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Potential use of heather to control gastrointestinal nematodes in goats☆

J. Moreno-Gonzalo[a], I. Ferre[a,*], R. Celaya[b], P. Frutos[c], L.M.M. Ferreira[d], G. Hervás[c], U. García[b], L.M. Ortega-Mora[a], K. Osoro[b]

[a] *Grupo SALUVET, Departamento de Sanidad Animal, Facultad de Veterinaria, Universidad Complutense de Madrid, Ciudad Universitaria s/n, 28040 Madrid, Spain*
[b] *Servicio Regional de Investigación y Desarrollo Agroalimentario (SERIDA), Área de Sistemas de Producción Animal, Consejería de Medio Rural y Pesca, Principado de Asturias, 33300 Villaviciosa, Spain*
[c] *Instituto de Ganadería de Montaña, CSIC-ULE, Finca Marzanas, 24346 Grulleros (León), Spain*
[d] *CECAV, Departamento de Zootecnia, Universidade de Trás-os-Montes e Alto Douro, PO Box 1013, 5000-911 Vila Real, Portugal*

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ABSTRACT

In the last decade, numerous studies have been carried out to evaluate the potential anthelmintic benefit of the consumption of bioactive plants in small ruminants, in order to reduce the dependence on conventional chemotherapy and supporting a sustainable control of gastrointestinal (GI) parasitism. This review summarizes the anthelmintic and nutritional effects of heather (shrub species belonging to the Ericaceae family, such as *Erica* spp. or *Calluna vulgaris*) supplementation in grazing goats naturally infected by GI nematodes. The experiments were carried out in a mountain area in north-western Spain where shrubby heather-gorse vegetation is dominant. Some plots were established, in which the vegetation had been improved by soil ploughed and dressing and sowing perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*), and removing any heather that was present. Cashmere goats reared outdoors under pasture conditions were used in the experiments. The trials compared the response to GI nematode infections, animal performance and nutrition in goats supplemented or not with heather. Interactions between heather availability and other alternative methods to control GI nematode infections based on grazing management (stocking rate) or nutrition (energy supply) as well as the potential adaptation of the rumen microbiota to the consumption of tannins, were also studied. The results suggest that (i) heather supplementation in grazing goats significantly reduces the level of GI nematode egg excretion, (ii) the faecal nematode egg count reduction could be associated with a decrease in worm fertility and/or reduction in the establishment of incoming third-stage larvae, (iii) consumption of heather is associated with an apparent greater resilience of goats to GI nematode infections, and (iv) the amount of tannins consumed by the goats supplemented with heather does not seem to be associated to anti-nutritional effects which eventually resulted in a better animal performance in the animals incorporating these shrubs in their diet. Practical application of this knowledge in temperate areas would support the management of plots integrating improved pastures with high nutritive value (ryegrass-white clover) with natural vegetation communities.

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* Corresponding author. Tel.: +34 913944094; fax: +34 913943908.
E-mail address: iferrepe@vet.ucm.es (I. Ferre).

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1. Promising use of plants as nutraceuticals in goats

Grazing small ruminants are commonly parasitized by gastrointestinal (GI) trichostrongyle nematodes (suborder Trichostrongylina) worldwide. In goats at pasture, GI nematodes infection reduces the efficiency of production by decreasing voluntary feed intake, live weight gain, milk yield, and carcass quality. In addition, they have a detrimental effect on the general welfare of the infected animals (Coop and Kyriazakis, 2001; Hoste et al., 2005b). To control these parasitic infections, the repeated administration of broad-spectrum anthelmintic drugs integrated, where practical, with grazing and management strategies, is the conventional method. However, the intensive chemoprophylaxis with anthelmintic drugs has led to a widespread development of anthelmintic-resistant populations of parasitic nematodes, particularly in sheep and goats, in both northern and southern hemispheres (Kaplan, 2004). Furthermore, there is an increasing public concern over drug residues in meat and milk products, and a potential risk for environmental contamination (Waller and Thamsborg, 2004). Anthelmintics may be also unavailable in developing countries due to their high cost. For these reasons, non-chemical strategies for the control of GI nematode parasites are being investigated (Ketzis et al., 2006; Stear et al., 2007). In small ruminants, alternative approaches for control of GI nematode infections include grazing management, biological control using nematode-destroying fungi, nutritional supplementation, development of vaccines, utilization of genetic resistance, and feeding or grazing plants containing bioactive compounds. For a rationale use of these novel approaches, Stear et al. (2007) suggest that no method could be recommended excluding all others, and that the combination of methods would be the optimal strategy.

