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Investigation of causes of “low worm egg count diarrhoea” in sheep in Western Australia

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Abstract
Nine flocks of sheep with “low worm egg count scouring” in the south west of Western Australia were investigated over a three-year period. There was no significant difference in the faecal worm egg counts of “scouring sheep” (diarrhoea and severe dag) compared to “normal sheep” (pelleted faeces and mild or no dag). Teladorsagia (Ostertagia) circumcincta and Trichostrongylus spp were the strongyles most commonly identified on total worm counts and differentiation of larvae recovered from faeces and pasture. Immature strongyle worms accounted for the largest proportion of total worm counts. Adult worm burdens were small in most sheep. Scouring sheep had significantly higher numbers of early fourth stage larvae. There was no histopathological evidence of bacterial or viral causes of scouring in any of the flocks that could be supported with bacteriology. Two flocks had marginal selenium status. One flock was diagnosed with helminthosis based on increased worm egg counts and high total worm counts. Larval hypersensitivity scouring, nutrition or a combination of these two factors were the most likely causes of scouring in the other eight mobs based on exclusion of other known causes of scouring. Treatment with moxidectin drench and an ivermectin controlled-release capsule did not change faecal moisture of treated sheep compared to untreated sheep three to five weeks after treatment.

Introduction
Diarrhoea (“scouring”) is a common and widespread problem in the south west of Western Australia. A questionnaire sent to farmers in the region in 2002 showed that moderate and severe dag is more common in the winter and spring months with approximately half of the respondents reporting moderate or severe dag in flocks of lambs, hoggets and ewes (Caroline Jacobson, unpublished). Scouring is a major risk factor for faecal soiling of the breech (“dag”) and is a production problem primarily because it increases the susceptibility of sheep to breech blowfly strike. Removal of dags and the treatment and prevention of blowfly strike is unpleasant work and represents a major economic cost for both sheep meat and wool producers.

However, despite the widespread nature of the problem and the serious economic consequences for producers, very little is known about what are the common causes of scouring in sheep of post-weaning age in Western Australia. Although there are a large number of infectious and non-infectious causes of scouring identified in sheep, diagnostic investigations of cases of scouring in sheep of post-weaning age are typically labour intensive, expensive and often unrewarding in identifying an aetiological diagnosis (or cause) of scouring.

Strongyle worms and nutritional factors associated with grazing lush green pasture are commonly implicated causes of scouring in the regions. Nutritional factors that may result in scouring have not been well described in the scientific literature and “nutritional scours” are a common diagnosis of exclusion in scouring sheep grazing lush pasture that are otherwise healthy and where no other cause of scouring can be identified. Sheep that accumulate large strongyle worm burdens (helminthosis) may show signs of scouring associated with high faecal worm egg counts (WEC).

Alternatively, a condition has been described in which sheep that have a well-developed immunity to strongyle parasites may develop “larval hypersensitivity scouring” syndrome associated with intake of larvae with pasture. Sheep with a well-developed immunity to strongyles generally do not develop high WEC and so “larval hypersensitivity scouring” syndrome is typically associated with low WEC scouring. There are no specific diagnostic tests or post-mortem findings available for larval hypersensitivity scouring syndrome and so this...
is also commonly a diagnosis made by exclusion of other causes.

This study looked to investigate the causes of “low WEC scouring” in flocks of sheep in the south west of Western Australia.

**Materials and Methods**

Nine flocks of sheep from eight properties were investigated in between 2002 and 2004. Requirements for inclusion were that sheep were at least 14 months old, actively scouring with a mean flock WEC of 150 eggs per gram of faeces (epg) or less performed within two weeks of the visit. With the exception of the flocks from the Bindoon and Tenterden properties, ewes with unweaned lambs were not included to avoid ewes subject to the periparturient relaxation of resistance.

Two separate flocks from the Bokerup property were investigated (mixed tag wethers and orange tag mixed sex). The flock on the Bindoon property were Damara and Merino-Damara crosses. All other flocks were Merino sheep. All nine flocks were investigated in the months of August to October (initial visit). Annual rainfall for the year in which sheep were sampled varied from 315 to 780 mm/annum on the nine farms. All nine properties had a winter rainfall pattern.

