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RESEARCH PAPER

## Finishing lambs on a chicory-plantain mixture or a temperate grass-based pasture: live weight gain and gastrointestinal parasitism

Daniel Alomar<sup>1</sup>, Paula Ruiz<sup>2</sup>, Oscar Balocchi<sup>1</sup>, Gastón Valenzuela<sup>3</sup>, and Daneska Goic<sup>1</sup>

<sup>1</sup>Universidad Austral de Chile, Facultad de Ciencias Agrarias, Instituto Producción Animal. Valdivia, 5090000, Chile.

<sup>2</sup>Universidad Austral de Chile, Facultad de Ciencias Agrarias, Escuela de Graduados. Valdivia, 5090000, Chile

<sup>3</sup>Universidad Católica de Temuco, Facultad de Recursos Naturales, Unidad de Parasitología. Temuco, 4780000, Chile

### Abstract

**D. Alomar, P. Ruiz, O. Balocchi, G. Valenzuela, and D. Goic. 2018. Finishing lambs on a chicory-plantain mixture or a temperate grass-based pasture: live weight gain and gastrointestinal parasitism. Cien. Inv. Agr. 45(1): 11-20.** Improved plantain (*Plantago lanceolata* L.) and chicory (*Cichorium intybus* L.) are attractive forage species for finishing lambs and contain compounds that might protect sheep from gastrointestinal nematodes. This study compared the live weight gain and parasite burden of weaned lambs finished on a plantain-chicory mix (PI-C) or a permanent grass-based pasture (PP) and treated with or without an endectocide. From mid-November, weaned lambs (n=72, average live weight 32 kg) were distributed into three paddocks per sward type for 30 d. Half of the lambs were initially treated with ivermectin. Fecal egg counts (FEC), larvae genera and the presence of infective larvae (L3) in pastures were evaluated. No differences (P>0.05) were obtained between the pastures for the initial (ca. 80 epg) or final FEC (322 epg) or type of eggs (Strongylid- or *Nematodirus*-type). Ivermectin treatment reduced (P<0.01) the total FEC (482 vs. 158 epg) and the Strongylid- (418 vs. 148 epg) and *Nematodirus*-type eggs (64 vs. 9 epg). No significant effects (P>0.05) of pasture type or anthelmintic treatment and no interactions were detected on the cultured larvae genera, except for *Cooperia*, which decreased with the anthelmintic treatment. By day 30, the number of L3 recovered from the pastures increased (P<0.05) in the PP (62 to 280 L3 kg<sup>-1</sup> DM), while the number was unchanged (P>0.05) in the PI-C (average 63 L3 kg<sup>-1</sup> DM). The parasite load estimated by the FEC reached low infection levels (<400 epg), preventing clinical signs. The live weight gain of lambs was similar (P>0.05) among treatments (average 173 g d<sup>-1</sup>), reflecting an adequate nutritional quality of both pastures and a moderate parasitism status of the lambs.

**Key words:** Herb swards, infective larvae, nematodes, sheep.

### Introduction

In humid temperate zones, permanent grass-based pastures are the basis of sheep production systems. Such systems are exposed to frequent

late spring and summer rainfall deficits, affecting pasture growth and animal performance. Improved cultivars of herbs such as plantain and chicory appear attractive for finishing lambs, since they have good nutritional quality and are more tolerant to water stress compared to most grasses. Parasitic diseases caused by gastrointestinal nematodes (GIN) are responsible for

important economic losses in lamb production systems based on pastures. Traditionally, the use of anthelmintics has been the main method to control the worm burden in lambs. However, resistance developed by GIN to common anthelmintics (Toro *et al.*, 2014) has forced the pharmaceutical industry to develop stronger drugs. Sheep producers in turn have been compelled to intensify their control strategies by adopting and rotating new drugs and increasing the deworming frequency. In recent decades, however, a holistic approach has emerged to help cope with sheep parasitism, involving different anthelmintic treatments and grazing management strategies. These treatments and strategies may result in better parasite control at more reasonable costs although not necessarily eliminating anthelmintic resistance.

