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EFFECT OF GRAZING SYSTEM AND ANTHELMINTIC TREATMENT OF EWES ON PARASITE CHALLENGE AND LAMB GROWTH

by

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SUMMARY

The adverse effect of parasites on lamb growth rate has been well documented. The combination of concerns about worm resistance to anthelmintics and consumer demand for products without chemical residues has increased the need to re-evaluate current control methods. In order to be effective and sustainable, control measures should include grazing management systems that exploit parasite life cycles. This will facilitate the rational use of anthelmintics.

The work undertaken, over three grazing seasons, was designed to evaluate the effect of a "safe" grazing system on the gastrointestinal parasite (roundworms) levels in ewes and lambs, on the number of infective larvae on herbage and on lamb growth. The study comprised 6 similar sized paddocks; 2 paddocks of permanently grazed sheep pasture ("contaminated") and 4 paddocks of which 2 were rested from lambs in alternate years to render them safe for lambs ("safe"). Ewes and lambs were set stocked on 2 "safe" and 2 "contaminated" paddocks each year. The first year was treated as an establishment year for the study.

The main results confirm the merits of not grazing ewes and their lambs on the same pasture from lambing to weaning in successive years in achieving lower numbers of infective *Nematodirus* larvae on pasture, which ultimately translates as "safer" levels in lambs.

There was a low level of residual over-wintered infection of "other trichostrongyles" on pasture in spring and this most likely could be attributed to the dosing regime used in the study which served to reduce contamination on pastures in late summer / autumn period.

While the anthelmintic treatment of ewes prior to turnout in spring reduced faecal egg count in ewes and the mid-summer build-up of “other trichostrongyle” larvae on pasture this was not reflected in an lower total faecal egg count in lambs. Significant differences in growth rate to weaning and to 4 weeks post-weaning therefore could not be attributed to parasite burdens. Consistent yearly differences in growth rates emerged between lambs that grazed the “contaminated” compared to “safe” pastures. As no differences in faecal egg count between groups of lambs grazing similar swards but exposed to different levels of infection the differences observed with respect to growth rate may only be attributed to the difference in pasture quality.

While there were some differences with respect to faecal egg count (i.e. *Nematodirus* but not the “other trichostrongyles”) observed between sibling lambs at 14 weeks, where one of each twin pair received a 10-week anthelmintic dose while the other did not, this was not reflected in growth performance.

The growth rate of lambs that went to after-grass post-weaning was higher than that observed in lambs that remained on their original pre-weaning plots. Faecal egg counts of lambs moved to after-grass at weaning (post-dosing) was lower than those that remained behind on the original plots regardless of the experimental group.

INTRODUCTION

The performance of grazing lambs can be seriously affected by parasite challenge. The internal parasites that commonly affect sheep belong to 4 groups: nematodes (roundworms) trematodes (flukes), cestodes (tapeworms and protozoans (coccidia & *Toxoplasma*). This report will focus on nematodes in sheep. Parasitic gastro-enteritis (PGE) (characterised by diarrhoea and lack of thrive) if caused by roundworms, is usually due to a mixed infection in which *Teladorsagia* (*Ostertagia*) *circumcinta* predominates. The other roundworm parasites, which may contribute, include *Trichostrongylus* species *Cooperia* and *Nematodirus* spp.

The life cycles of most of the major gastrointestinal nematodes are similar. The adult female worm produces eggs that are passed out on to the pasture in the host's faeces. Given suitable conditions of warmth and moisture the eggs (see Plate 1) will hatch, complete two free-living feeding larval stages (L1 to L2) to become a non-feeding infective third stage (L3) (see Plate 2). As a L3 retains the cuticle of the second larval moult and will survive on its lipid reserves, it is best equipped to survive adverse conditions and is able to survive for many months at low temperatures and can overwinter on pasture. When ingested by a suitable host the infective larvae (L3) mature to become adults and the females produce eggs. The length of time between larval ingestion and the appearance of eggs (known as the prepatent period) in faeces is about 3 weeks. *Nematodirus* is atypical in that all development to L3 occurs within the egg and in the case of *Nematodirus battus* a period of cold exposure is a prerequisite to hatching. As a result summer/autumn hatching is largely inhibited and a mass hatch of *Nematodirus battus* eggs occurs in late spring or early summer of the following year. *Nematodirus filicolis* may also be found but does not need the same preconditions to stimulate hatching and may therefore hatch within the same year. In Ireland, *Nematodirus* and *Teladorsagia* are the principal species found (Kearney, 1966, 1967, 1968).