On the day of sampling, sheep were yarded and a sample of at least 100 sheep were “dag scored” using a scale of 0 (no dag) to 5 (severe dag). Three flocks had been recently crutched and these were scored using a modified scale of 0 (no evidence of faecal soiling since crutching) to 3 (extensive evidence of faecal soiling since crutching).

Faecal samples were collected from “scouring sheep” (active diarrhoea and severe dag) and “normal sheep” (pelleted faeces and mild or no dag) for a modified McMaster WEC and larval differentiation. Pasture samples were collected for pasture larval counts.

Two or three scouring sheep and two or three normal sheep from each property were euthanased for post-mortem examination. Samples of the gut were taken from the rumen, abomasum (fundus and pylorus), jejunum (1m and 4m from common bile duct), ileum, caecum, proximal, spiral and distal colon, fixed in 5% neutral buffered formalin and used for histopathology. Total worm counts (TWC) from the abomasum and small intestine were conducted, including abomasal digest. Blood samples were collected for measurement of glutathione peroxidase (GSHPx). Sterile swabs were taken from the jejunum and large intestine for bacteriology. Mucosal scrapings were taken from the caecum and colon.

A sample of at least 20 actively scouring sheep with severe dag were treated with a moxidectin drench (Cydectin®, Fort Dodge Australia Pty Ltd) and an ivermectin controlled-release capsule (Ivomec Maximizer Controlled-release Capsule for Adult Sheep®, Merial Australia Pty Ltd). Faecal samples were collected for WEC from the treated sheep and a sample of 20 untreated control sheep that were also actively scouring with severe dag. The treated and control sheep were identified with stock spray and/or coloured ear tag. Faeces were collected from these sheep between 21 and 49 days later for measurement of WEC, faecal dry matter (eight flocks) and faecal consistency (three flocks).

**Statistical Analysis**

Categorical data were analysed using a Chi-square test for two-sided significance, specifically Pearson Chi-square or Fisher's exact test. Blood glutathione peroxidase and faecal consistency measurements were normally distributed and the variances were not significantly different and so these parameters were analysed using ANOVA. The distribution of WEC and TWC were non-normal and the variance of the scouring and normal sheep were significantly different, therefore WEC and TWC were compared using a two-tailed non-parametric Mann-Whitney U test.

A total pathogenic index (TPI) was calculated for the TWC based on a “points system” previously described in which 4000 *Trichostrongylus colubriformis*, 3000 *Teladorsagia* (Ostertagia) *circumcincta* and 4000 unidentified immature larvae (all species) were each considered to represent one point.

All statistical analyses were performed using SPSS 11.0.2 for Mac OS X.
Results

Oag distribution

The distribution of dag varied in the nine flocks with 30 to 85% of the flocks investigated having moderate or severe dag (dag score 3.0 or higher for the six flocks of uncrutched sheep, modified dag score 2.0 or higher for the three flocks of recently crutched sheep).

WEC and larval differentiation

The mean WEC in the scouring and normal sheep are shown in Table 1. There was no significant difference in the mean strongyle WEC of the scouring or normal sheep. The strongyle species cultured from faeces were predominantly Teladorsagia (Ostertagia) circumcincta and Trichostrongylus spp. Haemonchus contortus was identified in one flock (Bokerup orange tags), but the mean flock WEC was low (100 epg) and H. contortus accounted for only 8% of the larval differentiation.

Table 1: Mean faecal strongyle worm egg counts (eggs per gram of faeces) in scouring and normal sheep (non-parametric test for significance)

<table>
<thead>
<tr>
<th>Property</th>
<th>Scouring</th>
<th>Normal</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kendenup</td>
<td>42</td>
<td>725</td>
<td>n/a</td>
</tr>
<tr>
<td>Boyup Brook</td>
<td>180</td>
<td>204</td>
<td>0.070</td>
</tr>
<tr>
<td>Kojonup</td>
<td>87</td>
<td>4</td>
<td>ns</td>
</tr>
<tr>
<td>Bokerup (orange)</td>
<td>104</td>
<td>100</td>
<td>ns</td>
</tr>
<tr>
<td>Bokerup (mixed)</td>
<td>65</td>
<td>112</td>
<td>ns</td>
</tr>
<tr>
<td>Bindoon</td>
<td>476</td>
<td>525</td>
<td>ns</td>
</tr>
<tr>
<td>Dudinin</td>
<td>163</td>
<td>154</td>
<td>ns</td>
</tr>
<tr>
<td>Tenterden</td>
<td>36</td>
<td>71</td>
<td>ns</td>
</tr>
<tr>
<td>Broomehill</td>
<td>126</td>
<td>66</td>
<td>ns</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>134</strong></td>
<td><strong>163</strong></td>
<td><strong>ns</strong></td>
</tr>
</tbody>
</table>

n/a: not applicable (only 2 normal sheep sampled)
ns: not significant (p>0.100)

