New Zealand Journal of Animal Science and Production 2025 Vol 85. 61-66

BRIEF COMMUNICATION: Liveweight gain and faecal nematode egg counts from Romney lambs grazing five contrasting forage treatments

CT Westwood[1*], JWR Leslie[2], EL Butcher[1], SR Hunter[1]

[1]PGG Wrightson Seeds, Kimihia Research Centre, PO Box 69132, Lincoln 7640, NZ
[2]PGG Wrightson Limited, PO Box 292, Christchurch 8140, NZ
*Corresponding author email: cwestwood@pggwrightsonseeds.co.nz

Abstract

Anthelmintic resistance in gastrointestinal nematode (GIN) parasites is an increasing challenge for lamb finishing worldwide, necessitating alternative parasite management strategies. This study investigated the impact of different forage types on GIN reinfection and liveweight gain in weaned lambs. Lambs were allocated to perennial pasture (PP), first year chicory/clover (CC1), plantain/clover (PC), Raphnobrassica (RB), or second year chicory/clover (CC2) following treatment with an effective anthelmintic (Zolvix™ Plus). Over the 70 day period post-anthelmintic treatment, compared with PP lambs, lambs grazing CC1, PC and RB maintained significantly lower faecal egg counts (FEC) and achieved high liveweight gains without further requirement for drenching. These outcomes likely reflected reduced larval migration due to crop canopy architecture, lower environmental survival of larvae in crop microclimates, and improved lamb resilience to parasitism associated with enhanced nutrition. In contrast, lambs on CC2 and PP exhibited earlier increases in FEC and relatively lower liveweight gains than first year crop lambs. Higher populations of infective L3 larvae within CC2 and PP swards, and vernalisation of CC2 chicory reducing the palatability and nutritive value of CC2 may have contributed to less favourable outcomes for these lambs. Management strategies that maintain second year chicory in a vegetative state will improve lamb performance on multi-year chicory/clover crops. Incorporating well managed first year and potentially multi-year forage crops into lamb finishing systems can reduce reliance on repeated anthelmintic treatments. When combined with other sustainable parasite management strategies, forage crops can provide farmers with an additional effective tool to mitigate the challenges posed by anthelmintic-resistant GIN populations.

Keywords: lamb performance; gastrointestinal nematodes; faecal egg counts; chicory; plantain; raphanobrassica

Introduction

Across New Zealand, more than 19 million lambs are either finished or retained annually as ewe replacements (Anon, 2024). Gastrointestinal nematode (GIN) parasitism remains a major constraint to lamb production, reducing growth rates, and compromising animal health status and animal welfare. The traditional high reliance on the repeated use of anthelmintics as the only means of GIN control has contributed to the steadily increasing prevalence of anthelmintic-resistant parasite populations on New Zealand sheep farms (Riddy, 2025). Sustainable parasite control in lambs will therefore require the adoption of integrated, non-anthelmintic approaches (Ridler et al. 2024). Current strategies include the deliberate maintenance of refugia, implementation of targeted selective treatment (TST) protocols, co-grazing of sheep with cattle or use of cattle to prepare low-contamination pastures, and genetic selection of sheep with improved resilience or resistance to GIN.

Established perennial pastures provide favourable conditions for the survival of free-living stages of GIN, including eggs and the L1, L2 and L3 larval stages. Under conditions of warmth and moisture, lambs grazing such pastures are exposed to continual ingestion of infective L3 larvae, leading to the establishment of GIN populations within the gastrointestinal tract. Given that pasture contributes approximately 80–90% of the diet of New Zealand lambs and hoggets (Gibbs et al. 2017), reducing larval challenge under pasture-based systems is difficult to achieve. In comparison, summer forage crops typically support reduced levels of larval contamination. Leafy turnip (*Brassica rapa campestris*) has been shown to harbour fewer infective larvae than newly established ryegrass (Moss et al. 2011), while chicory (*Cichorium intybus* L.) has been reported to lower GIN burdens in grazing lambs, possibly through reduced larval availability in the grazing stratum (Moss and Vlassoff, 1993) and/or the presence of bioactive compounds with anthelmintic activity (Pena-Espinoza et al. 2018).

