
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

The effect of protein supply on the periparturient parasite status of the mature ewe

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ABSTRACT

Thirty two twin - and thirty two single - bearing ewes (W = 50.6 ± 0.13 and 48.9 ± 0.11kg respectively) were individually penned indoors nine weeks before lambing. Four dietary groups, balanced for pregnancy status were established utilising a 2x2 design for energy (E) and protein (P) levels. These were E1P1; E1P2; E2P1; and E2P2 (groups 1 - 4 respectively) and were based on a lucerne hay and barley diet. E1 and E2 were designed to promote 0 and +50g/d gain in maternal bodyweight, respectively. P1 and P2 contained approximately 120 and 200gCP/kg DM, respectively, the difference achieved through the inclusion of fishmeal in P2 diets. From seven weeks prior to and until parturition all ewes were trickle infected with 10,000 *Teladorsagia circumcincta* and 7,000 *Trichostrongylus colubriformis* larvae per day. Faecal egg counts were determined weekly from five weeks prior to and until three weeks after parturition when worm burdens were determined.

Geometric mean faecal egg counts (epg) and worm burdens were 1610 and 145 epg and 12020 and 1540 worms, respectively, on low and high protein diets ($P<0.01$ in both cases) and 310 and 750 epg (NS) and 2290 and 8090 worms, respectively ($P<0.01$) in single compared to twin-bearing ewes. There was no effect of energy level.

The periparturient breakdown in resistance to parasitic infection thus appears to be counteracted by protein supplementation. Supplementation of the ewe may provide an alternative parasite control strategy by reducing pasture contamination and may have greatest effect in prolific flocks.

Keywords: Periparturient ewe; nutrition; immunity; gastro-intestinal parasitism.

INTRODUCTION

With the continued reporting of incidences of anthelmintic resistance (Overend *et al.*, 1994; McKenna, 1995) and growing concerns over chemical residues in sheep products, alternative approaches to gastro-intestinal parasite control deserve greater research emphasis. One approach may be to reduce the contamination of grazing areas used by naive young stock and thus reduce the level of infection encountered by these animals.

In late pregnancy and early lactation the mature ewe experiences a temporary loss of immunity to nematodes (Leyva *et al.*, 1982). This relaxation of acquired immunity probably involves a combination of loss of resistance to establishment of incoming larvae, failure to restrict development of larvae in terms of arrested development and fecundity and failure to expel existing infection (Barger, 1993).

The consequence is a periparturient rise in faecal egg counts (PPR). For this reason the periparturient ewe has been identified as the major contributor to pasture contamination to which naive lambs are subsequently exposed (Dunsmore, 1965; Familton, 1991).

The precise cause of the PPR remains unclear (Lloyd, 1983; Barger, 1993). Hormonal suppression, stress and lack of antigenic stimulation have all been investigated. To date results have been equivocal (Barger, 1993). Nutrition has also been implicated but not investigated systematically (Dunn, 1957). There is strong evidence that, in the growing animal, the development and maintenance of immunity to gastro-intestinal parasitism is affected by nutrition (Gibson, 1963) and in particular protein supply (Abbott *et al.*, 1985a,b; Bown *et al.*, 1991; van Houtert *et al.*, 1995). The nutrient requirements of the ewe are at their highest during the periparturient period and if immunity in the adult sheep is also nutrition dependent, the peri-partum period is the period of greatest susceptibility to nutrition-induced breakdown. The objective of this study was to determine whether nutrient supply in late pregnancy affects parasite status of ewes during the periparturient period.

