Internal parasites and lamb production - a role for plants containing condensed tannins?

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ABSTRACT

Three experiments were undertaken to investigate the possibility that forages containing condensed tannins (CT) may affect nematode parasite burdens and their significance in lambs. In the first trial, lambs were infected with a single dose of 15000 *Ostertagia circumcincta* and 15000 *Trichostrongylus colubriformis* infective larvae. Those fed *Lotus pedunculatus* with or without polyethylene glycol (PEG) had lower faecal egg counts, higher liveweight gains and higher faecal dry matters than lambs fed ryegrass with or without PEG ($P<0.05$). In the second experiment, lambs with a low, mixed natural worm burden were grazed on sulla (*Hedysarium coronarium*), a CT containing legume, or lucerne, for 28 days. Lambs drenched with anthelmintic and fed sulla grew faster than those fed lucerne (321 v 215 g/day $P<0.05$) whilst undrenched lambs had similar growth rates on both species (250 v 220 g/day). In the third experiment, heavily parasitized lambs sired by rams selected for low faecal egg count (resistant) or conventional rams (non-resistant) were grazed on lucerne or sulla for 28 days. When anthelmintic drenches were withheld, the non-resistant sired lambs grew faster on sulla than lucerne (231 v 28 g/day; $P<0.0001$), as did the resistant sired lambs (181 v 72 g/day; $P<0.001$) respectively. Drenched non-resistant sired lambs grew faster on the sulla than on lucerne and faster than the resistant sired lambs.

These results suggest that forages containing condensed tannins may have an important role to play in developing lamb production systems with less reliance on anthelmintic use for parasite control.

Keywords: lambs, parasitism, nutrition, condensed tannins.

INTRODUCTION

Because of the increasing incidence of anthelmintic resistance and rising consumer concerns about chemical residues, approaches to gastrointestinal nematode control that are less reliant on anthelmintics are needed, particularly in pastoral lamb production systems. While much is known about the production losses caused by gastrointestinal nematode infections and how these are caused, little work has been done on minimising or restricting these losses other than by the use of anthelmintics. In particular, there has been little study of different forage types in reducing production losses associated with parasitism. Condensed tannins (CT) are polyphenolic compounds present in a variety of plants including a number of legumes which can be grown as forages. Tannins may have evolved as a defense mechanism against bacterial and insect predation and grazing by herbivores (Swain 1978). However, tannins have also been shown to protect plant proteins against ruminal degradation and so increase the availability of protein post-ruminally when fed to sheep (Waghorn *et al.*, 1987). The infusion of protein into the abomasum of lambs infected with *Trichostrongylus colubriformis* resulted in reduced worm burdens and substantial improvements in the gross efficiency of Metabolisable Energy (ME) utilisation in parasitised animals (Bown *et al.*, 1991).

It thus seemed possible that feeding plants containing CT's might reduce the effects of parasitism by increasing the post-ruminal availability of dietary protein and, conceivably, affect the establishment or persistence of gastrointestinal nematodes. A series of experiments to investigate these possibilities are described here.

MATERIALS AND METHODS

Experiment 1: Forty four 12-14 week old Polled Dorset lambs were raised helminth-free and were restrictively randomized on the basis of liveweight into 4 groups. Two groups were fed freshly cut ryegrass and two groups freshly cut *Lotus pedunculatus* . Both the ryegrass and lotus were harvested from paddocks which had not been grazed by sheep for at least 2 years. Feeds were available ab libitum to all groups. One group on each diet was dosed twice daily with polyethylene glycol (PEG) to block the protein binding properties of the CTs in the rumen. After a one week on the diets, each lamb was infected with a single dose of 15000 *Ostertagia circumcincta* and 15000 *Trichostrongylus colubriformis* infective larvae by stomach tube. Lambs were weighed weekly, faecal egg counts (FEC) made and faecal dry matters determined at 21 and 28 days after infection; The lambs were slaughtered 28-29 days after infection for abomasal and intestinal worm counts to be undertaken.