The objective of this study was to compare GIN reinfection and growth performance of weaned lambs grazing perennial pasture with those grazing four summer forage systems: first year chicory with red and white clovers, second year chicory with red and white clovers, plantain with red and white clovers, and raphanobrassica.

Materials and methods

The study was conducted in accordance with New Zealand Animal Welfare regulations and approved by the Lincoln University Animal Ethics Committee (application number AEC2024-41). The study took place over a 10-week period, from 17 December 2024 to 25 February 2025, at the PGG Wrightson Seeds Kimihia Research Centre (43.3651° S, 172.2923° E), situated 8 km north-east of Lincoln, Canterbury, New Zealand. The 4.55 ha study site comprised five paddocks of unequal size, each allocated to a different forage treatment.

Forage treatments consisted of Cleancrop™ Pallaton Raphno® brassica (a hybrid between kale *Brassica oleracea* L. and radish *Raphanus raphanistrum subsp. sativus L.*), referred to as 'RB', established on 0.5 ha; plantain (*Plantago lanceolata* L. cv. Ecotain®) with red clover (*Trifolium pratense* cv. Amigain) and white clover (*T. repens* cv. Quartz), referred to as 'PC', on 1.0 ha; first-year chicory (*Cichorium intybus* cv. Sika) with red and white clovers, referred to as 'CC1', on 1.0 ha; second-year chicory (cv. Sika) with red and white clovers, referred to as 'CC2', on 1.55 ha; and perennial pasture ryegrass (*Lolium perenne* cv. Vast) with red and white clovers, referred to as 'PP', on 1.0 ha.

First-year treatments (PC and CC1) were direct drilled into existing perennial pasture and clovers on 9 October 2024, following chemical spray-out with glyphosate (Lion DST, 490g / L at 4 L / ha) combined with an a organo-silicone penetrant (Pulse) at 200 mL / ha. Post-emergent herbicides of clethodim (Centurion Xtra, 360g / L at 1.2 L / ha), flumetsulum (Preside 800 g /kg at 65g / ha) and paraffin base petroleum oil (Peptoil 83%, 2L / ha) (CC1) and clethodim (Centurion Xtra, 360g / L at 1.2 L / ha) and paraffin base petroleum oil (Peptoil 83%, 2L / ha) (PC) were applied. Cleancrop™ Pallaton Raphno (RB) was drilled at 8kg / ha on 16 October 2024 after spray-out with glyphosphate (Lion DST, 490g/L at 4 L / ha) plus Pulse (200 mL / ha) and full cultivation, with a pre-emergence application of chlorsulfuron-methyl (Telar 750g / kg, at 20g per ha) plus clomazone (Magister 360g / L, at 300 mL / ha). The second-year treatments (PP and CC2) had been established in 2023, on 21 March and 18 October respectively, and grazed by lambs, hoggets and mixed-age ewes between establishment and the commencement of the present study. To eliminate grass weeds from CC2, on two occasions clethodim (Centurion Xtra, 360g / L at 1.2 L / ha), flumetsulum (Preside 800 g /kg at 65g / ha) and paraffinic oil / alkoxylated alcohol surfactant (Uptake, 1L / ha) were applied on 28 August 2024 and 26 November 2024.