MATERIALS & METHODS

A mob of one hundred Coopworth ewes (age range 3-6 years) were oestrus synchronised and mated. Nine weeks later they were pregnancy scanned and thirty-two twin bearing and thirty-two single bearing ewes (mean liveweight 50.6kg and 48.9kg, respectively) were selected for use in the trial. Animals in each group were then allocated to one of four dietary treatments, which were balanced for liveweight and body condition score, according to a 2x2 factorial design for dietary energy (E) and protein (P) levels. These were E1P1; E1P2; E2P1 and E2P2 (groups 1 - 4 respectively). Diets were based on lucerne hay and barley. E1 diets consisted of 70% lucerne hay and 30% barley, while E2 diets consisted of 30% lucerne hay and 70% barley. Diets E1 and E2 were fed at levels to promote 0 and +50g/d gain in maternal bodyweight, respectively, based on the recommendations of AFRC (1993). P1 and P2 diets contained 0 or 8% fishmeal to give approximately 120 and 200g CP/kg DM, respectively. The daily requirements of a 60kg ewe, averaged during the final seven weeks of gestation, are 10.8 and 12.9 MJ metabolisable energy (ME) (range 9.1-12.8MJ single; 10.1-16.3MJ twin) and 88 and 99g metabolisable protein (MP) (range 80-90g single; 85-115g twin) for single and twin bearing ewes, respectively, on a diet with an M/D (ME kg DM^{-1}) of around 11 (AFRC 1993). E1 diets supplied, on average, 10.7 and 12.9 and E2 diets 13.2 and 15.4 MJ ME/d, respectively, to single and twin bearing ewes, during the late pregnancy period. P1 diets supplied 94 and 113g and P2 diets 110 and 133g MP/d, respectively, to single and twin bearing ewes. During lactation E1 diets were designed to promote a liveweight loss of 100g/d and E2 to maintain liveweight. Requirements were based on the AFRC (1993) recommendations for lowland ewes with a milk yield of 2.0 and 3.0kg/d for single and twin litters, respectively. E1 diets supplied, on average, 19.3 and 28 MJ and E2 diets 23.6 and 32 MJ ME/d, respectively, to single and twin bearing ewes during early lactation. P1 diets supplied 170 and 248g and P2 diets 200 and 290g MP/d, respectively, to single and twin bearing ewes.

Nine weeks before parturition the ewes were treated with anthelmintic at the rate of 1ml/4kg bodyweight (Ivomec [0.08 w:v Ivermectin] MSDAgVet, New Zealand) and housed indoors in individual pens on slatted flooring. The nutritional treatments commenced at housing.

Ewe liveweight was recorded weekly from housing to parturition. Body condition score was recorded at housing and then at seven, four and one week before lambing. Ten days after housing the ewes were faecal sampled to assess parasite status and from seven weeks before lambing were trickle infected with 10,000 *Teladorsagia circumcincta* and 7,000 *Trichostrongylus colubriformis* larvae each day, on a three times a week basis. Trickle infection ceased at parturition. Faecal egg concentrations (FEC) were determined weekly from five weeks before and until three weeks after lambing using a modification of the McMaster method (M.A.F.F., 1979). All ewes were slaughtered 3 weeks after lambing. The abomasa and approximately 10 metres of small intestine, distal to the pylorus, were recovered, for determination of worm burden (Robertson and Elliot, 1966). In addition, abomasa were digested in acidified pepsin (Herlick, 1956) to recover immature larval stages of *T. circumcincta.*

Analysis of variance was carried out for data on changes in liveweight and body condition score and for faecal egg concentrations and worm burdens. Data for faecal egg concentrations and worm burdens were transformed before analysis by taking $\log_{10}$ (count + 1) to stabilise variance within groups.

RESULTS

Of the sixty four ewes in the trial, the pregnancy status of six was incorrectly diagnosed while five aborted in the latter stages of pregnancy. The ewes which had aborted returned positive results for toxoplasma latex agglutination test (Lincoln Animal Health Laboratory). These eleven ewes were excluded from the trial.

Liveweight

Mean liveweight gain from housing to parturition is given in Table 1. Pregnancy status, energy level and protein content of the diet all had a highly significant effect on liveweight gain (P<0.01 in all cases). Twin bearing ewes on average gained 5.2kg more weight than single bearers, ewes on the E2 diets gained 6.0kg more than those on the E1 diets and ewes on the P2 diets gained 2.4 kg more than those on the P1 diets. Interactions were not significant (P>0.05).

