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Consequences of infection pressure and protein nutrition on periparturient resistance to *Teladorsagia circumcincta* and performance in ewes

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ABSTRACT

The consequences of protein nutrition on the degree of periparturient relaxation of immunity to nematode parasites in sheep may be more pronounced at higher levels of infection pressure. Here, we investigated interactive effects of metabolizable protein (MP) nutrition and infection pressure on resistance and lactational performance of ewes. Twin-rearing ewes were trickle infected with either 1000, 5000 or 10,000 infective *Teladorsagia circumcincta* larvae and fed either at 0.8 (low protein, LP) or 1.3 (high protein, HP) times their estimated MP requirement. Expected interactions between feeding treatment and infection pressure were not observed. Periparturient relaxation of immunity, as indicated by variation in faecal egg counts, was higher in LP ewes than in HP ewes and FEC showed an inverse relationship with infection pressure indicating possible density dependency effects on worm fecundity. Plasma pepsinogen concentration linearly increased with infection pressure. Daily total nematode egg excretion, assessed at week three of lactation, was not significantly affected by infection pressure but was reduced by 65% in HP ewes compared to LP ewes. MP supplementation improved lamb performance but had little effect on ewe body weight and plasma protein concentrations, whilst lactational performance, as judged from lamb performance, tended to be reduced with increased infection pressure. The results suggest periparturient MP supplementation to ewes reduces nematode egg excretion independent of infection pressure and improves lactational performance of parasitized ewes even in the presence of moderate MP scarcity.

1. Introduction

The periparturient relaxation of immunity (PPRI) to nematode parasites plays an important role in the epidemiology of gastrointestinal nematode infections in grazing sheep. It is characterized by an increase in nematode egg excretion from periparturient ewes onto the pasture, which can be a main source of infection for the immunologically naïve lambs (Heath and Michel, 1969). Therefore, controlling worm egg excretion from periparturient ewes should be included in any strategy aimed at a reduction of parasitism in young grazing lambs.

It has been postulated that the extent of PPRI has a nutritional basis (Coop and Kyriazakis, 1999), arising from a prioritized scarce metabolizable protein (MP) allocation to reproductive rather than to immune functions at times

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when MP demand for progressing gestation and subsequent lactation are increased. The extent of PPRI to gastrointestinal nematode parasites can be characterized by increased faecal egg count (FEC) and/or worm burden in periparturient ewes relative to non-reproducing counterparts (Barger, 1993), and can indeed be reduced by reducing MP scarcity, e.g. through increased MP supplementation (see Sykes and Kyriazakis, 2007 for a recent review) or reduced MP demand through a reduction in the reproductive effort (see Houdijk, 2008 for a recent review).

So far, single levels of trickle infections have been used to investigate the effects of MP supplementation on gastrointestinal parasitism in periparturient ewes (Donaldson et al., 2001; Houdijk et al., 2006, 2001a, 2003b). Effects of MP supply on PPRI may depend on the level of MP demand (Houdijk, 2008), and the latter may be sensitive to infection pressure, arising from the expected negative effects of nematode infection pressure on host performance (Sandberg et al., 2007). For instance, lambs trickle infected with increasing doses of *Trichostrongylus colubriformis* (Steel et al., 1980) and *Teladorsagia circumcincta* (Sykes and Coop, 1977; Symons and Jones, 1983) showed progressively reduced performance. Such effects on host performance may be seen at least to some extent as the outcome of an increased nutrient (MP) demand arising from an increased infection pressure and this could also be applicable to periparturient ewes.

The objective of this experiment was to investigate interactive effects of infection pressure and MP nutrition in periparturient ewes on their lactational performance and extent of PPRI. We hypothesized that increased infection pressure would reduce periparturient performance most pronouncedly at times of MP scarcity, and that the beneficial effects of MP supplementation on PPRI would be most clearly observed in ewes trickle infected with the highest dose of infective larvae. The latter would be consistent with the view that effects of MP supply on PPRI are more pronounced at higher levels of nutrient (MP) demand (Houdijk et al., 2001b).