A total of 202 five-month-old cryptorchid Romney lambs, with an average liveweight of 29.2 kg, were enrolled in the study. On day zero (17 December 2024), lambs were orally treated with monepantel and abamectin (Zolvix™ Plus, Elanco), dosed according to the heaviest lamb in the cohort. Following treatment, lambs were randomly allocated to dietary treatments as follows: RB (n = 20), CC1 (n = 45), CC2 (n = 80), PC (n = 20) and PP (n = 37). Stocking rates were determined from pre-study dry matter (DM) yield estimates conducted four days before study commencement. Lambs were moved directly onto their allocated forages without a transition period; however, they had grazed pasture immediately prior and were considered to be "full" of pasture at time of introduction to forage crops. Thereafter, lambs were rotationally grazed within their designated treatment breaks, and crop-fed lambs were not offered pasture at any stage of the study.

For faecal sampling, 10 individually identified lambs were selected from each treatment group, with an additional 10 spare animals held in reserve should samples be unobtainable from the tagged lambs. Faecal samples were collected on day 13 following Zolvix™ Plus treatment ('DrenchCheck'), day 28 and weekly thereafter, placed on ice, and submitted to Awanui Veterinary for faecal egg counts (FEC). FECs were interpreted as an indirect measure of adult nematode burden, acknowledging the imperfect correlation between FEC and actual GIN numbers (Playford and Besier, 2024). A treatment mean FEC of ≥500 eggs per gram (epg) was considered indicative of a substantive adult nematode burden. When this threshold was reached, all lambs within that treatment group were drenched with a triple-active anthelmintic (Triplemax Oral, VETMED, Nexan Corporation Ltd, Auckland, New Zealand) and excluded from the study.

All lambs were individually EID tagged and weighed at the time of each faecal sampling event using Tru-Test™ MP600 load bars and an XR5000 weigh head (Tru-Test™ Group, Auckland, New Zealand).

Statistical analysis

A negative binomial generalised linear model (GLM) was fitted to the FEC data using the raw counts (Nødtvedt et al., 2002) using Genstat (VSN International, 2024). The negative binomial model had an aggregation parameter of $k=1.6$ which was significantly different ($p < 0.001$) to the Poisson model ($k=1$). The differences between the treatments were highly significant ($p < 0.001$) as measured by an approximate F test with ratio of 40.4, There was also with a smaller but highly significant ($p < 0.001$) interaction of treatment with date (F ratio = 2.3). Significance letters were assigned to groups to indicate means that were significantly different at the 5% level. The animal liveweights were analysed using a standard ANOVA (using Genstat) with a separate analysis for each date. Separate least significant differences at the 5% level (LSD) were calculated at each date.

Results and discussion

Faecal Egg Counts (FEC)

Average FEC did not differ significantly ($p>0.2$) between forage treatment groups at day 0 or day 13 following treatment with Zolvix™ Plus (Figure 1). The absence of strongyle eggs at day 13 confirmed satisfactory efficacy of the anthelmintic. Thereafter, patterns of FEC change changed markedly among treatments.

By day 28, lambs grazing PP and CC2 had significantly higher FEC ($p<0.001$) compared with lambs grazing CC1, PC, and RB. On day 34, average FEC in PP lambs exceeded the threshold of 500 epg, at which point these lambs were drenched with a triple-active anthelmintic and removed from the study. CC2 lambs were removed from the study on day 42 and drenched due to evidence of clinical parasitism (diarrhoea in approximately 15% of lambs), low average daily liveweight gain (93 g/lamb/day over the previous 14 days; Figure 2) despite the 42 average FEC not reaching the nominal threshold of an average of 500 epg. The day 42 average FEC of 435 epg was significantly higher (p<0.05) than CC1, PC and RB.