Body Condition Score

Mean body condition score decreased in all groups from nine until one week before lambing, with the exception of the single bearing ewes in group 4, where a slight increase of 0.2 of a condition score was observed (Table 1). Both energy and protein supply had highly significant effects on change in condition score (P<0.01). Body condition score decreased by 0.7 and 0.2 in E1 and E2 ewes and by 0.6 compared to 0.2 in P1 and P2 ewes, respectively. There was no effect of pregnancy status on body condition score change and there were no interactions (P>0.05).

Faecal egg concentrations

Faecal egg concentrations are presented in Figures 1a and 1b. Nematode eggs appeared in faeces from 28 days before lambing. Protein supply significantly suppressed faecal egg concentration from 21 days prior to parturition

TABLE 1: Mean liveweight & body condition score changes (± standard error) of single and twin bearing ewes from housing until parturition (9 weeks).

Group	Single bearing ewes (n)	Liveweight change (kg)	Body condition score change	Twin bearing ewes (n)	Liveweight change (kg)	Body condition score change
1 (E1P1)	(8)	10.1 ± 0.33	-1.0 ± 0.07	(6)	14.1 ± 0.44	-0.6 ± 0.09
2 (E1P2)	(7)	11.0 ± 0.37	-0.2 ± 0.08	(6)	15.8 ± 0.44	-0.8 ± 0.09
3 (E2P1)	(6)	14.7 ± 0.44	-0.3 ± 0.09	(6)	19.5 ± 0.44	-0.5 ± 0.09
4 (E2P2)	(8)	17.0 ± 0.33	+0.2 ± 0.07	(6)	24.0 ± 0.44	-0.1 ± 0.09

FIGURE 1A: Geometric mean (Log (FEC+1)) faecal egg concentration of single bearing ewes around parturition as affected by differential energy and protein supply.

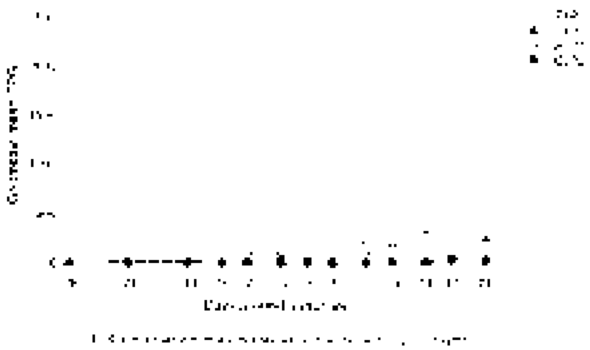
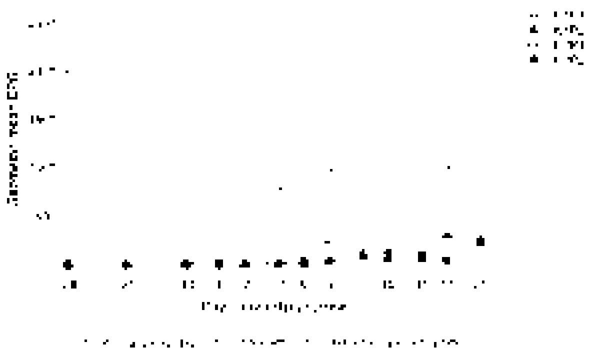


FIGURE 1B: Geometric mean (Log (FEC+1)) faecal egg concentration of twin bearing ewes around parturition as affected by differential energy and protein supply.



until the end of the study (P<0.05). From seven days before until 21 days after lambing this suppression was highly significant (P<0.01). Energy supply had only a short term effect on faecal egg concentration. Ewes on the E2 diets had a significantly lower faecal egg concentration than ewes on the E1 diets in the week before parturition (P<0.05). Faecal egg concentration in twin bearing ewes was significantly higher than in single bearing ewes from parturition until 14 days later (P<0.01).

Worm Burdens

Worm burdens are shown in Table 2. Mean worm burdens were 12,020 and 1,540 worms for ewes in groups P1 and P2, respectively (P<0.01). Pregnancy status also affected worm burden, with 2,290 and 8,090 worms being recovered from single and twin bearing ewes, respectively (P<0.01). There was no effect of energy supply (P>0.05). There were no immature worms found in the abomasa prior to digestion or in the small intestines. A small number of L4 *Teladorsagia* spp. were recovered after digestion of the abomasa (Table 2). Worm burdens consisted predominantly of adult *Teladorsagia* spp. with very low numbers of *Trichostrongylus* spp. in all groups, except in the twin bearing ewes offered the E2P1 diet which had a geometric mean count of over 3000 *Trichostrongylus* spp.