In addition to the ability of infective larvae (L3) to survive on pasture for many months at low temperatures, there are two factors, which affect the normal parasitic life cycle. These factors ensure the continuation of parasitism to the next season: (a) arrested larval development within the host and (b) the periparturient rise in faecal egg counts. Arrested/inhibited larval development can be described as the phenomenon whereby there is temporary cessation in development of the nematode. By remaining sexually immature in the host until more favourable conditions return, the parasite ensures the survival of another generation. Not all nematodes have the same disposition for arrested development (Urquart, Armour, Duncan, Dunn and Jennings, 1996). Larvae may be induced to arrest their development in response to host resistance or an external seasonal stimulus, such as, the increasingly colder temperatures experienced in autumn/winter which condition larvae to arrest on entry into the host.

The periparturient rise in faecal egg counts observed in ewes is a result of a temporary relaxation in their immunity. The source of the high egg count could be threefold - the maturation of arrested larvae (arrested because of host immunity), an infection (overwintered infective larvae) picked up on the pasture or an increased fecundity of an existing adult worm population. The importance of this rise in faecal egg count is that it occurs at a time when there is an increasing number of susceptible hosts i.e. lambs, thus enhancing the chances of parasite survival.
The level of parasitism acquired by the grazing animal at any one point in time is determined by a number of factors. These factors include the effects of seasonal conditions (which determine the availability of infective larvae on pasture), husbandry system, grazing behaviour, nutrition, previous

experience of infection (leading to immunity), physiological state of the host (notably in relation to the breeding cycle of the ewes) and the genetic make-up of the host. To a susceptible host the major epidemiological variable that influences the worm burden is the number of infective larvae ingested from the pasture each day. There is also clear evidence for genetic variation in the host's response to parasites (Stear and Wakelin, 1998; Hanrahan and Crowley, 1999; Good, Hanrahan and Crowley, 2000).

In contrast to adult sheep, which are mostly resistant to gastrointestinal parasitism, lambs are vulnerable because they have no previous exposure to infection and thus no resistance. The ability of a sheep to mount an effective immune to parasite exposure response is acquired over time. The time taken to develop this resistance and the degree of resistance acquired will depend not only on the genetic predisposition of the host to infection but also on the species of parasite. For example, *Nematodirus* can induce a long lasting resistance to infection. In contrast, despite adequate exposure, resistance to establishing an infection is slower to develop in *Teladorsagia* and may not persist under certain conditions.

In spring/early summer lambs are confronted with two sources of infection as soon as they commence grazing: (a) residual over-wintered larval population and (b) the larval population resulting from the ewe's increased faecal egg output around parturition and early lactation. Later in summer, as a result of acquiring infection from the above two sources, lambs will be exposed to an increased level of infection derived from their own contamination of the pasture.

The control of parasites in sheep at pasture is normally attempted by a combination of grazing management and use of anthelmintics. Several measures may be adopted to maintain "safe" levels of parasites on pasture.

- Avoid grazing ewes and lambs on the same pasture in successive years. This may be achieved by grazing sheep and cattle in alternative years or sheep grazing and cutting hay/silage in alternate years. This breaks the life cycle and should greatly reduce the risk of *Nematodirus* infection in lambs.

- Reduce over-winter infection of parasites on pasture. The main source of this infection is from lambs grazing in autumn. Eggs deposited on pasture in autumn may develop to L3 infective stage and survive on pasture over winter and cause infection in ewes and lambs in spring.

- Reduce the periparturient rise in faecal egg output of ewes by dosing them with anthelmintics at housing or lambing and at 5 weeks post lambing. This dose reduces the build up of infection on pasture in summer and as a consequence helps keep pastures safer for ewes and lambs.

- After weaning move lambs to after-grass for safer grazing and thereby avoid the pastures where a build up of infections may have occurred between lambing and weaning.

The overall aim of this project was to determine the effect of a “safe” grazing system and anthelmintic treatment of ewes and lambs on (a) the number of infective larvae on herbage, (b) parasite levels in ewes (c) parasite levels in lambs and (d) on lamb growth rate.

METHODS

Pasture and animal management

The study was conducted over the 3 years, 1998, 1999 and 2000. Permanent pastures on free draining soil were used and had been managed in a cattle/sheep mixed grazing system in the previous 7 years. Pastures were rested from early December, when ewes were housed, until ewes and lambs were turned out in spring. Groups of 24 to 30 ewes were set stocked with their lambs on 1.5 ha of pasture at stocking rates of 16 to 20 ewes per ha from birth to weaning. The number of lambs reared per ewe varied form 1.75 to 1.88. The aim of the grassland management was to maintain similar sward heights on all paddocks so that any differences in lamb growth would reflect the treatments used. The ewes were Belclare X Scottish Blackface and they were mated with Suffolk rams. Lambing dates were about 6 April, 27 March and 22 March in 1998, 1999 and 2000, respectively. The lams were weaned at 14 weeks of age.