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Experiment 2: Sixty Romney lambs, 15-16 weeks old, with a naturally acquired light mixed infection of gastrointestinal nematodes were randomized by weight and FEC and allocated to graze either lucerne or sulla. Lambs on each feed were either drenched once with ivermectin (Ivomec, Merke, Sharpe and Dohme) on Day 0, or left undrenched, in a 2X2 factorial design. All lambs were offered a similar dry matter allowance (5kg/lamb/day) estimated by measuring standing herbage dry matter and allocating sufficient area for 7 days grazing. Animals were weighed and faecal sampled at the onset of the trial, and fortnightly thereafter. The trial lasted 28 days.

Experiment 3: Ninety, five-month old Romney lambs sired by either conventional rams (non-resistant) or rams selected for low faecal egg counts (resistant) were managed to induce a high gastrointestinal parasite burden (FEC's 1300-2000 eggs per gram). Lambs were randomized according to sire and initial weight to graze lucerne or sulla, with groups drenched with ivermectin on Day 0, or left undrenched in a 2X2X2 factorial design. All lambs were offered a similar dry matter allowance (5kg/lamb/day) estimated by measuring standing herbage dry matter and allocating sufficient area for 7 days grazing. Animals were weighed and faecal sampled at the onset of the trial, and fortnightly thereafter. The trial lasted 28 days.

RESULTS

Experiment 1: Lambs fed lotus gained more weight than those fed ryegrass ($P<0.01$) in both the PEG and non-PEG groups (Table 1). The PEG treatment significantly increased liveweight gain ($P<0.05$) in the ryegrass-fed lambs but not the lotus-fed lambs. Lambs fed ryegrass had significantly ($P<0.05$) higher FEC's than those fed lotus on both day 21 and 28 post infection. PEG dosing did not affect FEC with the ryegrass treatment but did with the lotus treatment on day 21 but not day 28 (Table 1). Faecal dry matter (DM) differed between all treatments ($P< 0.05$), being lowest on the grass with PEG and highest on the lotus with PEG. When the results for each diet species are pooled, lotus treatments resulted in significantly higher liveweight gains and faecal dry matters (DM's) and lower FEC's than ryegrass ($P<0.001$).

Experiment 2: Drenched lambs grazing sulla had higher average daily gain (ADG) than drenched lambs grazing lucerne ($P<0.05$) (Table 2). Weight gains of undrenched lambs on lucerne and sulla and drenched lambs on lucerne did not differ significantly. Lamb FEC's did not differ between treatment groups on day 0, prior to drenching. On days 14 and 28 lambs in the drenched groups had virtually no FEC, while there was a slight increase in FEC's in the undrenched groups over the duration of the trial. Final FEC's did not differ significantly between lucerne and sulla.

Experiment 3: There were no significant differences between sire-groups in liveweight gain of drenched lambs grazing either sulla or lucerne (Table 3). However, with undrenched lambs, both resistant and non resistant sired groups grew more rapidly on sulla than lucerne ($P<0.001$, Table 4). While there was no difference in ADG between non-resistant and resistant sired lambs fed lucerne, non-

TABLE 1: Average daily gain (ADG), mean faecal egg counts (FEC) (eggs per gram fresh faeces) and faecal dry matter (DM) when of lambs fed ryegrass or lotus, with or without polyethylene glycol (PEG), after being infected with 15000 *Ostertagia circumcincta* and 15000 *Trichostrongylus colubriformis* larvae. (Experiment 1). Columns with different superscripts indicate differences between treatments at the 5% and 1% level.