Secondary metabolites from a number of plants show anthelmintic effects attributed either to an increased immune status of the animals resulting from improved protein nutrition or a direct deleterious effect on nematodes (Githiori *et al.*, 2006). Among such plants, plantain (*Plantago lanceolata*) and chicory (*Cichorium intybus*) are species of particular interest. Condensed tannins (plantain) and sesquiterpene lactones (chicory) are two groups of bioactive metabolites that have been reported to reduce nematode larval motility *in vitro* (Molan *et al.*, 2003) and worm burdens in grazing lambs (Githiori *et al.*, 2006). The action of tannins could be explained by their indirect effect on reducing the ruminal degradation of proteins and increasing amino acid absorption at the intestinal level (Waller and Thamsborg, 2004; Ramírez-Restrepo and Barry, 2005), as well as their direct deleterious effect on nematodes, by either damaging the larvae cuticle (Yoshihara *et al.*, 2015) or by decreasing oviposition in the reproductive stage (Waller and Thamsborg, 2004). Sesquiterpene lactones have been shown to reduce egg hatchability and larval motility or feeding ability (Peña-Espinoza *et al.*, 2015), which could explain the reduction in the establishment of incoming larvae.

Therefore, the use of these herb species could benefit sheep production systems by improving the availability of quality forage and maintaining a lower parasite burden, reducing the dependence on antiparasitic drugs and consequently helping to delay the development of the anthelmintic resistance commonly observed in systems with frequent drug usage. Although some previous research has been conducted in this area, it is important to gather information for locations where high winter rainfall and frequent summer droughts configure special environments in the context of global climatic change. The present work was carried out with the hypothesis that a chicory-plantain mixture could result in a lower parasitic load and hence a higher live weight gain in weaned lambs. Consequently, our objective was to evaluate the effects of the type of pasture (a mixture of plantain and chicory compared with a grass-based permanent pasture) and the application (or not) of an anthelmintic treatment on the live weight gain of weaned lambs, the load of gastrointestinal nematodes estimated through fecal egg counts (FEC), the larvae genera obtained from fecal cultures and the number of infective larvae in the experimental pastures (ILIP).

## Material and methods

Two swards, one containing a mixture of herbs (PI-C) and the other containing a permanent pasture (PP) with several species of grasses, were established in three paddocks of 1,500 m<sup>2</sup> for each mixture in mid-March in an Andisol (Duric Hapludand) soil Series Valdivia with a silty loam texture located at the Agricultural Experimental Station (Santa Rosa farm) of Universidad Austral de Chile in Valdivia, Chile. For the PI-C pasture species, cultivars and seed doses were as follows: plantain (*Plantago lanceolata* L., Tonic) 8.4 kg ha<sup>-1</sup> and chicory (*Cichorium intybus* L., Choice) 8.4 kg ha<sup>-1</sup>. For the PP pasture, the respective species, cultivars and values were as follows: ryegrass (*Lolium perenne* L., Rohan) 8.6 kg ha<sup>-1</sup>, bromegrass (*Bromus valdivianus* Phil., Poker)

11.52 kg ha<sup>-1</sup>, tall fescue (*Festuca arundinacea* Scrb., Kora) 8.64 kg ha<sup>-1</sup>, cocksfoot (*Dactylis glomerata* L., Safin) 5.76 kg ha<sup>-1</sup>, Yorkshire fog grass (*Holcus lanatus* L.) 2.88 kg ha<sup>-1</sup> and white clover (*Trifolium repens* L., Weka) 3.6 kg ha<sup>-1</sup>.

In mid-August and early October, the paddocks were intensively grazed for three days by ewes and their lambs to control pasture growth and ensure that a population of infective larvae were present when the experimental period started in mid-November.

