kg). High TWC – 29,000. Situation deteriorating.
6.	37	49	0	305 (100 – 650)	230	13	Nutrition high (P 19; Dig.64; E 10.0; FOO 1880). Pasture larvae minimal. TWC 7200.
7	40	84	0	245	264	11	Excellent pasture (P 26; Dig. 72; E 11.6; FOO 1385). TWC only 4,000 but 8,000 immature *T. circumcincta.*
8	37	84	0	170 (50 – 400)	135	9	Growth poor. Declining E to 8.7 and increasing NDF to 60%. Low pasture infectivity (300 l/kg). Little worm effect.

No.[a]	Start weight (kg)	Period (days)	WEC[b] (range)		Growth[c] (g/day)	Penalty[c] (g/day)	Comments (weather, management, pasture details[d], worm burdens - TWC[e])
			Start	End			
9	29	71	0	150 (0 – 250)	275	7	High quality pasture. FOO 1610. Low worm contamination (200 l/kg).
10	25	125	0	135 (0 -475)	169	7	Quality pasture (Dig. 80) but growth compromised by endophyte effects. Very low contamination. TWC 525.
11	23	99	0	253 (0 – 850)	265	4	Excellent pasture (P 27; Dig. 72; E 11.5). TWC 3,500.
12	42	75	0	75 (0 – 325)	107	3	Low worm challenge (260 l/kg). Poor pasture (P 16; Dig. 60; E 9.1; NDF 53) TWC 8650 worms.
13	27	92	0	77 (0 – 350)	135	1	Poor pasture quality. Challenge only 150 l/kg. TWC 8,000.
14	24	56	0	406 (175 – 975)	276	1	Excellent pasture (P 25; Dig. 66; E 10.5). TWC 6,600.
15	38	102	0	232 (50 – 425)	172	0	Low pasture infectivity (150 l/kg).

[a] 15 prime lamb "grow out" trials are described. Subdivisions (a,b,c) are consecutive intervals in a single trial.

[b] Faecal worm egg count (trichostrongylid eggs/g faeces) based on mean of individual samples with range of counts indicated (see text).

[c] Growth of control lambs receiving normal farm treatment program (g/day), including drenching. Penalty is the growth difference between controls and suppressive treated animals, adjusted for residual WEC when present in the latter.

[d] Pasture quality abbreviations as follows :P – crude protein (%DM); Dig. – digestibility (%DM); E – metabolisable energy (MJ/kg DM); NDF – neutral detergent fibre (%DM); FOO - food on offer – (Kg DM/ha).

[e] TWC - Indicative value for average adult scourworm (*Trichostrongylys* and *Teladorsagia*) burdens of flock derived from total worm counts of 4-5 control lambs. (Note: In earlier results TWC of individuals is related to other data for those individuals).

[f] Worm larval challenge (larvae/kg DM of pasture) – unless specified this is the average over the period.

The data in Table 2 may seem intuitive, but even in its simplest interpretation this is the first time that the interactions of measured factors such as WEC, pasture quality, pasture infectivity and growth rates of prime lambs have been assembled.

In line with common knowledge the data suggest that weaning of prime lambs on to heavily infected pastures is a most dangerous practice (examples 1b, 2b). However this may not necessarily lead to an immediate loss of production (examples 1a, 2a) and may (examples 2bc, 3b)) or may not (example 1b) be clearly evidenced by a substantial increase in flock WEC.

In general, a flock WEC greater than 400 epg is cause for attention (examples 2bc, 3b, 4, 5), but not when growth is uncompromised by other factors. Example 14 documents an excellent growth rate of 276 g/day with negligible penalty from worms despite an average WEC of 406 epg after 56 days, with individual counts up to 975 epg. However, there is convincing evidence in these trials that when the flock growth rate is greater than 200 g/day it follows that effective management of other important productivity parameters is such that internal parasites are unlikely to be present in sufficient numbers to seriously impair flock productivity. A corollary is that if it becomes necessary to drench prime lambs more than once (other than at marking or pre-summer when dams with sucker lambs are crutched, or at weaning), then the enterprise will likely suffer compounded losses from internal parasites because it does not have other critical production requirements in order.