In accordance with the project objectives, four treatments were evaluated:

(1) "Safe" pasture, ewes dosed (SD)
(2) "Safe" pasture, ewes undosed (SU)
(3) "Contaminated" pasture, ewes dosed (CD)
(4) "Contaminated" pasture, ewes undosed (CU)

"Safe" pasture is defined as pasture that had been cut for silage in the previous spring and no lambs grazing after 31 August. "Contaminated" pasture is defined as pasture that was grazed in previous spring by ewes and lambs and lambs grazing in autumn. A cut-off date of 31 August for grazing lambs on pasture intended for "safe" grazing was used for two reasons. Firstly, eggs deposited after this date are more likely to contribute to over-winter infection and, secondly, the remaining lambs not drafted by 31 August may with some planning, be grazed on an area of the farm not reserved for sheep grazing in the following spring.

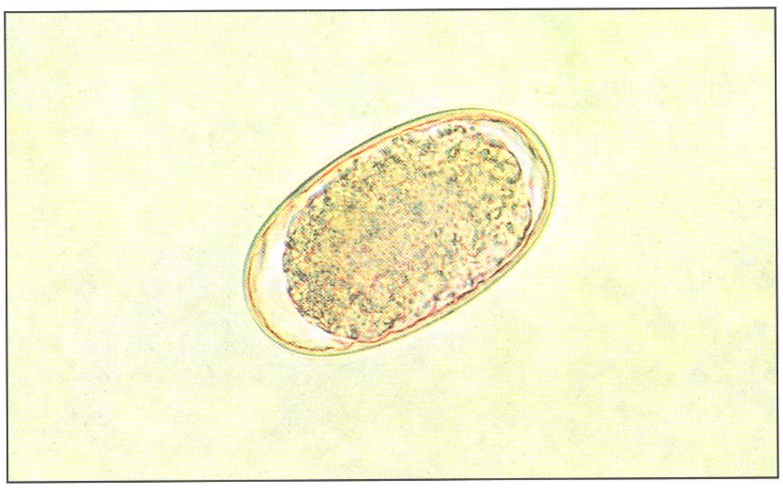
A total of 6 similar sized paddocks were used. Paddocks, 1, 2, 5 and 6 were identified as "safe" pastures and L and M the 'contaminated' pastures. Paddocks 1 and 2 were cut for silage in June 1997 and 1999 while paddocks 5 and 6 were cut for silage in June 1998. These paddocks could therefore be regarded as "safe" from *Nematodirus* infection in the subsequent trial year. Paddocks L and M were grazed by cattle and sheep in 1997 and sheep only in subsequent years and so were expected to be "contaminated "in the following spring.

A summary of the anthelmintics given over the 3 years is shown in Table 1. Ewes were dosed prior to turnout and at 5 weeks post lambing except in year 1998 when <u>all</u> ewes were dosed with Moxidectin at housing due to concerns that the flock had been in contact with sheep that might have had sheep scab. In subsequent year ewes were dosed with Benzimadazole based products because of their proven efficacy against arrested parasitic stages. A Levamisole based product was not used because of varied reports on its efficacy against immature nematodes. Lambs on each treatment were dosed at 5, 10 and 14 weeks of age each year and every month thereafter (Years 2 and 3). In Years 2 and 3, the 10-week dose was omitted from 1 lamb in each of 8 sets of twins in each treatment group. In accordance with the guidelines on delaying the spread of resistance the anthelmintic type was changed annually.

The trial ended at weaning in year 1 but was continued during the post-weaning period in subsequent years. Weaned lambs grazed the same paddocks post-weaning in years 2 and 3 but a sub-sample from each treatment group was transferred to after-grass.

Table 1: Dosing protocol for ewes and lambs and the names of the active ingredient in the anthelmintic products used.

Year	Paddock ID	Ewes prior to turnout	Ewes, 5 weeks post-lambing	Lambs
1	1 & L	Moxidectin	Oxfendazole	Oxfendazole
1	2 & M	Moxidectin	Not dosed	Oxfendazole
2	5 & L	Oxfendazole	Albendazole	Levamisole
2	6 & M	Not dosed	Not dosed	Levamisole
3	1 & L	Ivermectin	Ivermectin	Ivermectin
3	2 & M	Not dosed	Not dosed	Ivermectin



Trichostrongyle egg recovered from faeces (X 400)

Measurements

Grass height: In Years 2 and 3, sward height in all paddocks was measured on a weekly basis using a plate meter. In order to maintain similar sward heights on all paddocks, older barren ewes were added and removed as necessary.