On November 14th, 72 Austral (Finnish Landrace x Romney) weaned lambs approximately four months old with an average live weight of 32 kg were randomly allocated to the trial, with 12 lambs for each paddock (36 per pasture type). All the lambs had been routinely dewormed in August, September and October with Rumiten® (fenbendazole and praziquantel). At the beginning of the trial, half of the animals (n=6) in each plot were treated with ivermectin 1% at a dose of 0.2 mg kg<sup>-1</sup> body weight. The remaining six lambs were not dewormed. The lambs were strip grazed with electric fencing (2 to 4 d in each break, six breaks per paddock) and determined by sward height, with a goal of 10 cm and 7 cm for the PI-C pasture for entering and exiting, respectively, and 8 cm and 5 cm for the PP pasture, respectively. At the end of the last break, the lambs returned to the first strip and so on, but in the last 4 to 6 d, each complete paddock was made available, as the lack of rain resulted in a forage shortage, especially in the case of the PP pastures. All the lambs were housed at night for security reasons in separate pens, one per paddock, in a nearby barn. The trial lasted 30 d (*i.e.*, was terminated by mid-December). All the lambs were weighed at the start and end of the experiment, in the morning, to compare the live weight gain between treatments. The pastures were sampled at days 8, 15 and 30 from the start of the experiment to determine crude protein, metabolizable energy, neutral detergent fiber, acid detergent fiber and total ash.

Individual fecal samples were taken at the beginning and end of the trial (day 30). The fecal egg counts were determined by the McMaster procedure for quantifying total nematode eggs and separating Strongylid- and *Nematodirus*-type eggs. Pooled samples of feces (10 g per paddock) were used to determine nematode genera by larval culture. The procedure provides favorable environmental conditions (humidity, temperature, aeration) for egg hatching and larvae development to the L3 stage. The fecal material was placed in a wide-mouthed jar with sterilized water, covered with a loose Petri dish and placed in an incubation oven for 10 d at 18 °C. At the end of this incubation period, the flask was inverted into the Petri dish, water was added to the dish border, and the system was left to settle. The larvae were recovered after four hours by extracting the liquid from the dish and transferring it to an assay tube, before being pipetted from the bottom of the tube to a slide and identified. The genera identification of L3 was performed by using the key of the Manual of Laboratory Techniques of Veterinary Parasitology (Ministry of Agriculture, Fisheries and Food, MAFF, 1971).

At the beginning (day 1) and end (day 30) of the trial, the herbage samples were collected from each paddock in the morning in a “double-crossed W shape” transect, every ten steps, close to the soil surface. The composite samples (*ca.* 1 kg) for each paddock were soaked in water for at least 6 h to loosen the larvae. The forage was removed and dried in a convective oven at 65 °C for 48 h to determine the dry matter content. The infective larvae (L3) were obtained from the sediment and identified at the genus level (MAFF, 1971). The results were expressed as the larvae number per kg of forage DM.

The statistical analysis was performed by means of a two-way ANOVA (Statgraphics Centurion software, version XVI). For the FEC (epg), a split-plot design was employed to estimate the effect of the type of pasture (PI-C or PP, main plot), en-dectocide treatment (sub-plot), and the interaction

between them. The same analysis was also used for the larval genera and live weight gain (LWG) of the lambs. The variables were transformed to their logarithmic values prior to the analysis to comply with homogeneity of variances. However, the results are presented as average values without transformation. For the ILIP analysis, the effects of pasture type and period (sampling day) were evaluated with a factorial arrangement (2 pastures x 2 periods). The paddock was employed as the experimental unit.

## Results

At the start of the experiment, the FEC were low and comparable between pastures, with an average of *ca.* 80 epg. At the end of the study the counts increased, with mean values of *ca.* 320, 283 and 37 epg for total, Strongylid- and *Nematodirus*-type eggs, respectively. Although no significant effects ( $P>0.05$ ) of pasture type were detected, a trend of higher counts was apparent for the herb pasture, especially if the FEC of the non-treated lambs were considered. Hence, the count for total eggs, separated by Strongylid and *Nematodirus* type, were 444 vs. 519 (total), 384 vs. 447 (Strongylids) and 56 vs. 72 (*Nematodirus*) for the PP

and PI-C swards of the non-treated lambs. The anthelmintic (ivermectin) treatment was more effective, as the treated lambs exhibited lower counts ( $P<0.01$ ) of total nematodes, Strongylid-type and *Nematodirus*-type eggs, in comparison with the non-treated lambs. No interaction was found between the type of pasture and endectocide treatment (Table 1).

