Dietary Enhancement of Resistance to Trichostrongylus colubriformis in Merino Weaners

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ABSTRACT: This research was conducted to determine whether short and long-term resistance of Merino weaners to infection from T. colubriformis could be manipulated by a brief period of differential feeding. Merino weaners infected with T. colubriformis for 10 weeks were restrictively fed diets to create 2 levels of digestible energy intake and 2 levels of metabolisable protein supply. Live weight reflected energy and protein supply and at the conclusion of the 10 weeks of infection there was a 4.8 kg difference between animals fed greatest and least levels of digestible energy and metabolisable protein supply. Neither digestible energy intake nor metabolisable protein supply affected faecal egg count. Total counts of T. colubriformis determined 10 weeks post infection were significantly lower in animals with greater levels of digestible energy intake but were unaffected by metabolisable protein supply. This research has demonstrated a novel finding that increased digestible energy intake enhances resistance to T. colubriformis in young sheep.

Key Words: Resistance, Trichostrongylus colubriformis, Energy, Protein, Sheep

INTRODUCTION

It has been estimated (McLeod, 1995) that the annual cost of gastrointestinal (GI) parasites to the Australian sheep industry is about $220 million of which 45% is associated with the cost of reduced animal production. In the Northern Tablelands of NSW, infection of spring-born Merino lambs with Trichostrongylus colubriformis during their first autumn and winter following weaning represents perhaps the greatest impost of GI parasites. Reduced production from infections of T. colubriformis is due to depressed feed intake (Poppi et al., 1985) and increased protein requirement (Poppi et al., 1986) which in combination reduce growth rate and wool production.

In the Northern Tablelands of NSW infection with T. colubriformis occurs typically at a time of decreasing pasture feed availability and quality. This is a significant observation because various studies (Bown et al., 1991; van Houtert et al., 1995) have demonstrated that improved nutrition and, in particular, increased metabolisable protein supply, enhances resistance to T. colubriformis.

Various authors (e.g. Hall, 1990) have suggested that the susceptibility of Merino weaners to T. colubriformis may be associated with inadequate post-weaning nutrition. A recent study (Datta et al., 1999) with crossbred weaners infected with Haemonchus contortus provides some support for this suggestion. These authors demonstrated that an increased plane of nutrition for a short period of time in the early post-weaning period improved the subsequent long-term resistance of sheep to GI parasites. If these results are confirmed and equally apply to T. colubriformis infections, this approach offers significant opportunities for inclusion into integrated worm control programmes. The aim of this experiment was to determine whether differences in metabolisable energy and metabolisable protein supply, during a 10 week period of infection with T. colubriformis, influence short-term expression of resistance. The results presented in this paper represent part of a larger experiment. Long-term effects of these dietary manipulations will be reported separately.

MATERIALS AND METHODS

Animals and Conditions

Eighty eight Merino wether weaners (6 months of age) that had been born and grazed on pasture were used in the experiment. The mean live weight of the animals when brought into the animal house was 22.0 kg (SD = 2.30 kg). Once in the animal house, animals were drenched to remove gastrointestinal nematodes (Numectin Nufarm Animal Health), treated against coccidia and clostridial diseases and received an intramuscular injection of vitamin B12. Animals were housed in individual pens with continuous access to water and had natural ventilation and illumination at all times.

Experimental design and infection details

Following a 2 week adaptation period, animals were fed ad-libitum (loose mix of 0.60 oaten chaff, 0.25 lucerne chaff and 0.15 barley) for 4 days to determine voluntary intake. Lambs were then stratified on the basis of live weight and allocated randomly from within each live weight group to diet (number of animals per diet given in Table 1). Mean daily intake did not differ between allocated diets.

All animals were orally infected with c. 1000 L3 T. colubriformis (McMaster strain), suspended in 2.5 ml of water, on 3 days each week for the duration of the experiment.

Experimental diets and feeding protocol

Four experimental diets (Table 1) were formulated such that restrictive feeding would generate low (diets E1) and moderate (diets E2) digestible energy (DE) intake and low (diets P1) and moderate (diets P2) metabolisable protein (MP) supply. Animals
Table 1. Ingredients, composition and number of animals allocated to the four experimental diets.

