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International Journal for Parasitology 35 (2005) 329–335

INTERNATIONAL Journal for PARASITOLOGY

www.parasitology-online.com

The consequences of short-term grazing of bioactive forages on established adult and incoming larvae populations of *Teladorsagia circumcincta* in lambs

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Received 8 October 2004; received in revised form 29 November 2004; accepted 29 November 2004

Abstract

The objective of this study was to investigate the consequences of short-term grazing on bioactive forages on (i) the viability and fecundity of established adult *Teladorsagia circumcincta* population and (ii) the establishment and development of incoming *T. circumcincta* infective larvae. Forty-eight, parasite naive, 3-month old, grazing lambs were artificially infected with 8000 infective larvae of *T. circumcincta* on day 1 of the experiment. On day 21 p.i., lambs were allocated to one of three bioactive forage grazing treatments; chicory (*Cichorium intybus*), sulla (*Hedysarum coronarium*), lotus (*Lotus pedunculatus*), and the control grass/clover (*Lolium perenne/Trifolium repens*) forage. On day 28 of the experiment a second dose of 8000 *T. circumcincta* infective larvae was administered to the lambs to investigate the effects of forages on the ability of infective larvae to establish within the host. All animals were slaughtered for worm recovery on day 35, while liveweight gain, feacal egg counts (FEC) and total worm egg output were monitored regularly throughout the experiment. Although FEC or total egg output were similar among the groups, adult worm burdens at slaughter were significantly affected ($P<0.05$) by forage treatment during the 2 week grazing period. Lambs grazing chicory had the lowest adult worm burdens and significantly lower numbers of male worms compared to those grazing on grass/clover ($P<0.01$), while the lambs grazing on sulla or lotus had similar adult populations to grass/clover fed animals. The results from the worm recoveries of the second dose (immature worm burdens) were affected by physiologically and/or immunologically mediated mechanisms, which reduced larval establishment in all treatments. Nevertheless, immature worm burdens at slaughter were similar between chicory, sulla and grass/clover group, while the immature worm recoveries from the lotus group were significantly higher ($P<0.05$) compared to those from lambs grazing grass/clover. Overall, the results of the present study support the view that chicory can be a promising candidate species in pasture management practices to control *T. circumcincta* burdens.

Keywords: *Teladorsagia circumcincta*; Sheep; Nematoda; *Cichorium intybus*; *Hedysarum coronarium*; *Lotus pedunculatus*

1. Introduction

The need for alternative, non chemical, control strategies in sheep production systems has increased in the last decade due to development of anthelmintic resistant strains of parasitic nematodes (Jackson and Coop, 2000). Proposed alternative approaches against gastrointestinal nematode infections include vaccination (Meeusen and Piedrafita, 2003), nematophagous fungi (Larsen, 1999), exploitation of genetic resistance of sheep, dietary supplementation of growing lambs and the use of bioactive forages (Waller and Thamsborg, 2004).

For *Teladorsagia circumcincta* infections, field studies have suggested that grazing sheep on certain bioactive forages can reduce their worm burdens compared to sheep grazing on conventional forages. Sheep grazing on chicory (*Cichorium intybus*) have reduced *T. circumcincta* burdens

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doi:10.1016/j.ijpara.2004.11.013

in mixed parasite infections (Scales et al., 1994; Marley et al., 2003b), while similar reductions have been observed in sheep given access to tanniferous legumes like sulla (*Hedysarum coronarium*) (Niezen et al., 1994, 2002), lotus (*Lotus pedunculatus)* (Niezen et al., 1998) and birdsfoot trefoil (*Lotus corniculatus)* (Marley et al., 2003b). The mode of action of these forages is not known, but it is suggested to be either a direct anthelmintic-like effect or an indirect effect as a consequence of nutritional effects upon immunity and/or resilience. In vitro studies using compounds extracted from chicory (Molan et al., 2003), lotus, sulla and sainfoin (*Onobrychis viciifolia*) (Molan et al., 2000a, 2000b, 2002) have demonstrated an anthelmintic like effect against immature stages of several nematode species (Cervine *Dictyocaulus* and *Ostertagia*; and Ovine *Haemonchus contortus*, *Trichostrongylus colubriformis* and *T. circumcincta*). To our knowledge, there is no report studying in vivo the bioactive forage effects on specific developmental stages of *T. circumcincta*. Such study could enhance knowledge of the mechanism of bioactive-forage action as well as suggest opportunities for optimum pasture management practices.