A small number of total larvae was obtained from the feces culture, approaching 0.05 as a fraction of the total FEC. No effect ( $P>0.05$ ) of pasture type was found on the larval genera recovered, and a similar pattern was found for anthelmintic treatment, except for the *Cooperia* larvae that were negatively affected ( $P<0.05$ ) by the endectocide. No interaction was apparent ( $P>0.05$ ) between the pasture type and anti-parasitic treatment neither for the total L3 nor for any larval genera (Table 1).

The L3 identified in the pasture samples comprised the genera *Trichostrongylus* spp., *Ostertagia* spp., *Chabertia* spp. and *Cooperia* spp. (Table 2). The numbers were lower for the PI-C compared to the PP sward, with significant differences ( $P<0.05$ ) for total L3 and *Trichostrongylus* L3 and a tendency to decrease for *Chabertia* and *Ostertagia*.

**Table 1.** Effects of pasture type and ivermectin treatment of grazing lambs on fecal egg counts (epg) and larvae obtained from feces cultures at the end of the study.

Variable	Pasture type		Ivermectin		SEM	P-Value		
	PP	PI-C	Yes	No		Pasture	Ivermectin	Interaction
Fecal egg counts (epg)								
Total FEC	286.78	352.78	157.62	481.94	46.04	0.359	0.001	0.922
Strongylids	253.94	312.50	148.39	418.06	42.25	0.248	0.002	0.998
<i>Nematodirus</i>	32.84	40.28	9.23	63.89	8.82	0.806	0.003	0.603
Larvae from fecal culture								
Total larvae	15.7	15.2	7.8	23	4.22	0.97	0.15	0.53
<i>Ostertagia</i>	12.2	8.7	5.8	15	2.85	0.68	0.18	0.65
<i>Trichostrongylus</i>	2.2	1.3	1.2	2.3	0.33	0.37	0.16	0.16
<i>Chabertia</i>	1.0	4.5	0.7	4.8	1.52	0.38	0.24	0.24
<i>Cooperia</i>	0.3	0.7	0.2	0.8	0.12	0.42	0.04	1.0

PP: Permanent pasture, PI-C: Plantain-chicory mixture, SEM: Standard error of the mean, Interact.: Interaction, FEC: Fecal egg counts, epg: eggs per gram.

Concerning the effects of pasture type and sampling period (initial and final), it can be seen (Table 3) that throughout the experiment, total L3, *Ostertagia* spp. and *Trichostrongylus* spp. larvae increased ( $P < 0.05$ ). A similar trend ( $P = 0.11$ ) was observed for *Chabertia* spp., whereas *Cooperia* spp. did not change ( $P = 0.54$ ). Higher numbers of total L3, *Trichostrongylus* spp. and *Chabertia* spp. ( $P < 0.05$ ) were obtained from the PP pasture in comparison to the PI-C mixture, with a similar tendency ( $P = 0.1$ ) for *Ostertagia* spp., but no effect ( $P = 0.24$ ) was observed for *Cooperia* spp. However, significant interactions ( $P < 0.05$ ) were observed between the pasture type and period for total L3 and *Trichostrongylus* spp. larvae. Specifically, both larval types increased significantly in the second period only for the PP pasture, whereas in the PI-C mixture, the larval counts were maintained (interactions not shown).