<table>
<thead>
<tr>
<th>Ingredient (g/kg)</th>
<th>E1P</th>
<th>E1P</th>
<th>E2P</th>
<th>E2P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oaten chaff</td>
<td>850</td>
<td>570</td>
<td>695</td>
<td>600</td>
</tr>
<tr>
<td>Barley</td>
<td>90</td>
<td>80</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>50</td>
<td>340</td>
<td>0</td>
<td>140</td>
</tr>
<tr>
<td>Urea</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ME (MJ/kg DM)</td>
<td>8.8</td>
<td>9.5</td>
<td>9.8</td>
<td>9.7</td>
</tr>
<tr>
<td>CP (g/kg DM)</td>
<td>123</td>
<td>218</td>
<td>100</td>
<td>155</td>
</tr>
<tr>
<td>MP (g/kg DM)</td>
<td>40</td>
<td>60</td>
<td>41</td>
<td>69</td>
</tr>
<tr>
<td>Minerals (g/kg DM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>4.2</td>
<td>4.3</td>
<td>4.2</td>
<td>4.1</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>3.8</td>
<td>3.8</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Animal numbers</td>
<td>24</td>
<td>14</td>
<td>14</td>
<td>36</td>
</tr>
</tbody>
</table>


RESULTS

Feed intake and energy and protein supply

Feed intake was largely restricted and hence generally reflected the amount of feed offered rather than voluntary consumption. Feed intake of animals fed diets E1 was less (P<0.001) than that of animals fed E2. There was no difference in feed intake between animals fed P1 or P2.

Digestible energy intake differed between diets (P<0.001) and as expected was greatest, throughout the experimental period, in animals fed E2 (P<0.001) (Figure 1). There was no difference in DE intake between diets E1P1 and E1P2 but DE intake differed between diets E2P1 and E2P2 when averaged over the experiment (P<0.05). This difference was a consequence of a low feed intake for animals fed diet E2P1 which was formulated to be deficient in rumen degradable protein. The low feed intake of animals fed diet E2P1 also resulted in the DE intake of animals fed diets P2 being greater than that for animals fed diets P1 (P<0.001). Nevertheless two distinct levels of DE intake were apparent throughout the experiment with the mean DE intake for diets E1 (0.28 MJ DE/ kg live weight /day) being c. 20% less than for diets E2 (0.34 MJ DE/ kg live weight/ day).

Calculated MP supply (AFRC 1993; Freer et al., 1997) differed between diets (P<0.001) but, as was intended, was similar between animals fed to have the same DE intake except at weeks 1, 2 and 6 p.i. (P<0.05 at those weeks) (Figure 2). As expected, calculated MP supply differed between diets formulated to provide different levels of MP (P<0.001).

Live weight

Live weight on day –7 (relative to infection) did not differ between diets and was used as a significant covariate (P<0.01) for subsequent recordings of live weight but not for live weight gain (kg/11 week period). Live weight differed between diets at every week (P<0.001) (Figure 3). Live weight of animals fed diets E2 was greater (P<0.001) than those fed diets E1 at all weeks. Live weight of animals fed diets P2 was greater than those fed P1, from the second week p.i. (P<0.001). There was no significant interaction between DE and MP for live weight.
Least squares mean (± SE) digestible energy intake (MJ/kg live weight/day) of Merino weaners infected with *T. colubriformis* and fed diets to provide for either a low (E1) or moderate (E2) digestible energy intake and a low (P1) or moderate (P2) MP supply.

![Figure 1](image1)

**Figure 1.** Least squares mean (± SE) digestible energy intake (MJ/kg live weight/day) of Merino weaners infected with *T. colubriformis* and fed diets to provide for either a low (E1) or moderate (E2) digestible energy intake and a low (P1) or moderate (P2) MP supply.

Least squares mean (± SE) calculated metabolisable protein supply (g/kg live weight/day) of Merino weaners infected with *T. colubriformis* and fed diets to provide for either a low (E1) or moderate (E2) digestible energy intake and a low (P1) or moderate (P2) MP supply.

![Figure 2](image2)

**Figure 2.** Least squares mean (± SE) calculated metabolisable protein supply (g/kg live weight/day) of Merino weaners infected with *T. colubriformis* and fed diets to provide for either a low (E1) or moderate (E2) digestible energy intake and a low (P1) or moderate (P2) MP supply.

