Modelling liveweight performance in parasitised lambs under varying grazing rotation lengths

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Abstract

A dynamic model for nematode parasites in lambs which links their adult worm burden with decrease in liveweight gain has recently been developed. This model allows for individual lamb variability in response to parasite infection. We use this model to track the liveweight performance of a mob of weaned lambs under six different grazing rotation length scenarios. In all scenarios, lambs with a low worm burden were weaned onto parasite-free pasture. Post-weaning, lambs were either grazed in a 12-week, 8-week, 6-week, 4-week or 2-week grazing rotation, or set stocked. Scenarios were run for 24 weeks with no anthelmintic intervention. The 12-week and 8-week grazing rotation scenarios provided lower worm burdens, higher liveweight gains and lower variation between individual lambs than the other scenarios due to the delay in grazing self-contaminated pastures. For systems that use little or no anthelmintics, being able to provide 8 weeks or more of parasite-free pasture to weaned lambs is likely to provide substantial benefits in the form of higher liveweight gains with less variation between individuals.

Keywords: grazing, lambs, liveweight, modelling, parasites

Introduction

Internal parasites are estimated to cost the sheep industry $300 million annually in lost production and drench use (Rattray 2003). Despite this large economic cost, very little work has been done in the modelling arena to link studies of parasite dynamics with their effect on host productivity. Moreover, the majority of parasite population models treat all hosts within a mob as identical with respect to their response to infection. However, it is a common observation that a small proportion of the mob harbours the majority of the total adult parasite burden (Barger 1985).

Farmers often drench lambs around the time of weaning. However, drenching affects only the parasites within the animal while the bulk of the parasite population is present either in the faeces or pasture as eggs or larval stages. Thus drenched lambs can be rapidly re-infected when grazing this contaminated pasture through the ingestion of third stage infective larvae (L3). The challenges to host productivity are greater in low-chemical or organic systems where drench use must be restricted. Many farmers report satisfactory lamb growth rates in these systems while on their mother but significant checks in growth can occur post-weaning.

One strategy to manage parasites without the use of drenches would be to periodically move lambs from pasture contaminated with larvae to non-contaminated (clean) pasture. This clean pasture might be newly developed, or previously grazed by resistant stock classes (e.g. older sheep, cattle) which remove the majority of the infective L3 and contribute few eggs in their faeces (Familton & McAnulty 1997). The timing of the move from contaminated pasture to prevent any lambs from developing a worm burden sufficient to cause a decline in growth rate is important. This will be particularly true for organic and low-chemical lamb finishing systems, where there is a substantial premium for lambs achieving slaughter weights with minimal or no anthelmintic use. A dynamic host-parasite model was used to investigate the effects of set stocking and different grazing rotation length on lamb liveweight, worm burden and L3 density on pasture.

