Supplementary feeding and gastrointestinal nematode parasitism in young grazing sheep

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ABSTRACT

Young Merino wethers (n=240) were allocated to 1 of 8 treatments in a replicated field experiment. Animals grazed semi-improved pasture and received supplements for 14 or 28 weeks based on fish meal (F14, F28), sunflower meal (S14, S28) or oat grain (O14, O28). Unsupplemented parasite-free (C-) and parasitised animals (C+) were included as controls. Animal performance and parasite status were evaluated.

During weeks 1-14 faecal egg counts (FEC) were below 120 eggs per gram (epg), due to low larval intake from pasture. Cumulative live-weight gain (LWG) over this period was increased as a result of supplementary feeding from 8.6 (mean C- and C+) to 11.4 kg (F14; $P<0.01$) or 9.9 or 9.7 kg (S14 and O14 respectively; $P>0.05$).

From week 15 animals were dosed fortnightly with 6000 *Trichostrongylus colubriformis* and 2000 *Haemonchus contortus* larvae. Lucerne hay was fed twice weekly from week 17 onwards (2 kg/sheep/week). The FEC increased to about 5900 epg in week 28 for groups C+, F14, S14, O14 and O28 and about 3000 epg for groups F28 and S28 ($P<0.05$). Cumulative LWG from weeks 15-28 for groups C-, F28, S28 and O28 (0.9, 1.1, 0.6 and 1.4 kg respectively) was higher than for groups C+, F14, S14 or O14 (-1.2, -1.7, -2.2 and -0.9 kg respectively; $P<0.05$).

Supplementation with F, S and O during parasite infection enhanced the resilience of grazing sheep to gastrointestinal nematodes, while supplementation with F and S appear to have reduced peak FEC.

Keywords: Nutrition; sheep; *Trichostrongylus colubriformis*; *Haemonchus contortus*.

INTRODUCTION

The pathology of gastrointestinal parasitism in ruminants is influenced by the nutritional status of the host. A number of recent studies with sheep kept indoors have shown that supplementary protein overcame the debilitating effects of *Trichostrongylus colubriformis* or *Haemonchus contortus* on animal health and production (Abbott *et al*., 1988; Bown *et al*., 1991; van Houtert *et al*., 1995a). Little is known, however, of the influence of host nutritional status on production responses in grazing sheep and on development of host immunity to nematodes. In a previous study we investigated the effects of supplementary feeding of young grazing sheep with high-protein sunflower meal, which substantially reduced the production losses attributable to infection with nematodes (van Houtert *et al*., 1995b). The aim of the present study was to obtain further information on the influence of supplementary feeding with high-protein and low-protein supplements on production responses and parasite status in young grazing sheep.

MATERIALS AND METHODS

Animals and feeds

A grazing study was carried out near Armidale, Australia, at a latitude of 30½ S and at an elevation of 1070 m. Average annual rainfall is 830 mm (range 500 to 1300 mm; 1950 to 1993), with 63% falling in the six months October to March. Average annual evaporation is 1270 mm (70% from October to March). Average daily maximum and minimum temperatures range from 25 and 12 ½C in January to 11 and 0½C in July. The experimental area had been sown with improved pasture species in 1964, and at the time of the experiment the predominant pasture species were *Phalaris aquatica*, *Holcus lanatus*, *Vulpia spp* and *Lolium perenne*, with few legumes present.

Fine-wool Merino wether sheep were born at pasture in September 1993. They were weaned at 3 months of age and treated orally with ivermectin (*ca* 0.25 mg/kg live weight (LW); Ivomec; Merck, Sharp & Dohme, Australia) and closantel (*ca* 9 mg/kg LW; Seponver; SmithKline Beecham Animal Health, Australia) to remove helminth parasites. They were accustomed to supplementary feeding over the next month.