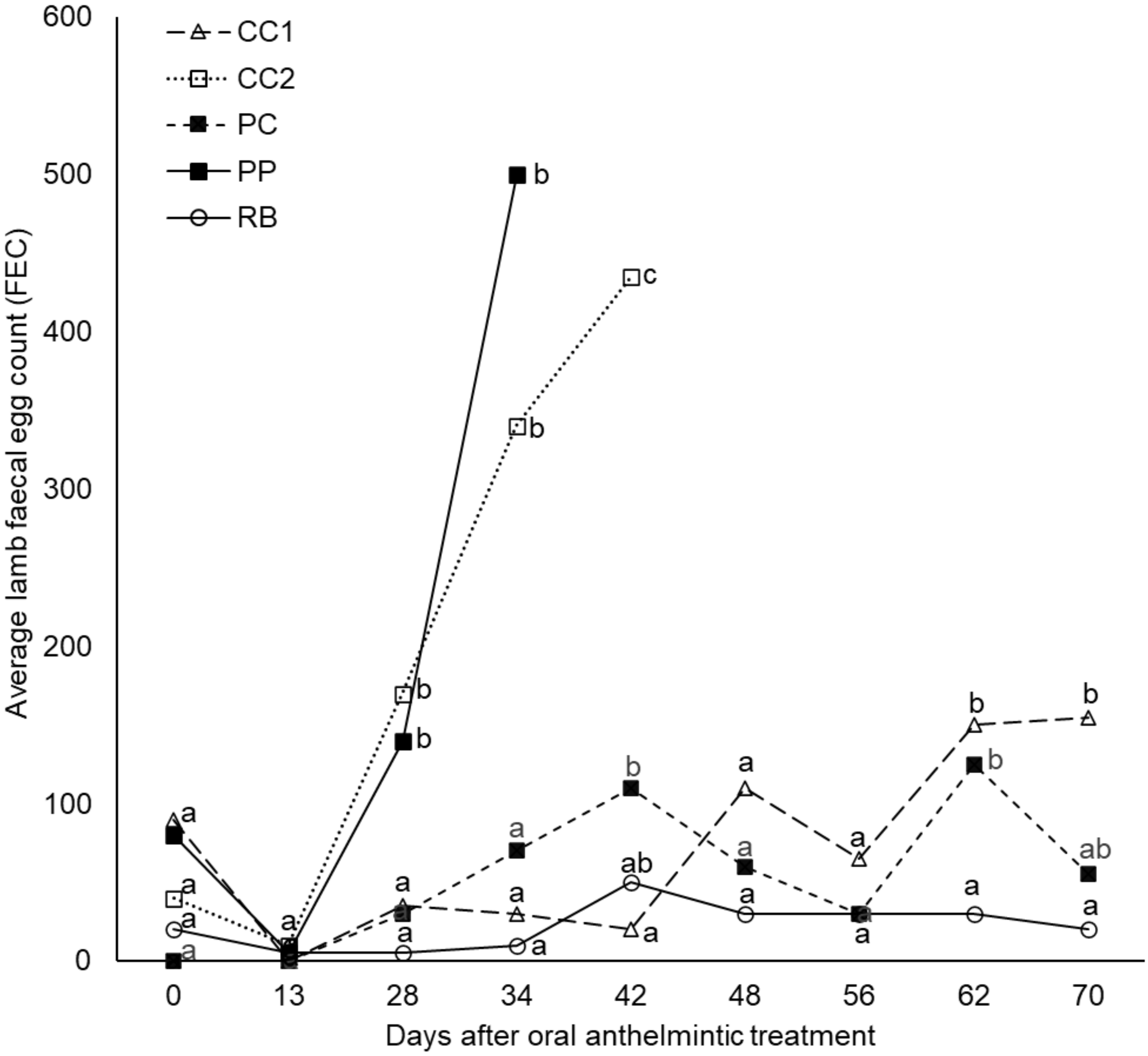

Figure 1. Faecal egg counts collected from lambs grazing five different forage treatments. Different letters indicate statistically significant differences (P<0.05). CC1; first year chicory (*Chicorium intybus* cv. 'Sika', red clover (*Trifolium pratense* cv. Amigain) and white clover (*Trifolium repens* cv. Quartz); CC2, second year chicory cv. 'Sika', Amigain red and Quartz white clovers; PC, plantain (*Plantago lancelolata* L. cv. Ecotain®), Amigain red and Quartz white clover; PP, perennial ryegrass (*Lolium perenne* cv. Vast), Amigain red and Quartz white clover; RB Cleancrop™ Pallaton Raphno®.