Total Worm Counts

The mean total worm counts (TWC) are shown in Table 2. There was no significant difference in the total number of adult worms (all species) recovered from the scouring sheep compared with the normal sheep. Immature larvae accounted for the largest proportion of the TWC. There was a trend towards a higher TWC and a higher TPI in the scouring sheep compared with the normal sheep.

Table 2: Mean total worm counts and total pathogenic index in scouring and normal sheep (non-parametric test for significance)

<table>
<thead>
<tr>
<th>Sheep (n)</th>
<th>Scouring</th>
<th>Normal</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teladorsagia</td>
<td>368</td>
<td>224</td>
<td>ns</td>
</tr>
<tr>
<td>Trichostrongylus</td>
<td>3225</td>
<td>2348</td>
<td>ns</td>
</tr>
<tr>
<td>Haemonchus</td>
<td>0</td>
<td>0</td>
<td>ns</td>
</tr>
<tr>
<td>Nematodirus</td>
<td>118</td>
<td>52</td>
<td>ns</td>
</tr>
<tr>
<td>Immature/L5</td>
<td>70</td>
<td>133</td>
<td>ns</td>
</tr>
<tr>
<td>DL4</td>
<td>414</td>
<td>395</td>
<td>ns</td>
</tr>
<tr>
<td>EL4</td>
<td>13860</td>
<td>5905</td>
<td>0.037</td>
</tr>
<tr>
<td>Abo contents</td>
<td>4750</td>
<td>987</td>
<td>0.037</td>
</tr>
<tr>
<td>Abo digest</td>
<td>7909</td>
<td>4460</td>
<td>ns</td>
</tr>
<tr>
<td>SI contents</td>
<td>625</td>
<td>45</td>
<td>0.009</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>18055</strong></td>
<td><strong>9057</strong></td>
<td><strong>0.089</strong></td>
</tr>
<tr>
<td>L3</td>
<td>636</td>
<td>631</td>
<td>ns</td>
</tr>
<tr>
<td><strong>TPI</strong></td>
<td>4.5</td>
<td>2.3</td>
<td>0.082</td>
</tr>
</tbody>
</table>

ns: not significant (p>0.100)
n: number of sheep
L3/L4/L5: Third/fourth/fifth stage larvae
DL4/EL4: Developed/Early fourth stage larvae
Abo: abomasum
SI: small intestine
TPI: Total pathogenic index

Pasture larval counts

The pasture larval count results are shown in Table 3. The pasture larval counts appeared to fall into three distinctive categories: “low” (less
than 500 larvae/kg pasture dry matter), “medium” (1000-2000 larvae/kg pasture dry matter) and “high” (more than 6000 larvae/kg pasture dry matter).

*Teledorsagia* spp. and *Trichostrongylus* spp. were the strongyle species most commonly isolated and differentiated from pasture grazed by the scouring flocks on the nine farms. *H. contortus* was cultured from pasture from one property (Bokerup orange tag), but *H. contortus* represented only 5% of larvae recovered from the pasture sampled.