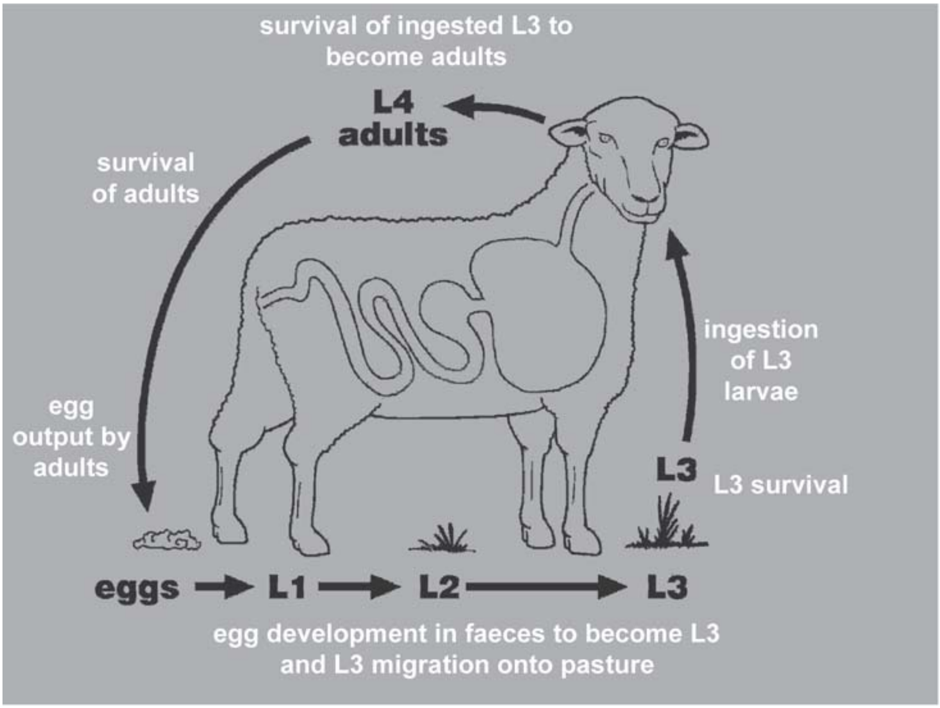
Methods

Model description

We have recently developed a dynamic model for internal parasites in lambs which can link their individual worm burdens with decreases in liveweight gain (Louie *et al.* 2006). The immunity level of each host lamb is assumed to be determined by its cumulative L3 exposure; increasing with L3 intake and declining if L3 intake ceases. The model also allowed for genetic variation in resistance to internal parasites within a mob of lambs. Thus a lamb that is highly resistant has a lower proportion of ingested L3 establishing as adults, higher worm mortality and lower fecundity than one of low resistance, even though both may have had the same exposure to L3 and hence are currently at the same immunity level.

The number of L3 on the grazing area increases because of development of eggs deposited in the faeces and decreases because of mortality and ingestion by the lambs. The egg-laying capacity of adult parasites decreases with increasing level of immunity. We also allow for the development time of eggs to the infective L3 stage and assume this is fixed at 2 weeks (see Fig. 1).

Figure 1 A simplified life-cycle of a sheep internal parasite



Ingestion of L3 occurs as pasture is eaten. In the model, lamb intake is modified in two ways; by pasture mass and worm burden. If pasture mass is very high the intake of pasture reaches a plateau value determined by the age of the lamb, and for lower pasture mass intake is assumed to vary with pasture mass. Secondly, lambs with a large worm burden are assumed to have their appetite depressed and consume less pasture than those with smaller burdens. Pasture mass is assumed to increase following logistic-type growth with seasonal variation and will decrease under grazing. Finally, the liveweight of each lamb will change according to its pasture intake and demands of metabolisable energy (ME) for maintenance and growth. In addition to allowing pasture intake to vary with worm burden, we also assume that worm burden affects the efficiency with which ME is utilised for maintenance and growth. Specifically, we postulate that lambs with high worm burden have lower efficiencies of utilisation of ME, and that this dependence follows an inverse curvilinear relationship with increasing burden. For the full statement of the model in mathematical terms we refer the reader to Louie *et al.* (2006).