For the remaining treatment groups (CC1, PC, RB), significant differences in FEC were detected at day 42, day 62, and day 70 (p<0.001; Figure 1). However, none of these lambs required anthelmintic treatment or removal from the study. At day 70, average FEC were 55 epg for PC, 155 epg for CC1, and 20 epg for RB.

Liveweight Gain

Cumulative liveweight gain differed significantly between forage treatments over the 70 day study period (p<0.001). During the first 13 days, PP lambs gained significantly more weight than lambs on other forages, most likely due to the absence of a requirement for PP lambs to 'transition' from pasture to high quality forage crop as was the case for lambs starting other high quality forage crop treatments. By day 28, however, liveweight gain of PP lambs had fallen below that of CC1, PC, and RB lambs, though liveweight gains remained greater than that of CC2 lambs.

Average daily liveweight gain prior to removal was 210 g/head/day for PP lambs and 140 g/head/day for CC2 lambs. At the time of removal, cumulative liveweight gain of CC2 lambs was almost 7 kg lower than that of CC1, PC, and RB lambs.

By day 62 and day 70, RB lambs had significantly lower cumulative liveweight gain compared with PC lambs (p<0.05), although they did not differ significantly from CC1. At day 70, average cumulative gains were 22.2 kg for

PC lambs, 21.0 kg for CC1 lambs, and 18.8 kg for RB lambs.