Treatment	n	Initial Weight (kg)	ADG (g/day)	FEC1 Day 21	FEC Day 28	Faecal DM (%)
Grass	11	19.4^{a}	33.3^{a}	2945^{a} (53.58)	3035^{a} (54.51)	38.1b
Lotus	11	18.9^{a}	184.3^{c}	1290^{c} (35.19)	1640^{b} (38.98)	41.3^{c}
Grass + PEG	11	19.4^{a}	62.2^{b}	2921^{a} (53.79)	3050^{a} (54.54)	31.5^{a}
Lotus + PEG	11	18.5^{a}	195.3^{c}	1875^{b} (44.24)	1463^{b} (38.13)	46.2^{d}
SEM		1.30	11.0	3.21*	2.89*	1.13

[1] Data for FEC's are shown as arithmetic means with the means of the square root transformed FEC's in parentheses. Statistical analysis was undertaken on square root transformed data.

* SEM's of FEC's are for square root transformed data.

TABLE 2: Mean lamb liveweight daily gain (ADG) and faecal egg counts (eggs per gram fresh faeces) when grazing lucerne or sulla for 28 days. (Experiment 2). Columns with different superscripts indicate differences between treatments at the 5% and 1% level.

Treatment	n	ADG (g/day)	Faecal Egg Count[1] (eggs/g fresh faesces) Day 0	Day 14	Day 28
Lucerne Drenched	13	215^{a}	251^{a} (12.41)	18^{a} (2.03)	9^{a} (1.42)
Sulla Drenched	8	321^{b}	168^{a} (10.03)	25^{a} (0.75)	12^{a} (0.77)
Lucerne Undrenched	24	220^{a}	97^{a} (8.62)	187^{b} (12.33)	280^{b} (16.30)
Sulla Undrenched	15	250^{a}	158^{a} (9.08)	172^{b} (10.81)	531^{b} (19.06)
SEM		35.2	2.742	2.32	2.73

[1] Data for FEC's are shown as arithmetic means with the means of the square root transformed FEC's in parentheses. Statistical analysis was undertaken on square root transformed data.

[2] SEM's of FEC's are for square root transformed data.

resistant sired lambs grazing sulla had a higher ADG than resistant sired lambs grazing sulla (P<0.05).

TABLE 3: Mean liveweight gain of drenched non-resistant sired lambs or lambs sired by rams selected for low faecal egg counts (resistant) and grazed on either lucerne or sulla. (Experiment 3). Columns with different superscripts indicate differences between treatments at the 5% and 1% level.

Treatment	n	ADG (g/day)
Lucerne Non-resistant*	6	263^{ab}
Sulla Non-resistant*	9	316^{b}
Lucerne Resistant**	7	226^{a}
Sulla Resistant**	8	288^{ab}
SEM		21.8

* lambs sired by unselected rams

** lambs sired by rams selected for low faecal egg count

All lambs started the trial with similar FEC's (P>0.05, Table 4). By day 14, non-resistant sired lambs on the lucerne had higher FEC's than the other 3 treatments (P<0.05). By the end of the trial, lambs on the sulla (resistant and non-resistant sire groups) had the lowest FEC's, non-resistant sired lambs on the lucerne the highest and resistant sired lambs on the lucerne were intermediate. Resistant sired lambs tended to have lower FEC's than their non-resistant sired counterparts on both the lucerne and sulla; this was consistent but non-significant (P>0.05).

DISCUSSION

From the lower FEC's observed in the lambs on lotus in Experiment 1, it would appear that the better growth rate on this diet was, at least in part, attributable to some effect on parasite establishment or fecundity. However, though interpretation of the counts is complicated by differences in faecal dry matter, the FEC reduction was of the order of 50%. This suggests that much of the effect was due to the lotus providing a substantially higher level of nutrition resulting directly in better growth rates. To what extent this reduction in FEC's is reflected in parasite numbers will become clear when the worm counts have been completed. It was anticipated that PEG would have eliminated any CT effects, so that lambs fed lotus and receiving PEG would have had higher FEC's and lower weight gains than those fed lotus without PEG. This was not the case and PEG did not appear to affect FEC's on either feed. The significant improvement in growth rates resulting from PEG administration in lambs fed ryegrass was unexpected and is inexplicable. There were no associated differences in FEC's indicating that the effect was not due to any effect of PEG on parasite burdens. Whether it was caused by the osomotic activity of PEG as suggested by Terrill *et al.*, (1992) is unknown. Clearly there is a need for more research on the effects of PEG in sheep.