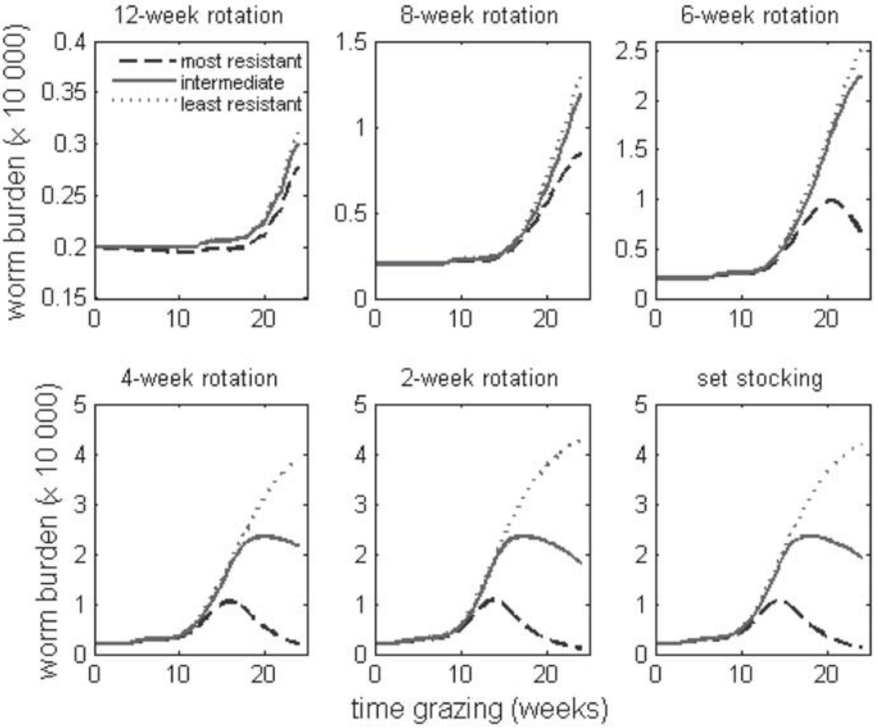
Model scenarios

We used the model to address the following question. A mob of 15 weaned lambs is required to be finished to a specified liveweight over 24 weeks on initially parasite-free pasture in a given area. With no use of drenches, is set stocking or rotational grazing the better strategy to minimise parasite infection and meet the required growth rate target? What effect does rotation length have on worm burden and liveweights? Drenching was left out

Table 1 The number of weeks spent in each paddock, rotation length and number of grazings in each paddock for the six treatments.

Treatment	Weeks per paddock	Rotation length (weeks)	Grazings per paddock over 24 weeks
1	2	12	2
2	1.33	8	3
3	1	6	4
4	0.67	4	6
5	0.33	2	12
6	24	0	continuous

Figure 2 The worm burden of three lambs (most, intermediate and least resistant) under the six treatments.



of this study, but is addressed by a computer decision making technique by Snow *et al.* (2006).

The available area for grazing was set at 1 ha divided into six equal-sized paddocks. Each paddock was grazed by the mob in succession for a total grazing duration of 24 weeks. The lambs were assumed to weigh 20 kg and carry a worm burden of 2000 at weaning. Initial pasture mass and larval density was 2000 kg DM/ha and 0 L3/ kg DM respectively. The lambs started with a low value for immunity as they were assumed to have ingested some L3 during the pre-weaning period. Six rotation lengths were tested, ranging from set stocking to a 12-week rotation (Table 1).

Results and Discussion

Figure 2 shows the worm burdens of three out of the 15 lambs under each treatment. The three lambs shown were the most and least resistant together with one of intermediate resistance. During the first few weeks there was very little change in worm burden because the mob was being moved to non-contaminated paddocks before L3 had developed. However, with shorter rotations and set stocking, the mob grazed paddocks for a second time more quickly, thereby being exposed to L3 earlier, and thus their worm burden increased sooner. There was a threefold increase in the worm burden of the least resistant lamb after 24 weeks grazing when rotation length was halved from 8 to 4 weeks. There was much less effect on the worm burden in the most resistant lamb although this decrease in rotation length caused the peak value to occur much earlier so that, by 24 weeks, the worm burden was lower in the 4-week rotation scenario. Once the rotation length was less than 4 weeks the effect of rotation length on worm burden was minor.

Figure 3 shows the liveweights of the same three lambs considered in Figure 2. The greatest change again occurred when rotation length was decreased from 8 through 6 to 4 weeks and was most noticeable in the less resistant lambs. This drop in liveweight gain was a consequence of the large worm burdens these lambs were carrying, and was severe enough to cause loss of weight in the least resistant and intermediate lambs under treatments 3 to 6 during the latter part of grazing.