The live weight gain of lambs for the complete experimental period averaged  $173 \text{ g d}^{-1}$ , and no effect ( $P = 0.72$ ) was detected for the type of pasture, anthelmintic ( $P = 0.51$ ) treatment, or their interaction ( $P = 0.64$ ). The average nutritional composition of the pastures throughout the study for the herb (PI-C) and grass-type (PP) swards were  $10.38$  and  $12.09 \text{ MJ kg}^{-1} \text{ DM}$  for metabolizable energy,  $214$  and  $191 \text{ g kg}^{-1} \text{ DM}$  for crude protein,  $348$  and  $450 \text{ g kg}^{-1} \text{ DM}$  for neutral detergent fiber,  $286$  and  $253 \text{ g kg}^{-1} \text{ DM}$  for acid detergent fiber, and  $136$  and  $86 \text{ g kg}^{-1} \text{ DM}$  for ash.

## Discussion

The low initial parasite load found in the present study is probably explained by the drenching applied to the experimental lambs previous to weaning and by the low worm burden expected

**Table 2.** Total infective larvae (L3), separated by genus, recovered from pastures (average number per kg DM) at the end of the study.

Variable	Pasture type		SEM	P-Value
	PP	PI-Ch		
Total L3	279.82	77.10	50.87	0.048
Ostertagia	151.71	59.80	39.35	0.174
Trichostrongylus	85.22	17.30	15.59	0.037
Chabertia	29.48	0	9.30	0.089
Cooperia	13.41	0	9.48	0.374

PP: Permanent pasture, PI-C: Plantain-chicory mixture, SEM: Standard error of the mean.

**Table 3.** Total infective larvae (L3), separated by genus (number per kg DM), obtained from each pasture type in two periods (days 1 and 30) and the associated interaction.

Variable	Pasture type		Period		SEM	Significance		
	PP	PI-Ch	1	2		Pasture	Period	Interaction
Total L3	170.9	62.8	55.2	178.5	18.48	0.019	0.010	0.034
Ostertagia	96.4	43.6	34.3	105.8	14.16	0.099	0.036	0.205
Trichostrongylus	48.5	19.2	16.5	51.3	5.97	0.039	0.019	0.012
Chabertia	17.0	0	2.2	14.7	3.47	0.040	0.110	0.110
Cooperia	8.94	0	2.2	6.7	3.53	0.242	0.544	0.544

PP: Permanent pasture, PI-C: Plantain-chicory mixture, SEM: Standard error of the mean.

in pastures that were sown early in the same year. Therefore, most L3 present in mid-November (at the beginning of the trial) probably developed from the dispersal of eggs from the previous grazing of ewes and their lambs. The subsequent increase in the FEC at the end of the trial was moderate, possibly a consequence of the residual effect of the endectocide applied, as no effect of the forage species was apparent. The results obtained for the effects of type of pasture do not support the main hypothesis, as no effect of pasture type was detected on the FEC. In fact, the epg for the PI-C treatment was over 20% higher than that of the PP, although this increase was non-significant. Anthelmintic administration to half the lambs at the beginning of the trial, on the other hand, resulted in a lower increase in total, Strongylid- and *Nematodirus*-type eggs. A possible explanation for the lack of effect of pasture type or its interaction with anthelmintic application on the total FEC and egg type could be related to the prepatent period of GIN. The prepatent period is the lapse between the infection of an animal by ingestion of L3 and the first egg production by the adult female parasite and it typically takes approximately three weeks (Sievers and Nannig, 2006).

All lambs demonstrated increased GIN loads by the end of the study, as estimated by the FEC. Even the lambs treated with anthelmintic exhibited a higher worm load at the end of the trial, despite the fact that a residual effect of ivermectin has been found up to 10 d after injection (Borgsteede, 1993). However, the anthelmintic-treated lambs showed a significantly ( $P < 0.01$ ) lower parasite burden ("low", with  $< 200$  epg) than the non-treated lambs ("moderate", with  $< 500$  epg). This included burdens of the genus *Nematodirus* that, with low counts, produced less ( $P < 0.01$ ) eggs in the treated (*ca.* 10 epg) than in the non-treated animals (*ca.* 64 epg). *Nematodirus* spp., a ubiquitous GIN found in small ruminants, is a common parasite in Southern Chile. An increasing resistance to ivermectin from this genus has been found in sheep (Toro *et al.*, 2014), but this was not the case in our results.

