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Effects of heather (Ericaceae) supplementation on gastrointestinal nematodes and live weight changes in naturally-infected Cashmere goats managed under two different stocking rates

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Abstract. The aim of this study, performed on 62 adult dry Cashmere goats grazing perennial ryegrass-white clover pastures and naturally-infected with gastrointestinal nematodes, was to investigate the effects of tannin-containing heather supplementation on faecal egg counts, parasite burden and body weight changes in goats managed under two different stocking rates. Goats were randomly assigned to four treatments in a 2 × 2 factorial arrangement: two feeding treatments (supplementation with heather *vs* non-supplementation) and two stocking rates (24 *vs* 38 goats/ha). Six goats per treatment were slaughtered at the end of the grazing period, with adult worms in the abomasum and small and large intestines of each animal recovered, counted, and identified according to species. Results showed that goats gained significantly (P < 0.001) more body weight when supplemented with heather. Faecal egg counts were significantly (P < 0.01) affected by stocking rate, however for heather supplementation, no differences were observed in goats under the lower stocking rate, but lower mean values were found throughout the experiment in the group receiving heather under the higher stocking rate (P = 0.07). Mean total abomasal worm counts of *Teladorsagia circumcincta* were lower in supplemented animals, but the difference was only significant (P < 0.01) in those managed under the higher stocking rate. In conclusion, although feeding heather to goats has the potential to contribute to the control of some abomasal nematode parasites, it could be dependent on grazing pressure and climatic conditions.

Keywords. Heather – Goat – Tannin – Gastrointestinal nematode – Live weight.

Effets de la supplémentation de bruyère Ericaceae sur les nématodes gastro-intestinaux et les variations du poids vif de chèvres Cachemire naturellement infestées et conduites sous deux charges animales différentes

Résumé. *L'objectif de cette étude, réalisée sur 62 chèvres Cachemire adultes, ayant accès à des pâturages semés avec ryegrass et trèfle et infestées naturellement par des nématodes gastro-intestinaux, était de rechercher les effets de la supplémentation avec des tanins, contenus dans la bruyère, sur le nombre d'œufs fécaux, les charges parasitaires et les changements de poids corporel chez des chèvres gardées sous deux chargements/ha différents. Les résultats ont montré un meilleur gain de poids (P < 0,001) quand les chèvres étaient supplémentées par la bruyère. Le dénombrement fécal des œufs était significativement plus élevé chez les lots pâturant en forte densité (P < 0,01). Dans le cas de la variable supplémentation par la bruyère, aucune différence n'a été observée chez les chèvres du lot à faible densité. Cependant, dans le lot à fort chargement, la valeur moyenne d'excrétion fécale des œufs était moins élevée pour les chèvres recevant de la bruyère (P = 0,07). Les animaux supplémentés en bruyère avaient aussi moins de vers abomasaux de l'espèce* Teladorsagia circumcincta*, mais ces différences étaient seulement significatives (P < 0,01) dans le lot à forte densité. En conclusion, même si la supplémentation avec de la bruyère peut contribuer au contrôle des nématodes abomasaux, le climat et la pression de pâturage sont des variables plus déterminantes affectant l'épidémiologie des infestations.*

Mots-clés. *Bruyère – Chèvres – Tanins – Nématode gastro-intestinal – Poids vivant.*

I – Introduction

Conventional methods of controlling gastrointestinal nematode (GIN) infections of grazing ruminants have been through the use of anthelmintic drugs. However, the resistance of nematode populations to all the major groups of broad-spectrum anthelmintics throughout the world and the increasing demand by consumers for "green" livestock products have prompted the investigation of alternative non-chemical control methods (Waller, 2006). In the last few years, a number of reports have been published on the anthelmintic effects of tannin-rich plants and forages on GIN infections in small ruminants (Hoste *et al.*, 2006). In naturally-infected goats, these studies showed a decrease in the establishment of third-stage nematode larvae or reductions in worm fertility and egg output when a moderate concentration of tannin-rich plants were consumed (Hoste *et al.*, 2006; Shaik *et al.*, 2006; Osoro *et al.*, 2007a,b). It is generally accepted that increasing stocking rate in ruminant livestock systems must be accompanied by providing more feed to the animals for them to remain productive, and that increasing stocking rate leads to increasing levels of parasitism in grazing livestock (Le Jambre, 1984; Thamsborg *et al.*, 1996). The objective of the current study was to investigate the interactions between the stocking rate and heather supplementation on egg output and adult stages of GIN, and live weight and body condition in Cashmere goats grazing perennial ryegrass-white clover pastures.