Herbage larvae: Grass samples were collected on a monthly basis (where possible within 1 week of faecal sample collection) from each of the 4 paddocks involved in any particular year. A 100 g sample of fresh grass was removed and dried to constant weight so that larval counts could be expressed as larvae per kg dry matter. Pasture larvae were recovered according to procedures described in MAFF (1986). In 1998 samples were taken over 3 months (May to July). In 1999 and 2000, the sampling period was extended to cover April through to August.

Faecal egg count (FEC): Within each treatment group, 8 ewes that were rearing 2 lambs were randomly chosen. The same ewes and lambs were monitored throughout. Faecal samples were taken from ewes and lambs prior to dosing. The number of eggs per gram (e.p.g.) of faeces was determined using the modified McMaster technique which included a salt flotation where less than 100 e.p.g. was observed (MAFF 1986). In Year 1, FEC were made in ewes and lambs at 5, 10 and 14 weeks post-lambing. In Years 2 and 3, FEC in ewes were assessed at lambing and 5, 10 and 14 weeks post-lambing. Faecal egg counts in lambs were assessed at 5, 10 and 14 and 19 weeks of age.

Lamb weight: All lambs were weighed at times of faecal collection.

Data Analyses

Data analyses employed parametric and non-parametric general linear model (GLM) procedures available using SAS software.

Herbage larvae: GLM procedures were used to examine the effects of factors on the number of infective larvae per kg dry herbage (*Nematodirus and* "other trichostrongyles"). As dry matter was not assessed for herbage in 1998, this data was excluded from results. Factors included in the model were year, ewe treatment (ewes dosed or ewes undosed), pasture type ("safe" or "contaminated") and the various interaction terms.

Faecal egg count (FEC): Data was log transformed to (ln (FEC+50) and analysed using parametric procedures. All FEC values expressed in the results are back-transformed values from the analysis on logscale. As all ewes were dosed in 1998, this data was excluded from the analysis. GLM procedures were used to examine the effects of factors on the egg counts from lambs for each sampling period (5, 10, 14 and 19 weeks postlambing). Factors included in the model were: year, ewe treatment (dosed or not), pasture type ("safe" or "contaminated") and various interactions for each sampling period. The interactions between year and all the factors listed above were also included. The effect of not administering an anthelmintic at 10 weeks of age to one of the twins in each pair set in each treatment group (n=8 per group) was explored in the model examining FEC on week 14. A FEC below 500 eggs per gram is interpreted in this report as a low egg count, between 500 to 2000 a moderate egg count and greater than 2000 a high egg count (Kingbury 1965, Tarazona, 1986).

Lamb weight: The effect of year (Years 2 and 3), treatment, sex, rearing type (single or twin) and age of dam on lamb growth from birth to weaning at 14 weeks was examined.

RESULTS - Year I

As Year 1 was the establishment year for the project, results for this season are summarised first followed by results for Years 2 and 3.

Results for the number of infective larvae in Year 1 are categorised according to treatments are shown in Table 2. It is evident that there was a low level of infection on pasture. No *Nematodirus* larvae were detected on pastures designated as "safe". The number of "other trichostrongyle" larvae were also low but were numerically higher on paddocks where ewes had remained undosed at 5 weeks.

Results on faecal egg counts in ewes and lambs at 5, 10 and 14 weeks post-lambing categorised according to treatment are shown in Tables 3 and 4 respectively. The results on faecal egg counts in ewes reflected the effect of dosing and the type and efficacy of product used. The injectable, avermectin used at turnout had residual activity that protected ewes from re-infection with "other trichostrongyles" but not *Nematodirus* whereas the oxfendazole based product used at 5 weeks had no residual activity which would protect the ewe from reinfection. The low faecal egg counts in lambs reflected the low level of exposure to parasites on pasture.