Figure 4 shows the L3 densities on the first paddock only, under the six treatments. The L3 densities on the other five paddocks were similar but with differences in the timing of peak values. In the first treatment, there was a single peak in L3 density which occurred near the end of grazing, and this peak value was much lower than in the other treatments. As the rotation length decreased, the L3 density increased to very large values between each grazing. However, the L3 density averaged over the six paddocks appeared to converge to the set stocking case as the rotation length neared zero.

Figure 3 The liveweight of three lambs (most, intermediate and least resistant) under the six treatments.

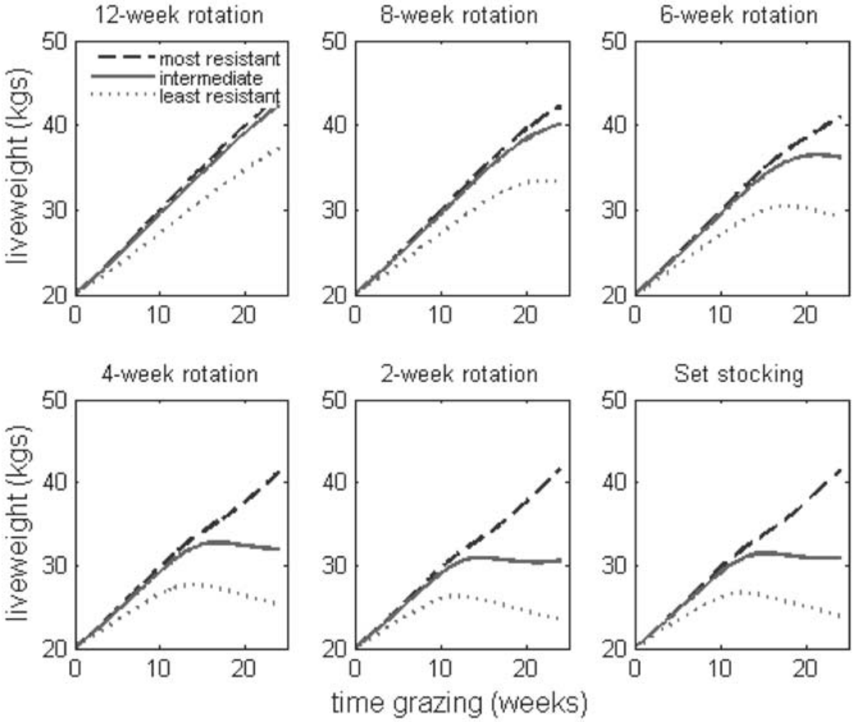


Figure 4 L3 density on paddock 1 (of 6) under the six treatments.