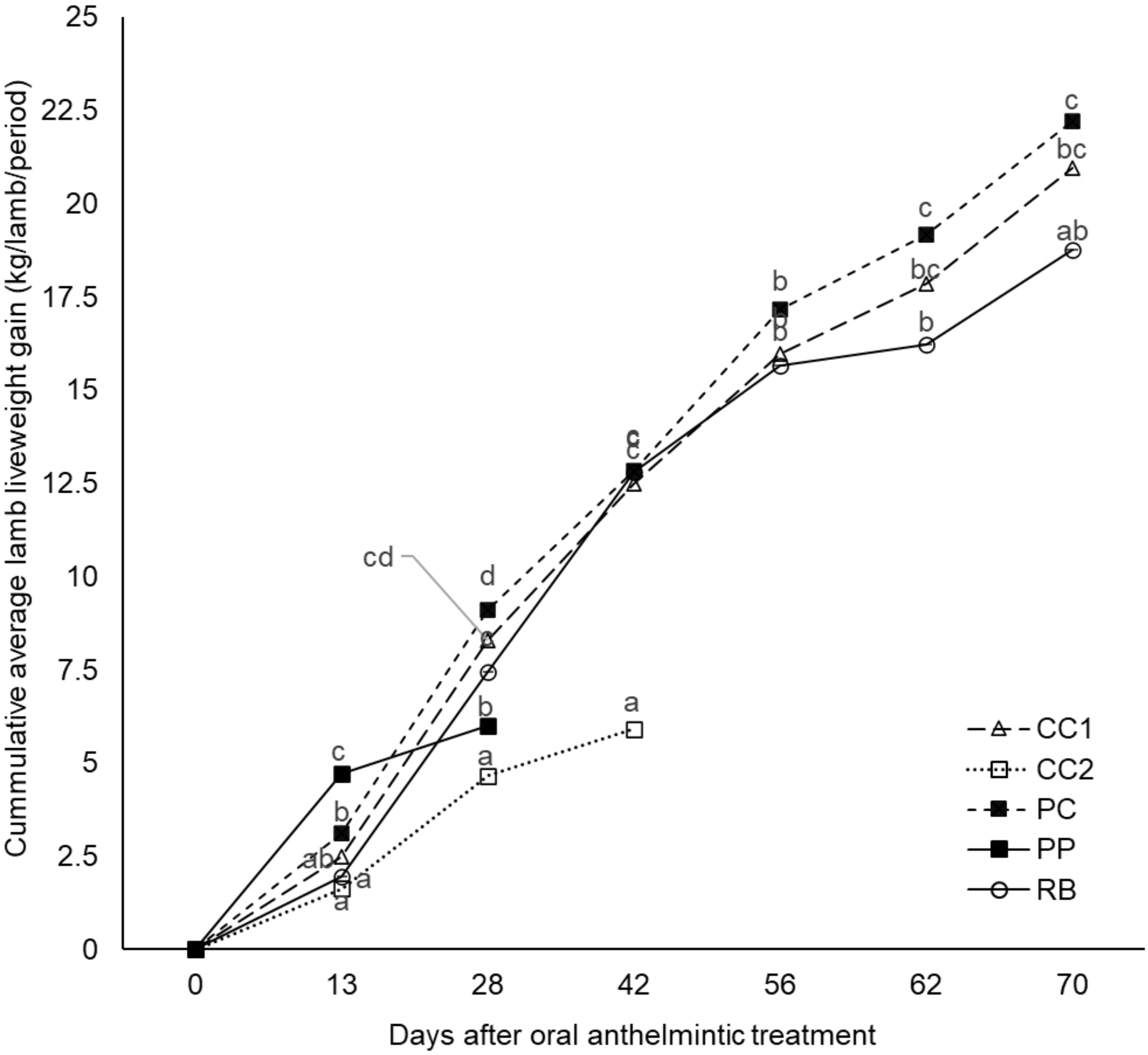

Figure 2. Cumulative liveweight gains by lambs grazing five different forage treatments. Different letters indicate statistically significant differences ($p<0.05$). CC1; first year chicory (*Chicorium intybus* cv. 'Sika', red clover (*Trifolium pratense* cv. Amigain) and white clover (*Trifolium repens* cv. Quartz); CC2, second year chicory cv. 'Sika', Amigain red and Quartz white clovers; PC, plantain (*Plantago lancelolata* L. cv. Ecotain®), Amigain red and Quartz white clover; PP, perennial ryegrass (*Lolium perenne* cv. Vast), Amigain red and Quartz white clover; RB Cleancrop™ Pallaton Raphno®.

The outcomes from this study demonstrated lambs that grazed first year sown summer forage crops CC1, PC and RB achieved high lamb liveweight gains of 300g/day, 320g/day, and 270g/day, respectively. These liveweight gains were in the absence of anthelmintic inputs for 70 days following the use of an efficacious anthelmintic treatment. The identification of mechanisms responsible for a reduced FEC by lambs grazing first year forage crops was beyond the scope of this study, yet likely reflect a combination of factors favourable to low FEC in crop-fed lambs.

Forage crops may reduce populations of infectious L3 larvae in the grazing horizon due to plant architecture reducing larval migration (Moss and Vlassoff 1993; Marley et al. 2006, Moss et al. 2011). Forage crops may increase desiccation of strongyle eggs and free-living larvae due to dryness, solar radiation, high temperatures and low humidity compared to a pasture microclimate more conducive to high populations of L3 (Bricarello et al. 2023). Within a chicory-clover sward Moss and Vlassoff (1993) found fewer than 15% of total plant-associated nematode L3 larvae populations at a height of greater than 7.5 cm mm above ground-level. In contrast, 34% and 47% of total L3 larvae populations were found at heights of greater than 7.5 cm above ground level for ryegrass and clover, and lucerne swards, respectively (Moss and Vlassoff 1993). Fewer L3 larvae per kg of dry matter were associated with leafy turnips (*Brassica rapa*; syn. *B. campestris*) than old pasture or other direct drilled or cultivated crop-pasture combinations (Moss et al. 2011).

Improved nutrition of crop-fed lambs that supports greater immunocompetency of lambs (Poppi et al. 1990) may contribute to low FEC from lambs that graze first year forage crops. Protein nutrition is of particular importance, with a greater supply of metabolisable protein to the abomasum and small intestine associated with improved immunological competency (Crawford et al. 2020).