In late January 1994, the sheep (n=240) were allocated to and commenced with one of eight treatments. Each treatment was replicated on three paddocks in a randomised complete block design, with a total of 24 paddocks (0.8 ha each with 10 sheep/paddock). The paddocks were considered to be lightly and evenly contaminated with nematode eggs, as they had been last been grazed four months earlier by 6 sheep/paddock with mean nematode egg counts in fresh faeces (FEC) of 250 eggs per gram (epg; range 100 to 600). No further steps were taken to contaminate paddocks prior to starting the current study.

Experimental design and observations

Animals were orally treated with ivermectin (as above) and given a selenium pellet (0.5 g elemental selenium; Tri-sel; Arthur Webster Pty Ltd) and cobalt pellet (3 g

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cobalt oxide; Permaco; ICI Australia Operations) on day 1. Feed supplements were given for 14 or 28 weeks on Mondays, Wednesdays and Fridays ($2^1/_2$, 2 and $2^1/_2$ daily rations respectively). Supplements were fish meal/lucerne pellets (50/50; 100 g/animal/day; F14 and F28) or sunflower meal/lucerne pellets (67/33; 150 g/day; S14 and S28) or whole oat grain (150 g/day; O14 and O28). Control groups of unsupplemented animals were used (C- and C+; see below).

By week 14 the extremely low FEC of all sheep provided strong evidence that numbers of infective nematode larvae (L3) on pasture were negligible. All sheep except those in group C- were therefore dosed orally with 6000 *T. colubriformis* L3 and 2000 *H. contortus* L3 (in 4 ml water) every fortnight from week 15 onwards. The C- sheep were treated orally with ivermectin in week 8 and again in week 21 (dose as indicated above), ensuring they remained essentially parasite-free throughout the study.

Animals were weighed at four-weekly intervals. Faecal samples were obtained from the rectum at the same time, for FEC and bulk (*i.e.* per paddock) larval cultures. All sheep were crutched in week 4 of the experiment. Greasy fleece weights were obtained at shearing at the end of the experiment. Dyebanded wool staples were used to estimate greasy wool production during the experimental period (weeks 1-28).

Analytical methods

A modified McMaster technique was used to estimate FEC. Sub-samples of faeces from sheep in each paddock were bulked and cultured for 7 days at 25 ½C to L3, after which trichostrongylid genera were identified.

Feed samples were analysed for dry matter (DM), organic matter (OM), and crude protein (CP). The dacron bag technique (Orskov *et al*., 1980) was used to determine DM and CP degradability of the supplements. Feed samples were incubated for 0, 4, 8, 16, 24, 48 and/or 72 h in the rumens of two mature fistulated steers, which were grazing pasture similar to that used in the main experiment. Losses of DM and CP were determined and effective degradability of CP calculated (after McDonald, 1981).

Mean fibre diameter of wool samples was estimated from 1000 fibres/sample using a Sirolan-Laserscan Fibre Diameter Analyser.

Statistical methods

Paddock means (mean for each measurement for sheep in each paddock) were used as the experimental units in the analyses of all data. Results were analysed by one-way analyses of variance. Two sub-periods within the experiment are considered separately, i.e. weeks 1 to 14 with 4 treatment groups (supplement effect; n=6 per treatment group) and weeks 15 to 28 with eight treatment groups (supplement type and duration effects; n=3 per treatment group). The FEC data required logarithmic transformation ($\log_{10}(\text{count} + 50)$) in order to stabilise variance within groups. Geometric group means were calculated.

RESULTS

Two sheep from group S28 died in weeks 27-28 from haemonchosis. Missing data for LW and FEC for these sheep at week 28 were estimated.

Supplement composition and intake

Drought conditions prevailed throughout the study (rainfall 220 mm and evaporation 570 mm from week 1-28), which resulted in low availability of pasture. To ensure animal survival lucerne hay was fed twice weekly from week 17 onwards (2 kg/sheep/week).