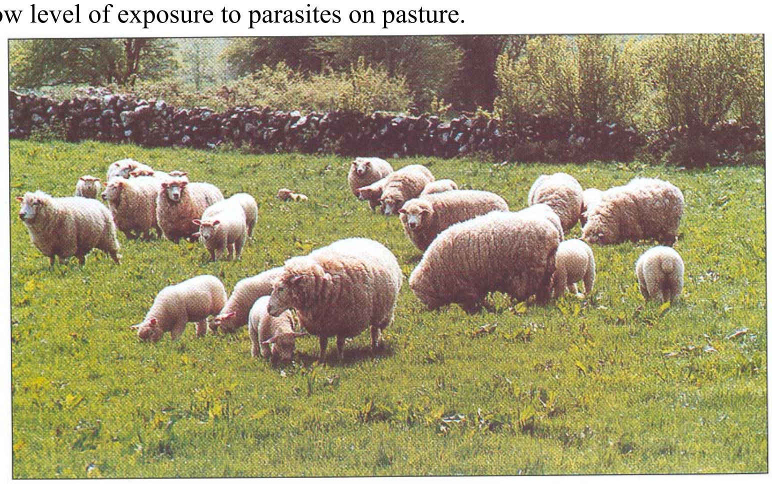


Table 2: Number of infective larvae on herbage in Year 1 (per kg fresh weight).

Treatment*	*Nematodirus*			"Other trichostrongyles"		
	May	June	July	May	June	July
CD	7	0	0	79	86	64
CU	13	5	0	114	117	75
SD	0	0	0	49	41	57
SU	0	0	0	90	66	72

* CD = "contaminated" paddock with dosed ewes
CU = "contaminated" paddock with undosed ewes
SD = "safe" paddock with dosed ewes
SU = "safe" paddock with undosed ewes

Table 3: Faecal egg counts in ewes at 5, 10 and 14 weeks post-lambing (e.p.g.).

Treatment*	*Nematodirus*			"Other trichostrongyles"		
	5	10	14	5	10	14
CD	13	0	0	0	0	105
CU	1	0	0	0	8	39
SD	1	1	7	0	1	11
SU	0	0	0	0	1	17

* See footnote Table 2.

Table 4: Faecal egg counts in lambs at 5, 10 and 14 weeks of age (e.p.g.).

Treatment*	*Nematodirus*			"Other trichostrongyles"		
	5	10	14	5	10	14
CD	0	21	41	0	1	96
CU	7	25	46	0	9	163
SD	0	3	9	0	0	14
SU	0	23	29	0	0	20

* See footnote Table 2.

RESULTS - YEARS II & III

Grass height

The results for grass height measurements taken in years 2 and 3 are shown in Figures 1 and 2. A relatively consistent height was achieved overall across all treatment groups. Height was generally in the range of 5 to 7 cm up to weaning and 7 to 9 cm post-weaning. These heights are consistent with the guidelines for achieving good lamb growth rates when lambs are set stocked (Grennan, 1999).

The paddocks selected as "safe" or "contaminated" contained mainly perennial ryegrass and were considered to be quite uniform. It subsequently emerged during the course of the experiment that the "safe" pasture contained an earlier heading ryegrass cultivar and became "stemmy" earlier than the "contaminated" pasture. This adversely affected lamb growth in mid-season, especially in the 10 to 14 week period and confounded the benefit that might be expected from grazing lambs on the "safe" pasture. As shown in This is reflected in the lamb growth rates as discussed and shown later in Tables 15, 16 and 17.

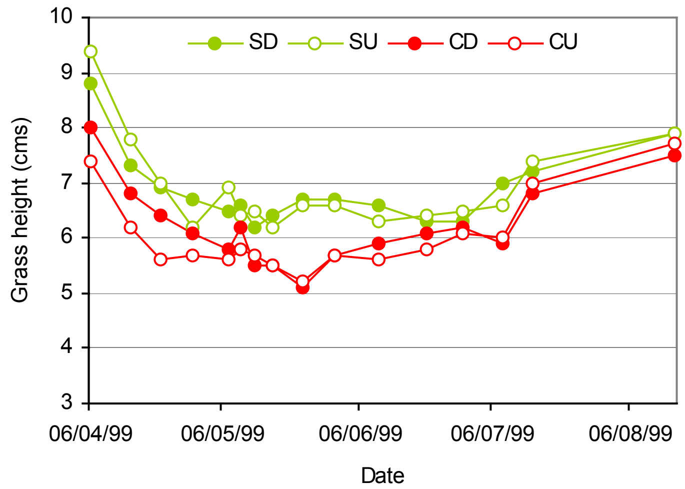


Figure 1: Grass height in Year 2 (Legend: see footnote Table 2).