Liveweight gains by lambs grazing first year summer forage crops were significantly higher than lambs grazing pasture or a second year CC2 chicory/clover crop. These findings are in agreement with previous studies reporting higher liveweights for lambs grazing brassica or herbs (Phillips, 2025) compared to pasture-fed lambs. Lambs that grow more quickly and attain heavier liveweights at a younger age may benefit from an earlier onset of acquired immunity, conferring greater immunocompetency (Greer and Hamie 2016).

The similarity between FEC and liveweight gains for lambs grazing the first-year sown crops supports the option to use any one of these forages as a method to reduce burdens of strongyle parasites in weaned lambs. The second year CC2 treatment delayed the onset of elevated FEC in lambs by 6 days compared to PP lamb FEC, providing a small benefit to CC2 crops by slightly delaying the requirement for anthelmintic treatment compared to pasture-fed lambs. The CC2 treatment was intentionally grazed with in lamb ewes then ewes with lambs during the winter and spring before the study began. A high strongyle egg load on the CC2 treatment, combined with a reluctance by CC2 lambs to graze vernalised and lignified reproductive chicory CC2 plant parts likely explains the early elevation of CC2 FEC. Lambs selectively overgrazed the red and white clovers of the CC2 crop to low post-grazing residuals. Better grazing management of CC2 vernalised chicory with an alternative stock class such as cattle may have improved lamb performance outcomes for the CC2 treatment. Lambs that grazed a 3-year-old Ecotain/red clover pasture maintained lamb FEC counts at less 500 epg for 70 days post-Zolvix™Plus drench in a Southland based study that followed the same study protocol as for the current study (Butcher, pers. comm.).

For second and subsequent years herb-clover mixes to be protective against strongyle reinfection of lambs, the crop should be winter/spring grazed by non-sheep stock classes and manage reproductive development of chicory by hard grazing or mulching. For high performance stock classes, post-grazing residuals for herb/clover swards should be maintained higher than 8 cm (Cranston et al. 2015), a height that should support optimum lamb nutrition whilst greatly reducing intake of L3 larvae (Moss and Vlassoff 1993).

First year forage crops limited the re-establishment of strongyle parasites in lambs and supported high lamb liveweight gains. Second year forage crops such as chicory/clover crops may provide benefits for parasite management however second year reproductive development of chicory must be well managed to maintain chicory in a vegetative, palatable state.

The exclusion by crop-fed lambs to pasture areas and preventing or minimising establishment of grasses and weed species within and beneath forage crops will be important when transferring findings from this study to commercial farming situations. Pasture access and/or grasses and weeds in crops will harbour infective L3 larvae, potentially reducing benefits associated with forage crops to minimise transfer of L3 larvae to the grazing horizon.

Repeated faecal egg counting is an essential part of protocols for using forage crops to reduce reliance on repeated anthelmintic treatments in crop-fed lambs. Verifying the efficacy of the initial anthelmintic treatment through FEC 7–10 days post-drench (‘DrenchCheck’) is critical. If the initial treatment is ineffective or its efficacy is reduced, the benefits of maintaining lower GIN burdens in crop-fed lambs will be substantially diminished.

Acknowledgements

The authors would like to acknowledge PGG Wrightson Seeds team members Richard Goldie for agronomic support and oversight of crops and pastures, and Brent Macauley for assistance with stockwork. Thank you to Dr David Baird (VSN NZ Ltd.) for statistical analysis. This project was part of a collaborative joint project between PGG Wrightson Seeds and PGG Wrightson Limited.

References

Anonymous. 2024. Lamb crop report. 2024. Beef and Lamb New Zealand Limited. https://beeflambnz.com/knowledge-hub/PDF/lamb-crop-report-2024.pdf [Accessed 30 April 2025].