The necessity for a weaning drench was demonstrated in 2 concurrent studies, only one of which is reported in Table 2. Two similar cohorts of lambs, one drenched, the other not drenched, were weaned on to the same moderately infected pasture in mid-October 2006; both had a worm suppressed control group. The cohorts differed genetically (lambs given no weaning drench were first cross [Border Leicester/Merino], drenched lambs were second cross [Poll Dorset X Border Leicester/Merino]. As expected from their genetics, worm-free second cross lambs grew faster than worm-free first cross lambs through November (208 g/day *vs* 191 g/day). However there was a separate massive growth penalty from worms of 62 g/day in the lambs which were not drenched compared with only 3g/day in drenched lambs. There is likely to be a contribution of genetic resilience from the second cross lambs to the difference in growth penalty from worms. Nevertheless, it is reasonable to conclude that a significant part of the worm penalty followed from failure to drench the first cross lambs at weaning, providing an extreme example of the critical importance of a weaning drench in the overall prime lamb health program.

McKenna and Simpson (8) summarised the degree of damage inflicted upon the host by parasitic infection as “not only dependent upon the number and genera of worms present but also upon such host factors as size, weight, general health and genetic constitution.” Our investigations have showed that a lack of robustness as evidenced by poor growth rate is an important independent contributory factor in prime lamb production systems. Initial high worm challenge in spring, followed by decline of pasture quality with senescence and the advent of hot weather can lead to escalating losses. The most serious growth losses due to worms all occurred in flocks which had suboptimal growth rates related to various other causes. Shortage of protein did not present itself as the obvious limiting factor. In several cases loss from parasites accompanied senescence of pasture with increasing NDF levels reducing the capacity of lambs to consume adequate pasture to support robust growth. A declining energy and protein source very rapidly became even less accessible to them. Nutritional stresses may also have forced lambs to forage closer to the ground thereby increasing their exposure to larvae that otherwise they might not have encountered. However, it is not possible to separate the contribution of independent factors in a range of trials in different production systems and environments over several seasons.

As parasites accumulate over the course of a lamb grow out their penalty on growth increases with time. This can be clearly seen in examples 1-3. Overall, in the 28 trials reported by Carmichael (3), in instances where daily penalties due to worms were greater than 10 g/day the percentage growth penalty (22%) during the last weighing interval (average 49 days) was double that across the duration of the trial.

As described above WEC is a useful management tool on a flock basis but interpretation benefits from repeated measures and consideration of the complex influencing factors. Caution needs to be exercised in assuming (see examples 11, 13, 15 Table 2) that the presence of some high individual WECs in a flock confirm an impact of parasites in that flock.

On-farm worm infections in this study were not as consistently severe as those suggested from an abattoir survey by Besier, Ryan and Bath (2004) for Western Australia. However, although an abattoir survey undoubtedly provides useful background information, in the context of prime lamb industry dynamics it may very well be misleading.

The elevated worm egg counts reported by the above authors may be only partly ascribed to concentration of eggs in faeces due to water and feed deprivation imposed through the processes of marketing, transport and holding in lairage prior to slaughter, but they still do not fit with the extensive SA field observations. In the Western Australian study some very high WEC values and scouring suggested that numerous abattoir consignments were heavily infected with worms. Average worm egg counts in flocks of lambs repeatedly measured on-farm in South Australia and Victoria rarely exceeded 400 epg in 28 growth studies over 4 years (Carmichael, 2009) and scouring was not seen in any prime lambs consigned to market. Notwithstanding the fact that the WA survey preferentially targeted scouring lines of sheep, it is illogical that a serious prime lamb producer would consign heavily worm-infected, scouring prime lambs to market or that they could attain prime lamb specifications with heavy worm burdens. It is also unreasonable to conclude that Western Australian prime lamb producers are poorer managers than their eastern counterparts.

A plausible explanation for the severe infections in Western Australia might be that the sampled population was largely represented by unfinished lightweight lambs (≤16 kg carcase weight) or Merino lambs rather than prime lambs. This is likely given the nature of the seasons at that time. In years of food scarcity many slaughter lambs are effectively culls due to ongoing reduction of overall sheep numbers, particularly Merinos, or include underweight Crossbreed lines, discarded because they are unable to be finished to trade specifications. Although slaughter lamb production has increased nationally in recent years, a response to drought in the early to mid-2000s was that only 64% of lambs were sold as prime lambs, well below longer term pre-drought averages of almost 90%. In 2005-2006 only 37% of lambs nationally were sold as prime lambs (6). Under such circumstances drenching of slaughter lambs (as opposed to prime lambs) is unjustified because it would bring meagre financial reward in classes of lambs that are destined to realise low market prices.

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