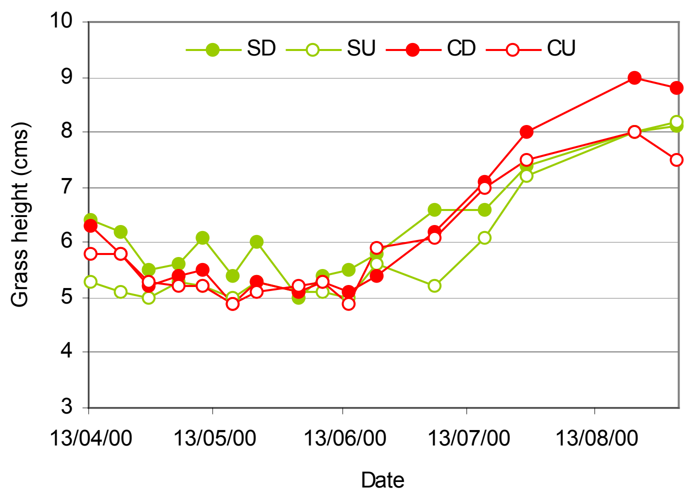


Figure 2: Grass height in Year 3 (Legend: see footnote Table 2).

Herbage larvae

As shown in Tables 5 & 6, a wide range of trichostrongyle larvae was evident on paddocks over the grazing season. When the results from four treatments were pooled as illustrated in Figures 3 and 4, it is evident there is a seasonal distinction in the type of trichostrongyle observed. *Nematodirus* was the most prevalent type of trichostrongyle found in April while the "other trichostrongyle" larvae predominated later.

Table 5: Species composition of larvae (per kg DM) observed in herbage in Year 2.

	April	May	June	July	August
Nematodirus spp	27	8	2	0	27
Ostertagia	17	88	101	400	142
Trichostrongylus spp	0	2	5	120	55
Cooperia	0	39	17	25	42
Bunostomum	0	6	0	9	42
Haemonchus	0	3	0	12	21
Oesophagostomum/ Chabertia	0	2	0	7	0

Table 6: Species composition of larvae (per kg DM) observed in herbage in Year 3.

	April	May	June	July	August
Nematodirus spp	84	183	90	12	125
Ostertagia	20	181	682	265	186
Trichostrongylus spp	0	61	148	41	79
Cooperia	0	14	5	23	13
Bunostomum	0	70	51	12	8
Haemonchus	0	4	0	13	6
Oesophagostomum/ Chabertia	0	10	5	2	2

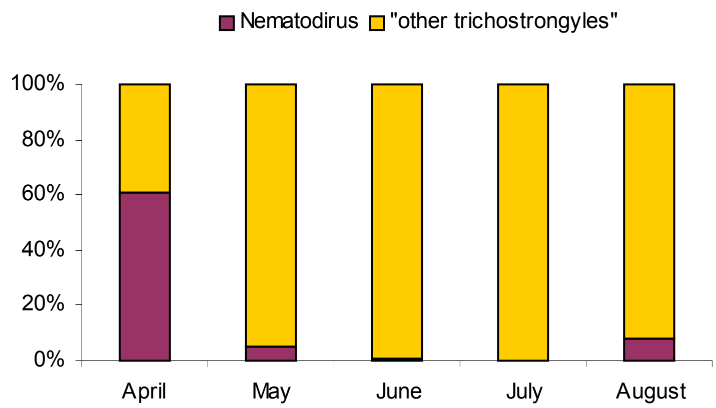


Figure 3: Categories of larvae observed on herbage by month in Year 2 (average of 4 treatments).

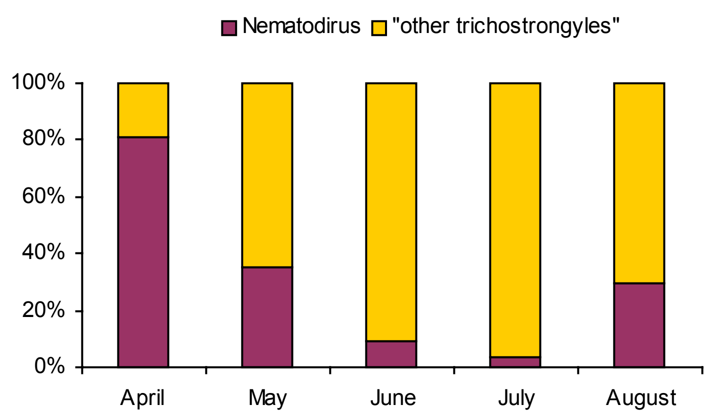


Figure 4: Categories of larvae observed on herbage by month in Year 3 (average of 4 treatments).

Nematodirus

Herbage larvae: The number of infective *Nematodirus* larvae present on herbage for each treatment is shown in Figures 5 and 6. There was a significant difference in the number of larvae between years ($P<0.05$); more larvae were evident in Year 3 than in Year 2. In general, *Nematodirus battus* (which has specific hatching requirements) was the predominant *Nematodirus* species recorded in the spring and N. *filicolis* (which can hatch within the same year) became more evident as the season progressed.