**Table 3: Pasture larval counts**

<table>
<thead>
<tr>
<th>Property</th>
<th>Larvae/kg pasture DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kendenup</td>
<td>73</td>
</tr>
<tr>
<td>Boyup Brook</td>
<td>1052</td>
</tr>
<tr>
<td>Kojonup</td>
<td>68</td>
</tr>
<tr>
<td>Bokerup (orange tag)</td>
<td>1780</td>
</tr>
<tr>
<td>Bokerup (mixed tag)</td>
<td>1018</td>
</tr>
<tr>
<td>Bindoon</td>
<td>6424</td>
</tr>
<tr>
<td>Dudinin</td>
<td>767</td>
</tr>
<tr>
<td>Tenterden</td>
<td>6140</td>
</tr>
<tr>
<td>Broomehill</td>
<td>330</td>
</tr>
</tbody>
</table>

DM: dry matter

**Table 4: Mean faecal dry matter for treated and untreated scouring sheep 21-49 days after treatment with moxidectin and ivermectin controlled-release capsule (ANOVA test for significance)**

<table>
<thead>
<tr>
<th>Property</th>
<th>Treated</th>
<th>Control</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kendenup</td>
<td>18%</td>
<td>18%</td>
<td>ns</td>
</tr>
<tr>
<td>Boyup Brook</td>
<td>19%</td>
<td>21%</td>
<td>ns</td>
</tr>
<tr>
<td>Kojonup</td>
<td>21%</td>
<td>20%</td>
<td>ns</td>
</tr>
<tr>
<td>Bokerup (orange)</td>
<td>21%</td>
<td>21%</td>
<td>0.090</td>
</tr>
<tr>
<td>Bokerup (mixed)</td>
<td>18%</td>
<td>21%</td>
<td></td>
</tr>
<tr>
<td>Bindoon</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Dudinin</td>
<td>16%</td>
<td>16%</td>
<td>ns</td>
</tr>
<tr>
<td>Tenterden</td>
<td>19%</td>
<td>18%</td>
<td>ns</td>
</tr>
<tr>
<td>Broomehill</td>
<td>22%</td>
<td>21%</td>
<td>ns</td>
</tr>
<tr>
<td>TOTAL</td>
<td>19%</td>
<td>20%</td>
<td>ns</td>
</tr>
</tbody>
</table>

ns: not significant (p > 0.100)

**Table 5: Mean faecal consistency score (scale 1-5) for treated and untreated scouring sheep 21-49 days after treatment with moxidectin and ivermectin controlled-release capsule (ANOVA test for significance)**

<table>
<thead>
<tr>
<th>Property</th>
<th>Treated</th>
<th>Control</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dudinin</td>
<td>3.8</td>
<td>3.5</td>
<td>0.091</td>
</tr>
<tr>
<td>Tenterden</td>
<td>3.8</td>
<td>4.0</td>
<td>ns</td>
</tr>
<tr>
<td>Broomehill</td>
<td>3.8</td>
<td>3.9</td>
<td>ns</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3.8</td>
<td>3.8</td>
<td>ns</td>
</tr>
</tbody>
</table>

ns: not significant (p > 0.100)

**Histopathology**

Of the 43 sheep that underwent post-mortem examination, one normal sheep from the Broomehill property had histopathological evidence of a recognised non-parasitic cause of diarrhoea, specifically microabscessation of the duodenum consistent with yersiniosis. One scouring sheep (Bindoon) and one normal sheep (Dudinin) had histological changes consistent with coccidiosis, however the same scouring sheep from Bindoon also had a very high TWC (31 000 worms).

There were no consistent differences in the nature or severity of morphological changes in the scouring sheep compared with the normal sheep. The most common histological finding was “globule leukocyte hyperplasia” in the small intestine and/or large intestine and caecum. There was no significant difference in the
number of scouring sheep (16/22) with evidence of enteritis compared with the normal sheep (12/21, Pearson Chi-square p=0.284). The cellular infiltrate was described as “eosinophilic” in 20/28 sheep with evidence of enteritis, but there was no significant association between a diagnosis of “eosinophilic enteritis” and scouring (p=0.280).

There was a trend towards histological changes consistent with gastrointestinal parasitism (including atrophy, clubbing, blunting and/or fusion of the small intestinal villi) being more commonly observed in the scouring sheep (14/22) compared with the normal sheep (8/21, Pearson Chi-square p=0.090).

**Bacteriology**

None of the post-mortem examinations identified known pathogenic bacteria in conjunction with histological changes indicative of bacterial disease. *Salmonella* spp. were not isolated from any sheep in the study.

One normal sheep from the Broomehill property had histological evidence of yersiniosis but no *Yersinia* spp. was cultured to support this diagnosis. *Yersinia enterocolitica* was cultured from three normal sheep from the Kojonup property, but there were no histopathological changes consistent with yersiniosis in any of the sheep from this property.