Supplement F contained 903 g DM/kg, 808 g OM/kg DM and 376 g CP/kg DM; values for supplements S and O and for lucerne hay were 900, 855, 241 and 910, 971, 82 and 909, 918, 159 respectively. Effective degradability of CP for F, S and O was estimated as 59%, 73% and 93% respectively (assuming a feeding level of 1.6 and associated rumen outflow rate of 4%/h; Agricultural and Food Research Council, 1993).

Intake of the supplements F, S and O was incomplete during the initial weeks of the experiment (see Fig. 1). Mean DM intake (g/day) was 76 (F), 126 (S) and 133 (O), providing an estimated 0.9, 1.2 and 1.6 MJ/day metabolisable energy (ME) and 29, 30 and 11 g CP/day respectively. Based on the effective CP degradation rates, supplements were estimated to have provided 12, 8 and 1 g/day of undegraded dietary protein (UDP) available for intestinal digestion and absorption respectively.

Animal performance

Sheep were essentially parasite free (see below) until the start of oral dosing with L3 at week 15. Cumulative LW gain (LWG) from weeks 1-14 for sheep given no supplement was 8.8 kg and for supplements F, S or O was 11.8, 10.3 and 10.1 kg respectively. Supplementation with F significantly increased LWG (see Fig. 2; $P<0.01$), but the effect of S and O on LWG was not significant ($P>0.05$).

FIGURE 1. Mean proportion of supplements F (○), S ( ) and O (□) which was consumed by young Merino sheep grazing improved pastures, during experimental weeks 1 to 8. Supplements offered to relevant groups between weeks 9 to 28 were completely eaten (data not shown in graph).

Cumulative LWG from weeks 15-28 in unsupplemented sheep was 0.9 kg for parasite-free animals (C-) and -1.2 kg for parasitised sheep (C+; P<0.05). Supplementation in the period prior to infection (F14, S14, O14) had no effect on cumulative LWG during infection, and was -1.7, -2.2 and -0.9 kg respectively, compared to -1.2 kg for infected controls (C+; P>0.05). Cumulative LWG from weeks 15-28 for sheep supplemented before as well as during the infection period (F28: 1.1 kg; S28: 0.6 kg; O28: 1.4 kg) did not differ from uninfected controls (C-: 0.9 kg; P>0.05), but was higher than for infected controls (C+: -1.2 kg; P<0.05). Cumulative LWG from weeks 15-28 did not differ significantly between groups F28, S28 and O28.

Greasy wool production over the 28 week period was not significantly affected by the parasite infection imposed during weeks 15-28 (Table 1). Supplementation with F28 and S28 increased greasy wool production from 7.4 g/d (C+) to 10.3 g/d (F28) and to 9.3 g/d (S28; P<0.001). Supplements F14, S14, O14 and O28 had no significant effect on greasy wool production. Mean fibre diameter was increased from 16.9 µ (C+) to 18.4, 18.6 and 18.6 µ (F14, F28 and S28 respectively; P<0.001). Supplements S14, O14 and O28 had no significant effect on fibre diameter.

FIGURE 2. Mean live weight change for young Merino sheep grazing improved pastures during weeks 14 to 28, as affected by supplementary feeding and parasite status (for details see text).