II – Materials and methods

1. Experimental site and design

The study was carried out in a mountainous area in northwest Spain (Sierra de San Isidro, Illano, Asturias), where shrubby heather-gorse vegetation is dominant (mainly composed by *Calluna vulgaris* and *Erica umbellata*). Four plots of 5000 m^2 each were established since 2001, in which the vegetation had been improved by sowing perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*), and removing any heather that was present. A total of 62 adult non-lactating Cashmere goats were balanced by live weight (LW) and body condition and randomly assigned to one of four treatment groups in a 2×2 factorial arrangement. The main treatments were two stocking rates (24 *vs* 38 goats/ha) and two feeding treatments (supplementation with heather *vs* non-supplementation). Supplemented groups were offered freshly cut heather *ad libitum*, every 3 days, in the morning. Two weeks before the experiment started, all goats were dosed orally with ivermectin. All goats grazed continuously throughout the entire trial which was conducted between 6th May and 21st October, 2005.

2. Sampling procedures and analysis

In order to control grass availability, sward surface height was measured weekly using a HFRO swardstick (Barthram, 1986), taking 100 measurements at random in each plot. Heather offered to the supplemented goats was analyzed in June, August and September for total tannins by measuring total phenols by Folin-Ciocalteu reagent before and after treatment with polyvinylpolypyrrolidone, as described by Makkar *et al.* (1993). All goats were weighed at the beginning and at the end of the experiment and also at monthly intervals. At the same time, the body condition score (BCS) was assessed (Russel, 1990). Grazing season was divided into 2 periods: Period 1 from May 6 to August 19 (higher sward availability) and Period 2 from August 19 to October 21 (lower sward availability). Individual faecal samples were collected monthly, directly from the rectum to perform faecal egg counts (FEC) by a modified McMaster procedure (MAFF, 1978). Faecal cultures were prepared monthly of pooled samples from each treatment group to allow identification of third-stage nematode larvae genera. At the end of the trial, six goats from each treatment were slaughtered and adult worms recovered from the abomasum and intestines. Gastrointestinal nematodes were then counted and identified according to species and sex. Fertility per female worm of *Teladorsagia circumcincta* and *Trichostrongylus* spp. was determined by direct counting of the eggs *in utero* after clearing of each female worm with lactophenol. Counts were performed on at least 20 female worms per goat. Data of goat LW and BCS changes, and FEC (data transformed to $\log_{10}$ x + 1) and GIN measurements were subjected to a factorial analysis of variance (ANOVA) to evaluate the effects of the two main factors, stocking rate and heather supplementation and their interaction, in a completely randomized design. Sward height and log transformed FEC data were also analysed by repeated measures of ANOVA using plot means to examine the within-subject effects of sampling data and the between-subject effects of heather supplementation or stocking rate independently.

III – Results and discussion

1. Pasture and heather

Sward height achieved maximum values in June and decreased later, mainly from June to August, but it was maintained during the Period 2 (Fig. 1). Significant differences ($P < 0.05$) in the mean sward height across the grazing season were observed between lower and higher stocking rates (11.2 and 9.2 cm, respectively). No significant differences in sward height as consequence of heather supplementation were observed. Tannin content showed a mean value of 7.7 ± 1.20 (in g tannic acid equivalents/100 g DM).