DISCUSSION

This work has clearly shown that the parasite status of the breeding ewe around parturition can be influenced by nutrition. Several studies have demonstrated the importance of nutrition, and in particular protein supply to the ruminant, in countering the pathophysiological damage of parasitic infection in the growing animal and also in enhancing an immune response (Dobson & Bawden 1974; Abbot *et al.,* 1985; Bown *et al.,* 1991; van Houtert *et al.,* 1995). The results obtained here extend these findings to the periparturient ewe and indicate the relative importance of protein over energy. This latter finding is in agreement with those of Bown et al ., (1991) who reported that post-ruminal infusion of casein had a greater impact in terms of reducing the debilitating effects of *T.colubriformis* infection in lambs than did infusion of an isoenergetic amount of glucose.

One of the well documented manifestations of resistance seen in ewes is the inhibition of development of certain species of nematode larvae, resulting in large numbers of immature 4th stage larvae (Jackson *et al.,* 1988). The low numbers of immature worms found in all treatment groups in the present study indicate that larval inhibition was not a feature of the apparent enhanced immune response resulting from protein supplementation.

Several workers have indicated that the periparturient breakdown of immunity is species specific (Brunsdon, 1970; O'Sullivan & Donald, 1973; Gibbs & Barger, 1986). In the present study worm counts were considerably lower

TABLE 2: Geometric mean (Log10 (count + 1) worm burdens (± standard error) of single and twin bearing ewes three weeks post partum

Group	Single bearing ewes			Twin bearing ewes		
	T.colubriformis	*T.circumcincta*		*T.colubriformis*	*T.circumcincta*	
	L5	L4	L5	L5	L4	L5
1 E1P1	172 ± 0.2	30 ± 0.1	6713 ± 0.1	288 ± 0.2	70 ± 0.1	11116 ± 0.1
2 E1P2	1 ± 0.2	8 ± 0.1	578 ± 0.1	7 ± 0.2	64 ± 0.1	3326 ± 0.1
3 E2P1	90 ± 0.2	18 ± 0.1	9225 ± 0.1	3051 ± 0.2	112 ± 0.1	13090 ± 0.1
4 E2P2	3 ± 0.2	11 ± 0.1	458 ± 0.1	140 ± 0.2	59 ± 0.1	3539 ± 0.1

in *T. colubriformis* than *T. circumcincta*. This may suggest that the relaxation of immunity to *Teladorsagia* infection was greater than to *Trichostrongylus* infection, which is in agreement with the findings of Jackson *et al.,* (1988).

This work clearly shows that the periparturient breakdown in resistance to parasitic infection can be susceptible to protein supply and by implication to the prolificacy of the ewe. This does not however, rule out involvement of other factors such as interaction between nutrition and the endocrine system.

It should be noted that to achieve this effect, metabolisable protein supply was well in excess of the requirements predicted by AFRC (1993). This might suggest that the conventional factorial approach of assessing nutrient requirements, for defined rates for growth, pregnancy, lactation etc. may need to include a component for the immune system.

The results would indicate that in the future there is the potential to reduce larval contamination of the grazing areas through careful consideration of nutrient supply of the breeding ewe. The need to look for solutions such as this will be particularly important in prolific flocks, not only because of the greater capacity of the ewe to contaminate pasture, but also because twin suckling lambs are likely to be exposed to infection at an earlier stage while receiving an inferior dietary protein supply than single suckled lambs.

ACKNOWLEDGEMENTS

We acknowledge the technical support provided by the staff of the Johnstone Memorial Laboratory, Lincoln University and also Robert Zyskowski, Lincoln University for computer programming. Thanks also to Helen Christie, University of Aberdeen, Scotland & Annet Velthuis, University of Wageningen, The Netherlands.

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