Host nutrition can directly affect GI nematodes through the ingestion of plant compounds or nutrients that may penalize parasite fitness or alter the gut (nutritional) environment in which the parasites reside (Hoste et al., 2005b, 2008). Recent *in vivo* and *in vitro* studies, showed that bioactive plants containing secondary metabolites, such as tannins, sesquiterpene lactones and flavonol glycosides, are a promising option for use in integrated nematode control in farm production systems (Brunet et al., 2008a,b; Hoste et al., 2006; Terrill et al., 2007, 2009). These plants with anthelmintic properties, known as nutraceuticals, are considered for their beneficial effects on health rather than for their direct nutritional value. The supplementation with bioactive plants in goats can enhance their ability to regulate the biology of parasite worm population (resistance) as well as their ability to withstand the negative pathophysiological effects of nematode infections (resilience) (Hoste et al., 2005b).

Condensed tannins (CT) or proanthocyanidins, polymers of flavonoid units (flavan-3-ols, flavan-3,4 diol), have been associated to ruminant nutrition benefits by increasing post-ruminal protein availability and thus reducing the consequences of GI nematode parasitism (Waghorn, 2008). Most studies on the anthelmintic properties of CT, either in experimentally or naturally infected sheep, show a reduction in nematode burdens, worm female fecundity and faecal egg count (FEC) when a moderate concentration of CT are consumed and could, therefore, contribute to modulate the epidemiology of these parasitic diseases (Hoste et al., 2006). Recently, the number of reports showing the anthelmintic effect of CT rich plants on goats, naturally and experimentally infected by GI nematodes, has increased. As previously described for sheep, a reduction in egg excretion and in fecundity of the female worms have been reported in goats fed bioactive plants such as sainfoin (*Onobrychis viciifolia*, Hoste et al., 2005a; Paolini et al., 2003b, 2005b), sericea lespedeza (*Lespedeza cuneata*, Min et al., 2004, 2005; Moore et al., 2008; Shaik et al., 2006; Terrill et al., 2007, 2009), sulla (*Hedysarum coronarium*, Pomroy and Adlington, 2006), and *Viscum verrocosum* (Madibela and Jansen, 2003). These results were obtained in trials where goats were naturally or experimentally infected by GI nematodes, but under controlled conditions. However, data from grazing goats fed on tanniferous plants and naturally infected with a mixed GI nematode burden are scarce in the literature (Kabasa et al., 2000; Min et al., 2004, 2005; Moore et al., 2008). The feeding behavioural differences between sheep (mainly grazer) and goats (mainly browser), and various physiological and metabolic adaptations of goat favouring the consumption of nutritional sources rich in potentially toxic metabolites, such as CT, indicate that goats are better adapted to exploit secondary compounds rich range vegetation (Cheeke and Palo, 1995; Hoste et al., 2005b). Furthermore, the efficacy required for novel control methods, such as CT, not only should be shown in controlled laboratory studies, but also a confirmation in farm-based trials showing a reliable economic benefit is needed (Ketzis et al., 2006).

2. Studies on heather supplementation in grazing goats

Heather-gorse communities are frequent in the botanical composition of natural vegetation in mountain communities of humid temperate areas such as northern Spain. Heather includes shrub species belonging to the Ericaceae family, such as *Erica* spp. or *Calluna vulgaris*, with a relatively high content of CT but low nutritive quality (Frutos et al., 2002). Goats are able to include high proportions of heather in their diets, browsing on heathlands even with high pasture availability (Celaya et al., 2007). Osoro et al. (2007b) showed the limitation of these shrub species located in marginal lands with poor soils to develop sustainable ruminant production systems. However, the availability of these shrub species, together with areas of improved grass-legume pastures, could be an effective tool to achieve the sustainability of ruminant production systems and animal welfare in these marginal mountain areas (Celaya et al., 2008).

Recently, a number of studies have been conducted to investigate the anthelmintic and nutritional effect of heather supplementation in naturally infected grazing goats by GI nematodes (Table 1). Although Bahuaud et al. (2006) studied the effect of tannin extracts from *Erica erigena* on the exsheatment of third-stage infective larvae of *Haemonchus contortus* and *Trichostrongylus colubriformis*, to our knowledge, the anthelmintic activity of heather in goats was not addressed by other research teams.