There was a significant difference between pasture treatment groups ($P<0.05$) with "safe" paddocks having lower numbers of larvae compared to the "contaminated" paddocks. Dosing ewes had no effect on the number of *Nematodirus* larvae observed on paddocks.

Faecal egg counts in ewes: As expected, the number of *Nematodirus* eggs observed in ewes was negligible (Table 7). This confirms a more absolute resistance to *Nematodirus*, which is not observed in other parasites such as *Teladorsagia.*

Table 7: Mean *Nematodirus* faecal egg count in ewes (e.p.g.).

Treatment	Weeks post-lambing							
	Year 2				Year 3			
	0	5	10	14	0	5	10	14
CD	0	9	0	0	0	0	0	0
CU	7	1	0	0	3	1	0	0
SD	0	1	1	0	0	1	0	0
SU	7	1	0	0	21	26	0	0

* See footnote Table 2.

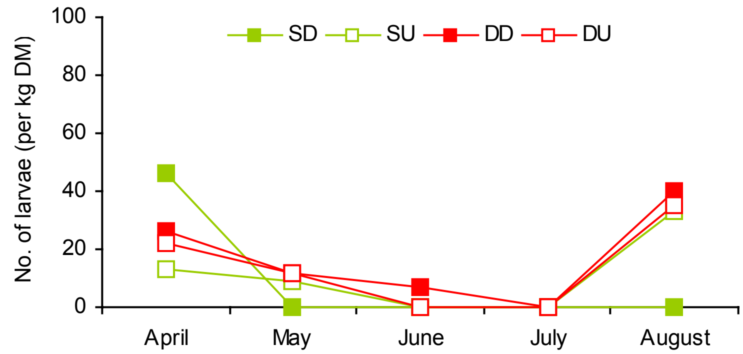


Figure 5: Number of infective *Nematodirus* larvae on pasture in Year 2 (Legend: see footnote Table 2).

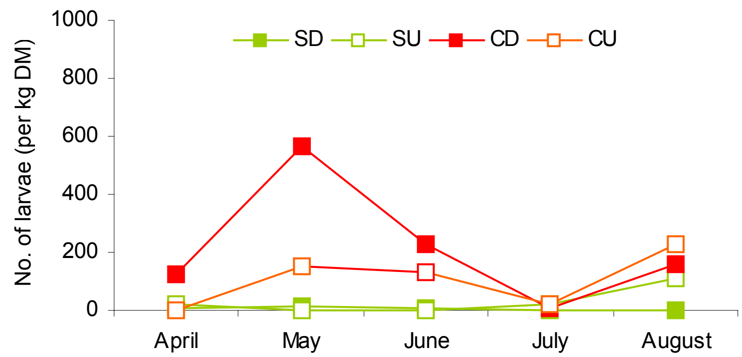


Figure 6: Number of infective *Nematodirus* larvae on pasture in Year 3 (Legend: see footnote Table 2).

Faecal egg counts in lambs: The results for *Nematodirus* faecal egg counts in lambs from each treatment group in year 1 and 2 are shown in Figures 7 and 8. A significantly higher FEC was observed at weeks 14 and 19 in the third compared to the second year ($P<0.0001$).

Pasture type had a significant effect on the FEC ($P< 0.05$) observed at 10 and 14 weeks of age Overall, lambs grazing the "contaminated" pasture had higher FEC than lambs grazing "safe" pasture

There was a significant interaction between year and pasture type at weeks 10 and 14 post-lambing ($P<0.001$), which means that the differences found between treatment groups depended on the year. Faecal egg counts were higher and the difference between treatment groups more marked in Year 3 compared to the previous year. This reflects the higher number of *Nematodirus* larvae observed on herbage in Year 3. By week 19, *Nematodirus* FEC had decreased substantially which is consistent with the evidence in the literature that immunity *to N. battus* develops quite early in lambs (Gibson & Everett 1963, Taylor & Thomas 1986) and as a consequence would be marked by a decline in faecal egg count.