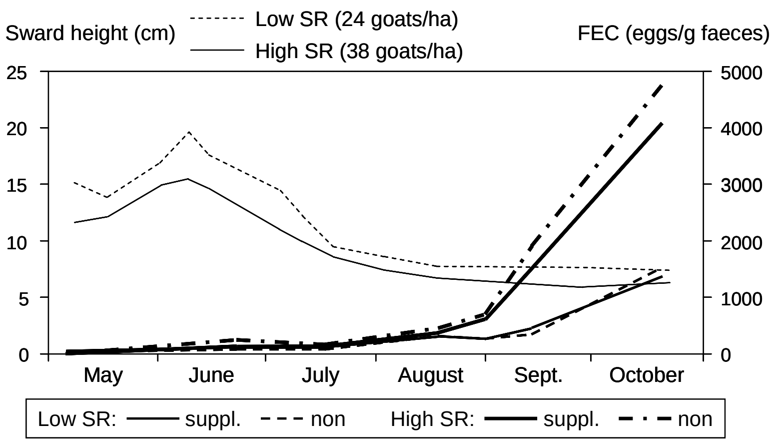

Fig. 1. Mean sward height and faecal gastrointestinal nematode egg counts (FEC) during the experimental grazing period in goats grazing perennial ryegrass/white clover pastures, under different stocking rates (24 *vs* 38 goats/ha) and heather supplementation (supplemented *vs* non-supplemented).

2. Faecal egg counts and coprocultures

The FECs increased in all goats over the grazing season (Fig. 1). In September and October, the animals from plots with 38 goats/ha had significant ($P < 0.01$) higher mean FECs than those on lower stocking rate. Although lower mean FECs were detected in goats supplemented with heather in September and October samplings, especially in plots with higher stocking rate, the differences were not significant. No significant interaction was found between stocking rate and heather supplementation. GIN genera, identified on third-stage larvae obtained from coprocultures, were *Teladorsagia*, *Trichostrongylus* and *Chabertia*. *Teladorsagia* was most frequently identified in June and July (60-93%) in the four plots, decreasing sharply thereafter. In contrast, *Trichostrongylus* was predominant from August to October (33-100%). *Chabertia* was detected in all plots but in lower percentage (0-31%), except in August sampling from goats non-supplemented with heather under higher stocking rate (52%). The FEC kinetics over the grazing season and GIN genera identified in coprocultures were in accordance with previous epidemiological data obtained in the same goat research farm (Osoro *et al.*, 2007b). The significant stocking rate effect on FEC confirmed previous results obtained in Angora goats naturally infected with *Te. circumcincta* and *Haemonchus contortus* (Le Jambre, 1984) and in grazing sheep (Thamsborg *et al.*, 1996). Although not overall significant, there was a strong trend towards lower mean FEC in goats supplemented with heather (P = 0.07). It was in accordance with our previous results (Osoro *et al.*, 2007a,b). The lack of significance could be due to the lower infection pressure when compared to previous grazing seasons and probably caused by an anomalous dry year. Reductions in FEC have been reported in goats naturally infected by GIN and fed with other tannin-rich plants (Hoste *et al*., 2006; Shaik *et al*., 2006).

3. Adult nematode burden

Table 1 shows the mean adult worm burden in abomasum and small intestine, and fecundity *in utero* of female nematodes. Identified GIN species were *Te. circumcincta* and *Trichostrongylus axei* in the abomasum, *Trichostrongylus colubriformis* and *Trichostrongylus vitrinus* in the small intestine, and *Chabertia ovina*, *Oesophagostomum columbianum* and *Trichuris ovis* in the large intestine. In general, mean total worm counts were higher in animals from plots with 38 goats/ha. The differences were only significant (P < 0.01) small intestine worm counts. Mean *Te. circumcincta* counts were significantly (P < 0.01) lower in goats supplemented with heather than in non-supplemented goats from plots with 38 animals/ha, and similar to those recorded in goats from plots with 24 animals/ha. Mean *T. axei* counts in goats from plots with 38 animals/ha were significantly (P < 0.01) higher when compared to goats under lower stocking rate. Although *T. colubriformis* and *T. vitrinus* were identified in the small intestine on the basis of male identification, results are shown together. No significant differences were found between treatments for large intestine worm counts (data not shown). The female worm fertility was significantly (P < 0.01) lower for *Trichostrongylus* spp. in goats under higher stocking rate. In contrast, fertility of *Te. circumcincta* was lower in worms from goats under lower stocking rate, but significantly (P < 0.01) higher in goats supplemented with heather from plots with 38 animals/ha.