Bricarello PA, Longo C, da Rocha RA, Hotzel MJ 2023. Understanding animal-plant-parasite interactions to improve the management of gastrointestinal nematodes in grazing ruminants. Pathogens 12: 531. https://doi.org/10.3390/pathogens12040531

Cranston LM, Kenyon PR, Morris ST, Lopez-Villalobos N, Kemp PD 2015. Effect on post-grazing height on the productivity, population and morphology of a herb and legume mix. New Zealand Journal of Agricultural Research 58: 397-411. https://doi.org/10.1080/00288233.2015.1044014

Crawford CD, Mata-Padrino DJ, Belesky DP, Bowdridge SA 2020.Effects of supplementation containing rumen by-pass protein on parasitism in grazing lambs. Small Ruminant Research 190: 106161https://doi.org/10.1016/j.smallrumres.2020.106161

Gibbs J, Sise J, McCorkindale B and Fennessy P 2017. Analysis of supplemental feed use in the New Zealand sheep industry. Ministry for Primary Industries, New Zealand. https://www.mpi.govt.nz/dmsdocument/20909-analysis-of-supplemental-feed-use-in-the-new-zealand-sheep-industry [Accessed 30 April 2025].

Greer AW and Hamie JC 2016 Relative maturity and the development of immunity to gastrointestinal nematodes in sheep: an overlooked paradigm? Parasite Immunology 38: 263-272. https://doi.org/10.1111/pim.12313

Marley CL, Fraser MD, Roberts JE, Fychan R, Jones R 2006. Effects of legume forages on ovine gastrointestinal parasite development, migration and survival. Veterinary Parasitology 138: 308-317 https://doi.org/10.1016/j.vetpar.2006.02.001

Moss RL and Vlassoff A 1993. Effect of herbage species on gastro-intestinal roundworm populations and their distribution. New Zealand Journal of Agricultural Research 36: 371-375. https://doi.org/10.1080/00288233.1993.10417734

Moss RA, Dynes RA, Goulter CL 2011. Effect of herbage species and renewal technique on the free living stages of gastro-intestinal roundworms. New Zealand Journal of Agricultural Research 54 (1), 15-22. https://doi.org/10.1080/00288233.2010.535488

Nødtvedt A, Dohoo I, Sanchez J, Conboy G, DesCĵteaux L, Keefe G, Leslie K, Campbell J 2002. The use of negative binomial modelling in a longitudinal study of gastrointestinal parasite burdens in Canadian dairy cows. Canadian Journal of Veterinary Research 66: 249-57.

Pena-Espinoza M, Valente AH, Thamsborg SM, Simonsen HT, Boas U, Enemark HL, Lopez-Munoz R, Williams AR 2018. Antiparasitic activity of chicory (*Cichorium intybus*) and its natural bioactive compounds in livestock: a review. Parasites and vectors 11: 475-489. https://doi.org/10.1186/s13071-018-3012-4

Phillips H 2025. Meat quality and fat deposition of lambs finished on different summer forages. Doctoral thesis, Massey University.

Playford MC and Besier RB 2024. Gastrointestinal nematode parasites of grazing ruminants: a comprehensive review of diagnostic methods for quantifying parasitism, larval differentiation and measuring anthelmintic resistance. New Zealand Veterinary Journal. https://doi.org/10.1080/00480169.2024.2415029

Poppi DP, Sykes AR, Dynes RA 1990. The effect of endoparasitism on host nutrition – the implications for nutrient manipulation. Proceedings of the New Zealand Society of Animal Production 50: 237-243

Riddy S 2025. Drench resistance update 2025. https://www.awanuivets.co.nz/drench-resistance-update-2025/ [Accessed 23 December 2025]

Ridler AL, Hytten K, Gray DI, Reid JI 2024. Reduced anthelmintic use on 13 New Zealand sheep farms: farmer motivations and practical implementation. New Zealand Veterinary Journal https://doi.org/10.1080/00480169.2024.2399654