It is important to consider that the egg count expressed as total epg or according to genera, *i.e.*, Strongylid-type eggs (*Trichostrongylus*, *Ostertagia*, *Cooperia* and *Chabertia* spp.) or *Nematodirus*-type eggs, only shows a general image of the level of nematode infection. It could be argued that the FEC does not necessarily represent the actual number of worms present, since it is affected by their maturity stage and oviposition capacity. Nonetheless, research suggests that the FEC presents a good correlation with worm counts, particularly for groups of animals in their first year of life (Ratnayake, 2003). In a recent paper, Laurenson *et al.* (2016) reported strong correlations (especially after a prepatent period) between worm burden and FEC values across nematode species, supporting the use of the FEC reduction test as a measure of anthelmintic efficacy.

The objective of the culture of feces was to verify the effects of pasture type and endectocide application on the recovery of L3, which in turn depends on the hatchability of GIN eggs and the factors affecting the development of larvae to the L3 stage. According to our results, a small number of L3 (total and different genera) were recovered from the feces culture, and no effects of pasture type or endectocide were apparent. Only *Cooperia* was negatively affected by the anthelmintic, with an average of less than one L3 recovered. The mean number of total L3 recovered represent *ca.* 0.05 of the total epg value for each treatment. It is possible that the lapse of the protocol used, particularly in the final extracting process, could have been insufficient to obtain more L3, even though three replicates were performed per group. It is also possible that some L1 or L2 did not survive the period trapped inside the feces. Uncertainties are also associated with the composition of feces and the moisture and temperature of the culture process, among other issues (Roebber and Khan, 2014), since ideal conditions vary for different species of nematodes. Conversely, Jørgensen *et al.* (1998) proposed that part of the hatching ability and survival of infective larvae depends on immune host factors that operate directly on

the eggs before they are expelled, though this hypothesis should be further studied. Roeber and Khan (2014) suggested that the results of larvae culture are useful to evaluate the species present rather than to quantify them. Several conditions can affect the process of obtaining L3 from feces culture, *e.g.*, naturally low fecundity that results in low numbers of eggs, low fertility or hatchability, low viability of intermediate larval stages and adverse conditions in the culture technique. These factors could explain the results obtained in our study, where the quantification did not follow any pattern related to pasture type or anthelmintic treatment (except for *Cooperia*). The relatively higher number of *Ostertagia* L3 obtained from the fecal cultures in our study could be related to the shorter prepatent period and high resistance to benzimidazoles of this genus (Bartley *et al.*, 2004) compared to other genera. *Nematodirus* L3 were not in the culture, because the larvae develop to L3 inside the egg and hatch after being ingested by the host. For a more detailed review on the limitations of larval culture techniques, the reader is referred to Roeber and Khan (2014).

The number of L3 in herbage provides important information concerning the risk of uptake of larvae by grazing animals. We assumed that the L3 load in the PI-C pasture would be lower in comparison with the PP pasture but it was also expected that the number would increase over time. Although, on average, both hypotheses are supported by our results, some interactions are evident, as initial counts were low and comparable between pasture types, though they tended to increase at the end of the study only for the PP pasture.

A lower recovery of larvae from pastures has been found for chicory compared to grass-clover swards (Kidane *et al.*, 2010). This could be related to the presence of secondary bioactive metabolites, such as sesquiterpene lactones among other compounds in chicory, that could affect motility and viability of GIN larvae (Hoste *et al.*, 2006). It has been noted that plantains contain several bioactive metabolites (not determined in this study), nota-

bly, the iridoid glycosides aucubin and catalpol and condensed tannins (Ramírez-Restrepo and Barry, 2005). Although there is interest in the anthelmintic properties of plantains, the evidence supporting a direct effect is scarce (Sievers and Nannig, 2006). However, important antimicrobial and anti-inflammatory effects have been found in iridoid glycosides from plantains, and these effects are even stronger in their degradation products (Viljoen *et al.*, 2012). It could be hypothesized that bioactive metabolites from herbs (chicory and/or plantain) or their derivatives excreted in feces affected the GIN eggs (lower hatchability) or the intermediary stage larvae (L1, L2) in the fecal environment, impairing migration or nutrition and affecting parasite survival.