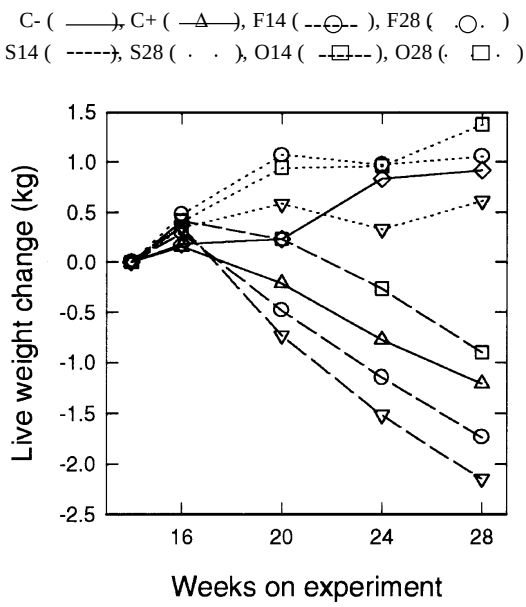
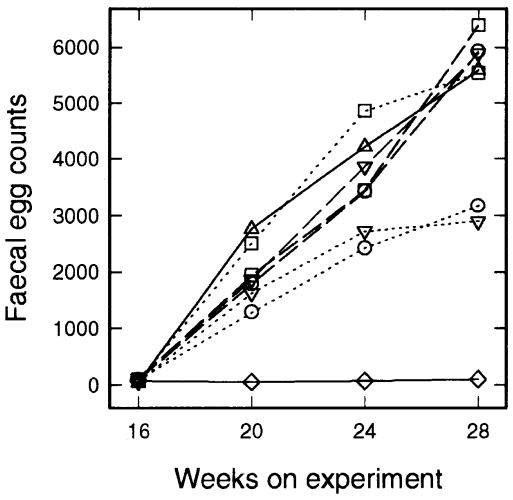


FIGURE 3. Geometric mean faecal egg counts for young Merino sheep grazing improved pastures during weeks 14 to 28, as affected by supplementary feeding and parasite status (for details see text; symbols as for Fig. 2).



Parasitology

Group means for FEC were below 120 epg during the first 16 weeks of the experiment and did not differ between groups (P>0.05). Mean FEC for groups F28 and S28 tended to be lower at week 20 (respective means 1300 and 1600 epg; see Fig. 3) and week 24 (means 2400 and 2700), than for groups C+, F14, S14, O14 and O28 (range 1800-2800 at week 20 and 3400-4900 at week 24 respectively), but the difference was not significant. In contrast, at week 28, mean FEC for groups F28 and S28 (range 2900-3200 epg) were significantly lower than for groups C+, F14, S14, O14 and O28 (range 5500-6400 epg; P<0.05).

During weeks 20-28, worm eggs being shed by the parasitised sheep were predominantly those of *H. contortus* (mean 63%) and *T. colubriformis* (mean 34%), with small proportions of eggs from the genera *Ostertagia* and *Oesophagostomum* (mean 2% and 1% respectively).

TABLE 1 Greasy wool production and mean fibre diameter of wool in grazing lambs, as affected by supplementary feeding and gastrointestinal parasitism.

	Treatment groups[1]								
Measurement	**C-**	**C+**	**F14**	**F28**	**S14**	**S28**	**O14**	**O28**	**S.E.M.**[2]
Greasy wool (g/d)	7.9^{ab}	7.4^{a}	8.9^{abc}	10.3^{c}	8.5^{ab}	9.3^{bc}	8.2^{ab}	8.3^{ab}	0.35
Fibre diameter[3] (microns)	16.7^{a}	16.9^{a}	18.4^{bc}	18.6^{c}	17.6^{abc}	18.6^{c}	17.2^{ab}	17.0^{a}	0.29

[1] C- and C+ refer to unsupplemented control sheep. F14, F28, S14, S28, O14 and O28 refer to supplements containing fish meal or sunflower meal or oat grain, fed from weeks 1 to 14 or from weeks 1 to 28. Sheep in all groups except C- were artificially infected with nematode larvae from week 15; sheep in group C- remained essentially worm-free (for details see text).

[2] Standard error of mean. Error degrees of freedom 16. Each mean is based on 3 plot observations with 10 sheep per plot.

[3] Mean fibre diameter of wool samples was estimated from 1000 wool snippets per sample using a Sirolan-Laserscan Fibre Diameter Analyser.