Campylobacter-like organisms were observed in mucosal scrapings taken from sheep from the Bokerup (mixed age) and Tenterden properties, but there was no histopathological changes consistent with yersiniosis in any of the sheep from this property.

**Selenium Status**

Serum glutathione peroxidase (GSHPx) was above the reference range (>50 U/g Hb GSHPx) in all of the sheep from all of the properties except for Kojonup and Broomehill. The flock mean GSHPx for the Broomehill property was 49.8 U/g Hb and for the Kojonup property was 47.2 U/g Hb. There was no histopathological evidence or history of clinical signs consistent with nutritional myopathy in either of these flocks. There was no significant difference in GSHPx in the scouring sheep (178 U/g Hb) compared with the normal sheep (204 U/g Hb, ANOVA p>0.100).

**Discussion**

**Distribution of dag**

The variation in the number of sheep with moderate or severe dag varied between the flocks, presumably due to flock differences in the severity and duration of scouring and variation in susceptibility of the breech to accumulate dag. Faecal consistency is probably the major factor determining dag accumulation\(^\text{16, 17}\). Susceptibility of the breech to accumulate dag is determined by a number of factors, including wool length and conformation of the breech. Breech conformation is in turn determined by factors including tail length, gender and the amount of loose skin around the anus. Variations in breech conformation factors are largely influenced by management practices such as shearing and crutching, genetics (both within and between breeds) and surgical interventions (tail docking and mulesing).

**Parasitology**

The finding that WEC were similar in the scouring and normal sheep was consistent with other studies demonstrating that susceptibility to scouring and dag is not associated with the size of WEC, particularly in adult sheep\(^\text{8, 9, 18}\). Despite screening flocks for low WEC, a number of sheep were found to have high TWC and eight of the nine flocks had at least one sheep with a TPI of at least 4.0. The association between TPI and pathogenicity of worm burdens are not well defined in adult sheep, however the findings suggest that even where large worm burdens may not be apparent on flock WEC, it is likely that a proportion of sheep will still be harbouring worm burdens at a level generally considered to be harmful. TWC are not normally distributed within flocks\(^\text{19}\). In addition, WEC do not reflect the magnitude of infection with immature strongyles stages, therefore WEC have a poorer correlation with TWC in mature sheep\(^\text{20}\). In this study, the immature stages accounted for the largest proportion of the strongyle populations. PME and TWC are the only means currently available of accurately assessing immature worm burdens in sheep.

The increased numbers of EL\(_4\) in the scouring sheep was a novel finding and cannot be easily explained with the existing level of knowledge. The immature stages recovered on TWC were
not identified by genus, but by far the largest proportion of EL₄ were recovered from the abomasal contents and digest suggesting that the majority of EL₄ recovered were Tel. circumcincta. A proportion of the EL₄ recovered were possibly arrested larvae, but there is currently no definitive means of distinguishing arrested larvae from developing larval stages. There was no reason to suspect different levels of larval intake in scouring and normal sheep grazing the same pasture and there was no difference in the number of L₃ or developed L₄ recovered from the scouring and normal sheep.

The pattern of hypobiosis of Tel. circumcincta in Western Australia is not well understood. L₄ are commonly observed that may well be inhibited, but there is no definitive test available to distinguish developing and arrested larvae. Parasitologists have not recognised hypobiosis as a routine phenomenon in Tel. circumcincta or T. colubriformis in this region, although this may be in part because of the widespread practice of summer drenching removing arrested L₃ (T. colubriformis) and L₄ (Tel. circumcincta) such that resumption of development has not been widely observed when inhibited larvae would be expected to emerge, specifically the following autumn as is seen with Ostertagia ostertagi in cattle in the same region.

Hypobiosis in Tel. circumcincta occurs at EL₄ in the mucosa of the abomasum and hypobiosis of T. colubriformis occurs as arrested L₃ in the mucosa of the small intestine. It is likely that the TWC technique used in this study would have underestimated arrested L₃ in the small intestine because small intestinal digests were not performed and some of the samples were formalised.