Sward architecture and plant surface structures could play significant roles as well. The spatial distribution and density of plants could be involved in the probability of L3 migrating in the plant profile. The plants in the PI-C sward were more erect and had a lower density than in the PP, and this could have been an obstacle to larval migration and survival. With respect to plant structures, Marley *et al.* (2006) found a significantly lower recovery of GIN L3 from chicory compared to ryegrass swards; although many factors could be involved, their results could be partially explained by the physical barrier represented by the presence of trichomes in chicory leaves that interfere with larval migration. Glandular trichomes act as metabolic factories in different plant organs where in the case of chicory and other members of the Asteraceae family, sesquiterpene lactones are produced and secreted to a subcuticular storage space at the apex of trichomes or excreted to the plant surface (Göpfert *et al.*, 2005). These terpenoids play an important role as deterrents to herbivory and are toxic to pathogens; therefore, they could also represent a chemical repellent to L3, restraining vertical movement.

A positive effect of the herbs sward and the endectocide application on the live weight gain of weaned lambs was hypothesized in the present

study, and an interaction was expected in the form of a lower gain for lambs in the PP without drenching, since no protection from GIN would be present either from the anthelmintic or the bioactive metabolites expected in the PI-C forage. However, this was not supported by our findings, as lambs from all the treatments had similar gains ( $P>0.05$ ) of  $173 \text{ g d}^{-1}$ , on average. The lack of effects may be explained by the relative low to moderate worm burden estimated from the FEC ( $<400 \text{ epg}$ ) at the end of the trial, although the epg increased through the experimental period. Both pastures had good nutritional quality, *i.e.*, sufficient protein and other nutrients that could have exerted a positive interaction with immunity development against GIN. There is evidence that during the early phases of acquiring immunity in the 2-3-month-old lambs, intake and productivity can be severely affected and a positive effect can be expected of an enhanced nutrient supply (Sykes, 2010). Immunity acts through a number of mechanisms, resulting in the rejection of incoming infective larvae, reduction of nematodes, impairment of worm development and fecundity and expulsion of adult nematodes (Athanasidou *et al.*, 2008). Kidane *et al.* (2010) found a greater live weight gain of lambs grazing on chicory compared with lambs grazing on ryegrass-clover. In another study, lambs from undrenched ewes grazing on chicory gained more live weight in comparison to lambs from undrenched ewes grazing on grass, but for lambs from drenched ewes, gains were similar between the swards. That study concluded that the growth of young, parasitized lambs is not penalized as a result of parasitism when grazing on chicory (Athanasidou *et al.*, 2007). Plantain, besides its high nutritional quality, has resulted in lower egg output of parasitic nematodes in calves (Sievers and Nannig, 2006) and presents distinct pharmacological value through anti-oxidant, anti-inflammatory and wound-healing activities from bioactive compounds such as phenylpropanoid glycosides, iridoids, triterpenes, flavonoids and phenolic acids (Goncalves and Romano, 2016). Thus, parasitized animals could maintain more effective resistance to GIN as a

result of a reinforced immune system or a better protected gastrointestinal tract or through direct anthelmintic activity following the consumption of bioactive forages (Athanasidou *et al.*, 2008). On the other hand, secondary bioactive metabolites can also adversely affect the parasitized herbivores through anti-nutritional factors resulting in lower dry matter intake or toxic effects. Therefore, the concentration of specific metabolites and amounts ingested represent a trade-off between positive and detrimental effects.