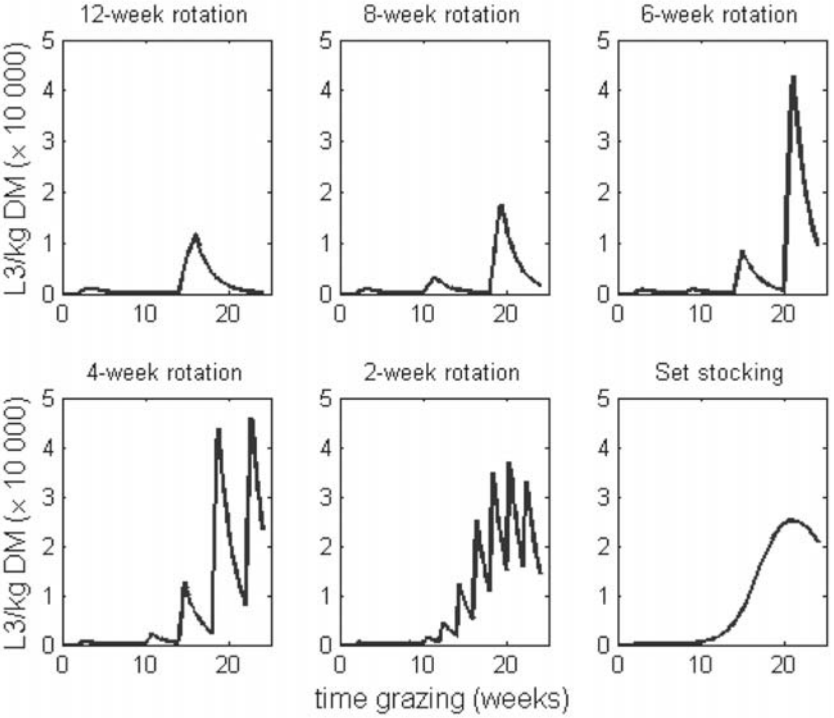


Figure 3 shows that a longer rotation length, which extends the time before the lambs return to paddocks they have previously contaminated, leads to better liveweight gain than set stocking or short rotations. However, this must be balanced with the need to ensure good pasture utilisation on the entire grazing area. Moreover, the optimum rotation length is likely to be highly dependent on the development time of L3 from eggs. In the model this has been fixed at 2 weeks whereas in reality it is temperature-dependent, with movement of L3 out of dung onto pasture also requiring moisture. The duration between egg deposition and movement of L3 onto pasture can range from 8 to 28 days in New Zealand (Vlassoff 1982). Survival of L3 on pasture is likewise affected by the environment, and is prolonged in cool conditions (Vlassoff 1982). With a fixed development time of 2 weeks, lambs on all treatments were always grazing clean pasture during the first rotation. Under a 12-week rotation, in the second half of the 24-week period, lambs were then ingesting L3 which have developed from eggs arising solely from their original (pre-weaning) small worm burden. As the rotation length decreased, ingestion of L3 in the third and later rotations included those produced by adult worms from eggs that had developed from L3 ingested from the experimental area. Figure 4 shows that the L3 density on paddocks in the later rotations can be very high as the rotation length decreases.

If the mob is going for slaughter within 10 weeks of weaning, then as long as the block that they remain on post-weaning starts off clean, grazing rotation will have little effect on liveweight gain, even when individual variability is considered.

This model demonstrates the individual animal liveweight variation that can exist under different grazing rotation lengths. It illustrates that there are resistant individual lambs that can cope with high-parasite situations. If a low-challenge environment can be maintained then this can result in less variation between individual animals.

The model has the potential to test a range of managements for parasite control in sheep. These include using other stock classes to “clean-up” L3 from those paddocks not currently grazed by the lambs, appropriate drenching intervals under different worm burdens or pasture contamination levels, removal or drenching of animals with high worm burdens, or improving nutrition. The results of this experiment show the importance of avoiding grazing management scenarios where lambs quickly self- contaminate pastures. The benefits of delaying the re-grazing of self-contaminated pastures were substantial in this analysis. These benefits will compound further if finishing stock are able to achieve slaughter weights earlier, thereby allowing lower stocking rate, and leading to lower self-contamination.

The importance of providing parasite-free grazing for weaned lambs is illustrated by the weight loss that occurred in many of the lambs under the shorter grazing rotations. The ease with which a farmer can generate parasite-free grazing varies according to the farm system that is operated. Methods for providing relatively clean feed include new pasture, fodder crops and pastures that have been grazed for an extended period with mature sheep or cattle only. These options become more important where there is limited ability to use anthelmintics.

Conclusion

When lambs carrying a small worm burden are weaned onto clean pasture there is little increase in worm burden and hence effect on liveweight in the first 10 weeks of grazing. After this period, rotation lengths greater than 6 weeks are likely to enhance animal performance but may be impractical for optimum pasture utilisation. For lambs retained for longer periods, further clean pasture will therefore be required.

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