The rate of arrested development is thought to be mediated by a combination of host immunity²¹-²³ and adverse climatic conditions with resumption of development typically occurring when environmental conditions for larval survival improve²⁴,²⁶. The south west of Western Australia has a Mediterranean climate with hot dry summers and cool wet winters. It was therefore interesting that large numbers of EL₄ were identified in the cool wet winter months in this study.

If the level of arrested development is mediated mainly by host immunity²¹-²³, then presumably genetic variation in the immune response could be expected. Several authors have suggested a genetic relationship determining susceptibility to scouring and severe dag that is independent of WEC²⁶-³². If higher numbers of EL₄ are found to be consistently associated with scouring, then this may provide a basis for further investigation of potential pathophysiological mechanism(s) behind “low WEC scouring” in mature sheep.

The WEC of sheep from the Bindoon property had risen sharply in the seven days between the “screening WEC” and the investigation. Sheep from this property also had very high TWC and a diagnosis of helminthosis was made in this flock and it was more likely that this flock was scouring due to high worm burdens than larval hypersensitivity scouring. The manager had not been monitoring WEC prior to the screening WEC. Sheep had been treated with an ivermectin drench prior to the screening WEC and were grazing what was subsequently discovered to be heavily contaminated pasture (Table 3). A subsequent faecal worm egg count reduction test demonstrated that ivermectin resistance was present on the property (86% efficacy). This flock demonstrated the importance of repeated monitoring of WEC and conducting TWC in cases of apparent “low WEC scouring”, particularly where worm control may be complicated by macrocyclic lactone resistance.

Larval intake
Assuming consumption of 1kg herbage dry matter per day, all flocks except at Kojonup and Kendenup had an estimated larval intake in excess of 2000 L₃ per week. This level of larval intake has been demonstrated as sufficient to induce diarrhoea in adult sheep susceptible to severe dag¹⁴.

Controlled-release capsules
There was no appreciable difference in faecal dry matter (eight farms) or faecal consistency (three farms) of the treated sheep compared with the control sheep 21 to 49 days post-treatment. This was surprising given that other studies have found that CRC are effective at reducing dag scores in treated sheep⁹, 33-37, although some studies have shown CRC may not reduce dag³⁵, 38.
Differences in the response to treatment with CRC may be due to a number of factors. Most other studies measure the differences in dag weight or dag score in treated and untreated sheep. The treated and control sheep in this study were all actively scouring and had severe dag at the time of treatment, hence other studies measure the differences in dag at the time of treatment, hence there is little published data on the effect of treatment of CRC on faecal consistency.

Sheep in this study were actively scouring with severe dag at the time of treatment and so had likely been scouring for some time prior to treatment. In most other studies, sheep were treated with the CRC prior to the onset of scouring or earlier in the duration of scouring. It is possible that CRC may be more effective at reducing faecal moisture if given earlier in the course of the scouring.

Different active ingredients may affect faecal dry matter. Ivermectin CRC were used in this study whereas several other studies have used albendazole CRC. Macrocyclic lactone resistance was common in Western Australia at the time of this study\(^\text{39}\). Ivermectin resistance can result in reduced efficacy of the drug to prevent establishment of incoming larvae\(^\text{40,42}\) and this may not be detected on a faecal worm egg count reduction test.

The treated sheep were returned to the same paddocks and were grazing with untreated sheep, thus treated sheep were exposed to ongoing larval intake. It was possible that there was ongoing antigenic stimulation in the treated sheep\(^\text{41}\) and this may have been complicated by potential ivermectin resistance whereby contact between dead or dying larvae and the gastrointestinal mucosa may have been sufficient to trigger a hypersensitivity reaction. Antigenic stimulation may arise from proteins present in the cuticle of the L\(^3\) \(^\text{43}\), therefore it is possible that once the host immune system is sensitised to larval antigen from incoming larvae, contact between dead or dying larvae and the mucosa may be sufficient to trigger a hypersensitive immune response. If this is the case, CRC may not reliably reduce scouring and dag in sheep susceptible to “larval hypersensitivity scouring” that are exposed to ongoing larval intake. However, this hypothesis warrants further investigation because other studies have found that antigenic stimulation may be suppressed following treatment with CRC\(^\text{44,45}\).