Table 1. Mean worm burden, and fecundity *in utero* of abomasal and small intestine nematodes in goats under different stocking rates and with or without heather supplementation

Stocking rate	Lower (24 goats/ha)		Higher (38 goats/ha)	
Heather supplementation	Yes	No	Yes	No
Abomasum (total)	3476[a]	4477[a,b]	3693[a]	6998[b]
Teladorsagia circumcincta				
Worm burden	3172[a]	4129[a,b]	3099[a]	6209[b]
Fecundity *in utero*	5.6[a]	6.6[a]	9.5[b]	7.7[a]
Trichostrongylus axei				
Worm burden	304[a]	348[a]	594[b]	789[b]
Fecundity *in utero*	13.1[a]	15.4[a]	9.4[b]	10.0[b]
Small intestine (total)	7077[a]	7671[a]	24592[b]	24733[b]
Trichostrongylus spp.				
Worm burden	7077[a]	7671[a]	24592[b]	24733[b]
Fecundity *in utero*	14.8[a]	18.8[a]	9.6[b]	11.2[b]

[a,b]Mean followed by different superscripts in the same row are significantly different (P < 0.01).

Our results showed a significant effect of stocking rate on *Trichostrongylus* but not on *Teladorsagia* worm burdens. This is in accordance with observations of Thamsborg *et al*. (1996). Heather supplementation reduced *Te. circumcincta* worm burden, but this effect was only significant in goats under high stocking rate. It is also noteworthy that fecundity *in utero* and length (data not shown) of *Te. circumcincta* females in heather supplemented goats were higher than that observed in non-supplemented animals, probably indicating a long term established population. Thus, heather could affect the development of the incoming third-stage *Te. circumcincta* larvae. When goats received condensed tannins before being infected with third-stage larvae of *Te. circumcincta*, reductions of 70% in *Te. circumcincta* worm numbers have been described (Paolini *et al*., 2003).

4. Live weight and body condition changes

The effect of stocking rate on LW changes was significant (P < 0.001) in Period 2 of the grazing season (Table 2). The goats under lower stocking rate gained 7 g/day more in Period 1 and lost 46 g/day less in Period 2 when compared with those under higher stocking rate. Heather supplementation also significantly affected LW changes in Period 1 (P < 0.05) and Period 2 (P < 0.01) of the grazing season. Goats receiving heather supplementation in Period 1 gained 17 g/day more and lost 21 g/day less in Period 2 than those animals not receiving heather. For the overall grazing season, LW changes were significantly (P < 0.001) affected by stocking rate and heather supplementation. Goats under lower stocking rate gained 30 g/day while those under higher stocking rate only gained 8 g/day. Likewise, goats supplemented with heather increased their weight 28 g/day while those non-supplemented goats gained 11 g/day. Body condition was significantly (P < 0.001) affected by the stocking rate in a similar way as described for LW changes, but heather supplementation did not affect BCS changes significantly.

Table 2. Effects of stocking rate and heather supplementation on goat live weight (LW) and body condition score (BCS) changes during the grazing season

Stocking rate (SR)	Lower (24 goats/ha)		Higher (38 goats/ha)		Significance		
Heather supplementation (H)	Yes	No	Yes	No	SEM	SR	H
LW changes (g/day)							
Period 1†	95	68	78	72	3.3	ns	*
Period 2†	–51	–61	–86	–117	4.6	***	**
Overall†	40	20	15	2	2.8	***	***
BCS changes (units)							
Period 1†	0.3	0.3	0.2	0.3	0.03	ns	ns
Period 2†	0.1	0.0	–0.5	–0.5	0.38	***	ns
Overall†	0.4	0.3	–0.3	–0.2	0.45	***	ns

†Period 1 = 6/5-19/8. Period 2 = 19/8-21/10. Overall = 6/5-21/10.
*P < 0.05; **P < 0.01; ***P < 0.001.

IV – Conclusions

Our results demonstrate that increasing the stocking rate may lead to greater exposure and establishment of gastrointestinal nematode infections in grazing goats. Although feeding heather to goats has the potential to contribute to the control of some abomasal nematode parasites, it could be dependent on grazing pressure and climatic conditions.

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