In experiment 2, although faecal egg counts were low and did not differ between groups on the two diets, there was a significant growth response to drenching on sulla. In these circumstances, it is difficult to see why a similar response was not obtained on lucerne. Growth rates of over 200g/day suggest the response was not limited by nutrient availability with the lucerne. The increase in FEC's during the experimental period may be due to the maturation of infection acquired before the experiment began.

In experiment 3, there was a clear effect of parasitism on growth rates with significant improvements resulting from drenching in all sire-groups on both forages. The response was considerably greater on lucerne than on sulla. The difference in performance of undrenched animals on the two diets was also very striking with growth rates on sulla approximately 2.5 times and 8 times greater than on lucerne for lambs from resistant and non-resistant sires respectively. This was reflected in the appearance of the animals. At the start of the experiment, as might be expected from the initial FEC's, all the lambs looked unthrifty and showed signs of diarrhoea with faecal contamination of the perineum. The lambs on lucerne did not improve their appearance during the period of observation whereas those fed sulla appeared plump and healthy with no signs of diarrhoea by the end of the experiment. It is interesting to note, however, that at the end of the trial, the mean FEC of the group on sulla was only about 25% lower than that of the group on lucerne. It is not known if this reflected worm burdens.

The effect of sire on daily gain was significant only for lambs fed sulla and then in favour of lambs from the unselected rams. There was a consistent, nonsignificant tendency for lambs from resistant sires to grow more slowly than those from unselected rams in both drenched and undrenched groups. These finding are similar to those of Howse *et al.*, (1992) who found that sheep from lines selected for high fleeceweight had higher FEC's than randomly mated con-

TABLE 4: Mean lamb liveweight gain and faecal egg counts (eggs per gram fresh faeces)of undrenched non-resistant sired lambs or lambs sired by rams selected for low faecal egg counts (resistant) and grazing lucerne or sulla. (Experiment 3). Columns with different superscripts indicate differences between treatments at the 5% and 1% level.

Treatment	n	ADG (g/day)	FEC[1] Day 0	FEC Day 14	FEC Day 21	FEC Day 28
Lucerne Non-resistant	12	28^{a}	2255^{a} (45.52)	3876^{a} (52.80)	2980^{a} (53.64)	2221^{a} (43.48)
Sulla Non-resistant	15	231^{c}	1894^{a} (41.83)	1604^{b} (38.08)	1741^{ab} (40.53)	1321^{b} (34.17)
Lucerne Resistant	14	72^{a}	1587^{a} (32.03)	1600^{b} (36.64)	3737^{a} (52.24)	2017^{ab} (39.72)
Sulla Resistant	19	181^{b}	2051^{a} (43.57)	1127^{b} (32.93)	1518^{b} (36.28)	1086^{b} (31.46)
SEM		21.8	4.64[2]	4.08	5.37	3.83

[1] Data for FEC's are shown as arithmetic means with the means of the square root transformed FEC's in parentheses. Statistical analysis was undertaken on square root transformed data.

[2] SEM's of FEC's are for square root transformed data.

trols and suggests there may be a production cost in selecting for low FEC's, although published genetic correlations between liveweight gain and FECs do not indicate such a reletionship (McEwan *et al.*, 1992).

Considering the results of these three experiments together, it would appear that at least some plants containing CT's may have an effect on the establishment or survival of nematodes in the alimentary tract of sheep though the effects on naturally acquired, established worm burdens under grazing conditions has yet to be determined. From the observations on FEC's, the reduction in worm burdens may be modest. However, the effects of both lotus and sulla on the growth rates of lambs with significant levels of parasitism appear to be very substantial and potentially of considerable practical importance. The extent to which these effects are due to the presence of CT's and their protective effect on dietary proteins has yet to be established. Further research is in progress.

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