Live weight gain from –1 to 10 weeks p.i. differed (P<0.001) among all diets. Live weight gain increased (P<0.001) with DE intake and MP supply. Least squares mean (± SE) live weight gain was 2.9 ± 0.24 kg for E1, 5.9 ± 0.23 kg for E2, 3.5 ± 0.24 kg for P1 and 5.3 ± 0.23 kg for P2. There was no significant interaction between DE and MP for live weight gain.

![Figure 3](image3)

**Figure 3.** Least squares mean (± SE) live weight (kg) of Merino weaners infected with *T. colubriformis* and fed diets to provide for either a low (E1) or moderate (E2) digestible energy intake and a low (P1) or moderate (P2) MP supply.

Faecal egg counts

Faecal egg count (epg) and total daily nematode egg output were unaffected by diet, DE intake, MP supply and interactions between these variables were not significant. However, when averaged over the experimental period there was a significant (P<0.01) effect of the DE x MP interaction for total daily egg output. Averaged over the 10 week period, increasing MP supply for diets E1 reduced egg output by 26% but for diets E2 increased egg output by 75%.

![Figure 4](image4)

**Figure 4.** Faecal egg counts (epg; arithmetic mean) of Merino weaners infected with *T. colubriformis* and fed diets to provide for either a low (E1) or moderate (E2) digestible energy intake and a low (P1) or moderate (P2) MP supply.
Worm burdens

The main effect of diet did not effect any of the measured worm variables at the 10 week post infection slaughter. However, animals fed diets E2 had fewer adult male (P = 0.06), adult female (P<0.05), total adults (P<0.05) and total (adults + juveniles) (P<0.05) T. colubriformis counts (Data pooled within DE and MP groups; Table 3). Differences in metabolisable protein supply did not effect T. colubriformis counts. There was no significant interaction between DE and MP for any of the measured worm variables.

Table 3. Numbers of T. colubriformis recovered 10 weeks post infection from Merino weaners fed diets to provide for either a low (E1) or moderate (E2) digestible energy intake (DEI) and a low (P1) or moderate (P2) metabolisable protein (MP) supply.

<table>
<thead>
<tr>
<th>Level</th>
<th>DEI</th>
<th>MP supply</th>
<th>Adult</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MJ/kg live</td>
<td>g/kg live</td>
<td>weight/day</td>
<td>female weight/day</td>
</tr>
<tr>
<td>E1</td>
<td>0.28</td>
<td>6303&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11827&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>E2</td>
<td>0.34</td>
<td>4513&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8541&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>1.7</td>
<td>5205</td>
<td>9817</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>2.7</td>
<td>5612</td>
<td>10552</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Total is the sum of adult male, adult female and juveniles. Means within columns followed by different superscripts differ significantly (P<0.05).

DISCUSSION

Despite grazing at pasture for the previous 6 months, animals appeared fully susceptible to artificial infection from T. colubriformis. That Merino sheep remain susceptible to infection from T. colubriformis until after 6 months of age is of interest because it has been shown that acquired immunity to T. colubriformis may be induced experimentally by artificial infection over a period of exposure as brief as 12 weeks (Barnes and Dobson, 1993).

Both DE intake and MP supply stimulated live weight gain but did not effect FEC during the 10 week period of artificial infection. Animals with a greater DE intake had fewer T. colubriformis recovered from the small intestine 10 weeks p.i.. This is in contrast to that reported by Bown et al. (1991) where abomasal infusions of casein (to increase the MP supply) but not glucose (to increase ME supply) significantly reduced T. colubriformis counts 12 weeks p.i.. To our knowledge this is the first report that a greater DE intake can enhance resistance in growing sheep to infection from T. colubriformis.

Whether these dietary effects on resistance continue in the longer-term is currently under investigation. On a practical level, this research has supported the view that resistance to T. colubriformis in young Merino sheep can be enhanced by dietary factors. Although diet did not effect FEC during this experiment it is likely that reduced worm burdens observed in animals fed diet E2 would have eventually resulted in reduced FEC. In that situation it would be necessary to account for diet when using FEC to assess the genetic potential of an animal to resist nematode infection.

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