It has been proposed that in late spring and early summer, mixtures of herbs (plantain or chicory) and clover are better options than ryegrass-clover mixtures for finishing lambs in temperate regions (Somasiri *et al.*, 2016). In our study, the combined effects of the factors discussed earlier did not result in better gains of lambs grazing on the mixed-herbs sward. The climatic conditions were beneficial for both types of swards in our experiment, with some precipitation and mild temperatures (results not shown) that, in addition to soil residual moisture, were adequate for the growth of ryegrass and other grasses in the first three weeks of the experiment. By the fourth week, the lack of rainfall resulted in a reduction of forage growth, particularly for the PP pastures; this precluded the extension of the study.

In conclusion, no effects were detected for the type of sward (chicory-plantain or permanent grass-based) on the FEC, in terms of the total, Strongylid- or *Nematodirus*-type eggs. Endectocide application, on the other hand, resulted in a reduction of the total, Strongylid-, and *Nematodirus*-type eggs. The total L3, as well as the larvae of the genera *Ostertagia*, *Trichostrongylus* and *Chabertia* obtained from fecal cultures, were not affected by pasture type or anthelmintic treatment, although *Cooperia* was reduced. The number of L3 recovered from forage at the end of the experiment was significantly lower for the chicory-plantain mixture compared to the permanent pasture, leading to a lower infective risk for the herbs sward.

In contrast to other works, the chicory-plantain mixture did not lead to higher live weight gains in finishing lambs in comparison to the grass-based sward. It is possible that prolonging the finishing period further into the summer could result in more evident effects in favor of the herbs sward, but this was not possible in our study.

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### Resumen

**D. Alomar, P. Ruiz, O. Balocchi, G. Valenzuela, y D. Goic. 2018. Engorda de corderos en una mezcla de achicoria-plantago o una pradera basada en gramíneas de clima templado: ganancia de peso y parasitismo gastrointestinal. Cien. Inv. Agr. 45(1): 11-20.** Variedades mejoradas de plantago (*P. lanceolata* L.) y achicoria (*Cichorium intybus* L.) son interesantes para engordar corderos y pueden protegerlos del parasitismo interno por sus metabolitos secundarios. Este estudio comparó la ganancia de peso y carga parasitaria de corderos destetados terminados en una mezcla de plantago-achicoria (PI-C) o una pradera permanente basada en gramíneas (PP), tratados o no con un endectocida. Setenta y dos corderos con peso promedio de 32 kg se distribuyeron en tres potreros por cada tipo de pradera, por 30 días desde mediados de noviembre. La mitad de los corderos se trató inicialmente con ivermectina. Se evaluó recuento fecal de huevos (FEC), géneros larvarios y recuento de larvas L3 en las praderas. La carga de FEC inicial (ca. 80 hpg) o final (322 hpg) fue similar ( $P>0.05$ ) entre praderas. El tratamiento con ivermectina logró menor ( $P<0.01$ ) recuento total (482 vs. 158 hpg), huevos tipo estrogilidos (418 vs. 148 epg) y *Nematodirus* (64 vs. 9 epg). Las cargas parasitarias finales estimadas fueron bajas ( $<400$  hpg). No hubo efecto del tipo de pradera, antihelmíntico o su interacción, para el número de larvas obtenidas del cultivo de fecas, excepto para *Cooperia* que disminuyó con la ivermectina. Las larvas L3 en la pradera aumentaron ( $P<0.05$ ) durante el estudio para PP (62 to 280 L3 kg<sup>-1</sup> MS) pero no para PI-C (promedio 63 L3 kg<sup>-1</sup> MS). La ganancia de peso fue similar ( $P>0.05$ ) entre tratamientos (promedio 173 g d<sup>-1</sup>) reflejando una calidad nutricional adecuada de ambas praderas y un parasitismo moderado.

**Palabras clave:** Hierbas forrajeras, larvas infectantes, nemátodos gastrointestinales, ovinos.

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