**Bacteriology, histology and selenium status**

There was no confirmed evidence of bacterial causes of scouring in the nine flocks studied. This suggested that known bacterial agents were unlikely to be a common cause of scouring in the nine flocks investigated. One normal sheep from Broomehill property with no evidence of active diarrhoea or dag had histological changes consistent with yersiniosis. *Yersinia* spp. were cultured on the Kojonup property, but there was no histological changes to support a diagnosis of yersiniosis in this flock. Interestingly, these were also the two flocks with marginal selenium status.

*Campylobacter*-like organisms were observed in sheep from Bokerup (mixed age wethers) and Tenterden, but as with the *Yersinia* spp., there were no histological changes to confirm a diagnosis of bacterial scouring. Both *Yersinia* spp. and *Campylobacter* spp. can be isolated from healthy sheep and diagnosis of bacterial scouring is based on a combination of history of “stress” (ie shearing, inclement weather), clinical signs, histopathological changes and identification of the causative organism on mucosal scrapings or culture\(^\text{3}\).

All of the properties with the exception of Dudinin were located in areas of known selenium deficiency. It was not clear whether the levels of GSHPx observed in the Broomehill and Kojonup flocks were sufficiently low to cause scouring and scouring is an inconsistent finding with selenium deficiency\(^\text{5}\). It has been suggested that selenium deficiency may result in increased susceptibility to internal parasites\(^\text{3}\), but several reviews have concluded that there is no evidence that selenium status has any influence on parasite establishment\(^\text{46-48}\).

The primary purpose of the histological examinations was to rule out recognised causes of scouring. The results showed that histopathological evidence of known causes of scouring other than strongyle worm infections were uncommon.

Eosinophilic enteritis and villous atrophy were common findings and may represent pathology attributable to larval hypersensitivity scouring. 
syndrome, although neither finding is specific to the syndrome. Further objective measurements such as villous:crypt ratios and differential cell counts would be required to evaluate if villous atrophy or eosinophilic infiltration of the pyloric and jejunal mucosa were associated with scouring in the flocks in this study.

Larval hypersensitivity scouring
It has been suggested that the larval hypersensitivity scouring syndrome may explain a large proportion of “low WEC scouring” in adult sheep in the south west of Western Australia. However, the pathogenesis of larval hypersensitivity scouring syndrome has not been fully described and there are no diagnostic tests or specific clinical findings currently available that allow a definitive diagnosis of larval hypersensitivity scouring. A presumptive diagnosis of larval hypersensitivity scouring is often made where other known causes of scouring have been ruled out, affected sheep have low WEC and “increased eosinophils” may be observed in the pylorus and proximal small intestine at post-mortem. However, there is no published descriptive grading system for the histological evaluation of “eosinophilic enteritis” in sheep making it difficult to determine whether eosinophilic infiltration in any given case is “normal” or indicative of “disease”.

Based on the results of this study and the existing level of knowledge, larval hypersensitivity scouring may well explain the scouring observed in at least eight of the nine flocks. Histology and bacteriology suggested that bacterial infections were an unlikely cause of the scouring observed in and the two flocks with marginal selenium status, the levels were not sufficiently low as to explain the high incidence and severity of scouring in the absence of other clinical signs more consistently associated with selenium deficiency. Pasture larval counts suggested that each of the flocks were exposed to ongoing larval intake of varying degrees. However, based on the lack of a diagnostic test means that larval hypersensitivity scouring syndrome was only a presumptive diagnosis by exclusion of other causes and a definitive diagnosis could not be made.

Grazing of lush green pasture and higher levels of larval intake from pasture are generally present concurrently in a Mediterranean environment, so it was difficult to isolate factors associated with larval intake and nutritional factors associated with grazing of lush green pasture. Other authors have suggested an interaction between factors associated with pasture and the rate of larval intake that may determine the severity of larval intake observed.

Conclusions
Investigation of scouring in nine flocks with low flock WEC found that one flock had helminthosis, but despite extensive diagnostic work, no definitive diagnosis could be made in the other eight flocks. The most likely cause was larval hypersensitivity scouring based on the existing level of knowledge of this syndrome, although scouring related to dietary factors in pasture could not be ruled out or may contribute to the severity of scouring observed. Bacterial infections did not appear to be a common cause of scouring in the flocks investigated. The most striking finding was increased numbers of EL₄ in the scouring sheep.

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