DISCUSSION

With the drought very few of the worm eggs deposited both before and during the experimental period appear to have developed into L3 on pasture. The low level of natural exposure of sheep to gastrointestinal nematodes was unplanned and in essence created two distinct experiments; during weeks 1-14 sheep were practically parasite-free while during weeks 15-28 artificial infection with L3 ensured sub-clinical to clinical levels of parasitism. During the "unparasitised" stage, mean LWG of unsupplemented sheep was 90 g/d, in spite of low pasture availability. Supplementation with F increased LWG by 34%, while S and O increased it by about 16%. As F provided least ME and most UDP, it appears that supply of metabolisable protein (MP) rather than ME was a major factor limiting animal performance. Reasons for differences in LWG responses between F and S may be due in part to differences in total UDP supply or amino acid composition of UDP and/or due to different effects on pasture intake. Lack of information on pasture intake does not permit estimation of total ME and MP supply, which hinders interpretation of the present results.

During the second half of the experiment, the effects of the dry weather conditions on pasture availability were reflected in a slow rate of LWG of unsupplemented parasite-free sheep (C-: 9 g/d) and in LW loss in unsupplemented infected sheep (C+: -12 g/d). Supplementation in the 14 weeks immediately prior to commencement of infection (F14, S14, O14) did not alleviate LW losses compared to C+ sheep. In contrast, supplementation of parasitised sheep over the term which included the infection period (F28, S28, O28) resulted in a slow rate of LWG (6 to 14 g/d) which was not significantly different from that of C- sheep. These results are in agreement with and extend findings from similar studies with pen-fed or grazing sheep (van Houtert *et al.*, 1995a,b).

Bown *et al.* (1991) showed that GI nematode infections induce a protein rather than an energy deficiency, and suggested that compensation may be more readily achieved with protein rather than energy supplementation. Earlier studies also highlighted the important role of protein supply in parasitised sheep (e.g. Downey *et al.*, 1972). However, in the present study supplementation with O28 was just as effective in overcoming the negative effect of parasitism on LWG as supplementation with F28 or S28, despite marked differences in ME and UDP supply from these supplements. The effects of these supplements on total supply of ME and MP to the host cannot be quantified without knowledge on amount and quality of pasture consumed. Nevertheless, the improvement in resilience obtained in the present study with oats as a low-protein supplement deserves further study, as grain-based supplements are considerably cheaper than supplements based on protein meals.

Mean FEC for groups F28 and S28 compared to other infected groups were reduced by about 35% at weeks 20 and 24 ($P>0.05$) and by 50% at week 28 ($P<0.05$). This suggests a reduction in worm establishment, an enhanced worm expulsion and/or reduced worm fecundity. Use of protein supplements for young sheep has been shown to reduce worm burden (i.e. number of worms per animal) and/or nematode fecundity (i.e. egg production per female), but to have little apparent effect on establishment of incoming parasites (i.e. proportion of L3 establishing and surviving to adulthood) (see Abbott *et al.*, 1988; Bown *et al.*, 1991; van Houtert *et al.*, 1995a,b). Effects of the different supplements on total nutrient intake and faecal output are unknown and thus changes in FEC due to dilution may have played a role. However, given the magnitude of the difference, particularly at week 28, it is unlikely that this factor would fully explain the observed change in FEC. Nevertheless, it is apparent that pasture intake and digestibility, and faecal output, need to be considered in future studies of this kind.

The negative effect of infection with nematode parasites on wool production is well documented (Barger, 1973; Barger & Southcott, 1975). In the present study, however, exposure to parasites during weeks 15-28 did not significantly affect cumulative wool production during weeks 1-28. This may be a consequence of inadequate sensitivity in measuring wool growth, as this was measured over weeks 1-28 rather than assessed separately for the parasite-free and the parasitised phases of the experiment.

It is concluded that the use of high and low protein supplements overcame production losses attributable to infection with nematodes in young grazing sheep. In contrast, use of the supplements in the months immediately prior to parasite infection was of no benefit to the host. While all three supplements enhanced resilience of the host to parasitism, FEC were reduced with high-protein supplements only and not with the low-protein supplement. Further studies are required to characterise parasitological responses to changes in ME and MP supply in young grazing sheep.

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