2. Materials and methods

2.1. Animals and housing

Seventy-two, 4–5-year old Bluefaced Leicester × Scot-Scottish Blackface ewes (Mules), scanned for twin pregnancy, were used in this experiment. The ewes were recruited from the same flock, had similar genetic background and grazing history. The experiment lasted for approximately 11 weeks, i.e. from day_{-56} to day_{+24} (day_0 was mean parturition day). Ewes were group housed from day_{-56} until day_{-24}, and then individually housed until the end of the experiment, in pens sized 1.48 m × 1.88 m. The shed received natural illumination, and was well ventilated. Fresh saw dust was used as bedding and added daily. Fresh water was supplied *ad libitum* and water troughs were checked daily and cleaned as needed. The experimental details described below were approved by the Animal Experiment Committee of Scottish Agricultural College (ED AE 03/2007) and carried out under Home Office regulations (PPL 60/3782).

2.1.1. Feeding

Two feeding treatments ($n = 36$ each) were designed to supply 0.8 (LP) and 1.3 (HP) times the estimated MP requirement of the ewes during the periparturient period (see below). These were achieved by providing restricted access to two iso-energetic feeds offered to supply metabolizable energy (ME) at 0.9 times the estimated ME requirement of periparturient ewes. For the estimation of nutrient requirements during pregnancy, we assumed a litter birth weight of 10.3 kg, no maternal bodyweight gain (Houdijk et al., 2005) and 20.4 g MP/day for wool growth (Agricultural and Food Research Council, 1993). We assumed similar requirements for wool growth during lactation, maternal body weight loss of 100 g/day and milk yields of 3.3, 3.6 and 3.9 kg/day in the 1st, 2nd and 3rd weeks of lactation, respectively (Houdijk et al., 2003b). All MP and ME requirement estimates were based on the Agricultural and Food Research Council (1993) recommendations.

The experiment consisted of three periods: mid-pregnancy (day_{-56} to day_{-21}), late pregnancy (day_{-21} to day_0) and early lactation (day_0 to day_{+24}). The latter two periods were collectively termed the periparturient period (day_{-21} to day_{+24}). The mid-pregnancy period was an adaptation period to reduce body reserves and to introduce the different levels of infection pressure (see below). The LP and HP feeding treatments were applied during the periparturient period. The daily allowance consisted of a mixture of medium quality hay and concentrates. During mid-pregnancy, all ewes were given *ad libitum* hay and 250 g of a low protein pregnancy feed (see Table 1). In the periparturient period, ewes were fed a restricted amount the feeds based on individually estimated ME requirements. Table 1 presents the ingredients and chemical composition of all feeds. The high MP diet was achieved through substitution of part of the LP diet with soypass, which is rich in rumen undegradable digestible protein. Since the estimated ME content of soypass was similar to that of the LP feed, substitution on weight for weight basis was not expected to affect ME content. The quantity of mineral premix in the feeds was adjusted to achieve similar mineral concentrations in the HP and LP feeds.

2.1.2. Experimental infection

Because the ewes were 4–5 years old, they were expected to have considerable prior exposure to gastrointestinal nematodes and were treated at housing on day_{-56} with levamisole (Levacide, Norbrook, Newry, UK) and ivermectin (Oramec, Merial, Harlow, UK) at a rate of 7.5 and 0.2 mg/kg body weight, respectively, to clear any resident worms. They were kept indoors throughout the experiment. Within each feeding treatment, ewes were then randomly allocated to one of three infectious pressure groups, with similar mean starting body weight, body condition score, expected lambing date and initial faecal egg count. Ewes were trickle infected from day_{-42} until day_{+24} with 1000 ($n = 12$), 5000 ($n = 12$) or 10,000 ($n = 48$) infective larvae (L_3) of *T. circumcincta*. Each infective dose was suspended in water and administered using 10 ml syringes, three days a week (Monday, Wednesday and Friday) during the morning hours. The number of ewes per