This study used a short-term grazing trial and artificially infected growing lambs to examine the effects of selected bioactive forages on (i) the viability and fecundity of adult *T. circumcincta* already established in the lamb abomasum and (ii) the ability of incoming L3 *T. circumcincta* larvae to establish and develop within the host. The bioactive forages used, were *C. intybus* (chicory), *L. pedunculatus* (lotus; greater lotus), *O. viciifolia* (sainfoin) and *H. coronarium* (sulla).

2. Materials and methods

2.1. Experimental plots

In spring 2001, 10 experimental plots of 0.1 ha each were established on fields that had never previously been used for grazing livestock (parasite free pastures). Replicate plots of 0.1 ha were sown as monocultures using the following rates: *C. intybus* (chicory) 7 kg/ha, *H. coronarium* (sulla) 15 kg/ha, *O. viciifolia* (sainfoin) 50 kg/ha, *L. pedunculatus* (lotus) 12.5 kg/ha and *Lolium perenne/Trifolium repens* (grass/clover) 37 kg/ha. The grass/clover plots were the control treatment against which all other plots were compared. Nitrogen fertiliser (Yara UK Ltd; $N<50$ kg/ha) was applied to all experimental plots in late August 2001, while in October 2001 all forages were topped to over-winter. In April 2002, all species started to re-grow, with the exception of sulla, which had to be re-sown. In July 2002, nitrogen fertiliser and a phosphorus-potassium mix (Yara UK Ltd; 100 kg/ha) were applied, following soil analysis. All swards were in the vegetative stage of growth throughout the experiment. No herbicides were used throughout the pre- and experimental period.

2.2. Animals

Thirty-one female and 29 castrated male Texel × Scottish Greyface lambs were used. They were reared outdoors until 3 months of age (from April to July 2002), on grass pastures that had been grazed by cattle for more than a year. Prior to weaning, lambs were treated orally with levamisole (Levacide 3% drench; Norbrook Laboratories Ltd, UK; 7.5 mg/kg liveweight). All lambs were also treated with ivermectin (Oramec drench, Merial Animal Health Ltd; 0.2 mg/kg liveweight), following weaning, at 10 weeks of age (10th of July) and moved to clean grass/clover pasture until the start of the experiment (23rd of July).

2.3. Parasites

The infective larvae used were of a strain of *T. circumcincta*, which has been maintained at the Moredun Research Institute for 5 years. Larvae were harvested from faeces of a monospecifically infected donor sheep using a standard Baerman procedure. Following harvesting, larvae (L3) were stored at 4 °C in tap water (1000 L3/ml) and used within 3 weeks of collection.

2.4. Experimental design

On day 1 of the experiment, all lambs were infected with a single dose of 8000 L3 *T. circumcincta*, weighed and faecal sampled. The larval dose (8000 L3) was based on the recommendations of the World Association of the Advancement of Veterinary Parasitology for the size of infection to evaluate the efficacy of anthelmintics (Wood et al., 1995). From days 1 to 21 lambs remained on the parasite-free grass/clover pastures. On day 21, they were allocated to one of the five treatment groups (12 animals per forage) based on both their liveweight and faecal egg counts on day 14 (mean ± SEM: 33.5 ± 0.66 kg and 16 ± 7 eggs/g, respectively). On day 28, a second single dose of 8000 L3 *T. circumcincta* was administered to the animals to investigate the effects of the bioactive forages on the establishment of infective L3. The animals remained on the experimental plots until day 35, when they were slaughtered for worm recovery (26 August 2002).

2.5. Agronomic measurements

Pre-grazing sward composition of the experimental plots was estimated by taking 20 randomised sward cuts from each plot (0.1 ha) on day 21 of the trial, using a herbage-gripping device (Barthram et al., 2000). The cut material from each plot was placed in nylon bags in the field and was later separated manually to the following fractions: the sown species of the plot, dead material and ‘other’ species. Each component was separately weighed, oven-dried (100 °C for 18 h) and re-weighed. Sown species representation in the plot was calculated as the dry matter (DM) percentage of