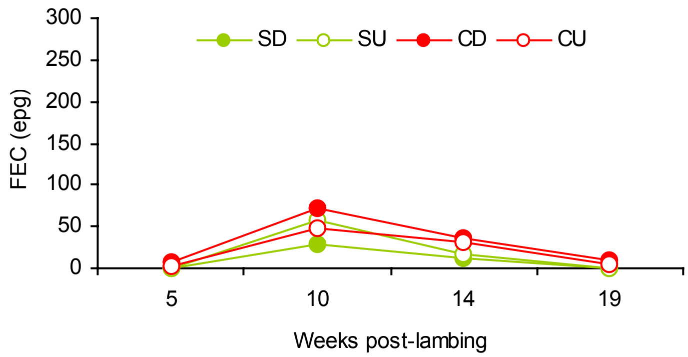


Figure 7: *Nematodirus* faecal egg count in lambs in Year 2 (e.p.g.) (Legend: see footnote Table 2).

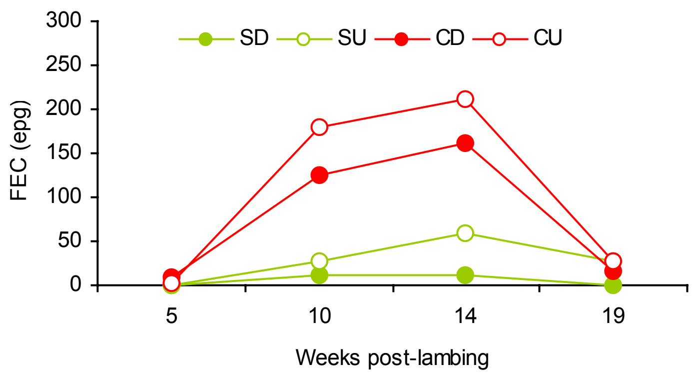


Figure 8: *Nematodirus* faecal egg count in lambs in Year 3s (e.p.g.) (Legend: see footnote Table 2).

Effect of omitting 10-week dose on the FEC in lambs: As might be expected, no difference was observed in the FEC of siblings on similar treatments up to 10 weeks of age (Table 9). A significant difference was noted at week 14. The undosed lambs had a higher FEC compared to the dosed lambs (P<0.0001). While this result suggests that worm burdens were higher in the undosed group, the low FEC in both cases indicate that worm burdens are likely to be low also.. No differences were noted at week 19.

Table 9: Mean *Nematodirus* faecal egg count according to whether dose was omitted at 10 weeks (e.p.g.).

	Faecal egg count at	
	Week 10	Week 14
Lambs dosed at 10 weeks	60	25
Lambs not dosed at 10 weeks	57	85

Effect of moving lambs to after-grass on FEC in lambs: Results are shown in Table 10. Year had a significant effect on the FEC observed in lambs moved to after-grass. (P<0.0001). The FEC observed at week 19 for both years is consistent with the pattern found in lambs that continued to graze the original paddocks post-weaning. In Year 2, *Nematodirus* was only evident in lambs at week 24. This was predominantly *Nematodirus filicolis*. In contrast, *Nematodirus battus* was predominantly evident at weeks 19 and 24 in Year 3.

Pasture type (from which lambs originated) also had a significant effect on the number of *Nematodirus* observed in the lambs moved to after-grass at weaning (P<0.05). Lambs, which had originated from "safe" paddocks pre-weaning had a higher FEC compared to lambs that originated from "contaminated" paddocks. A significant interaction between year and pasture type was observed at week 19 with clear differences in FEC being observed in 2000 but not 1999 between lambs that originated from "safe" paddocks compared to lambs originated from “contaminated” paddocks. This may reflect the generally higher numbers of *Nematodirus* larvae on pasture observed in Year 3 compared to Year 2 and suggests differences between these groups of lambs in their acquisition of immunity.

Table 10: Mean *Nematodirus* FEC in lambs according to treatment groups from which they originated who were moved to after-grass at weaning (e.p.g.).

Treatment*	Weeks post-lambing in 1999		Weeks post-lambing in 2000	
	19	24	19	24
CD	0	35	23	1
CU	0	9	23	1
SD	0	81	83	9
SU	0	42	49	2

- See footnote Table 2.

“Other trichostrongyles” (excluding *Nematodirus*)

Herbage larvae: The number of infective “other trichostrongyles” larvae present on each paddock is shown in Figures 9 and 10. There was no significant difference in the overall number of larvae found between years but there was a significant difference between sampling periods (i.e. month) ($P<0.05$). The number of larvae peaked in June/July depending on the year. Paddocks where ewes had been dosed had lower numbers of larvae than paddocks where ewes had not been dosed ($P<0.001$). The number of “other trichostrongyle” larvae was unaffected by the grazing history of the paddock (i.e.” safe” or “contaminated”) indicating that the contribution from over wintered infection was low. The fact that lambs were dosed on a monthly basis in late summer and autumn may explain the low level of over-winter infection observed.

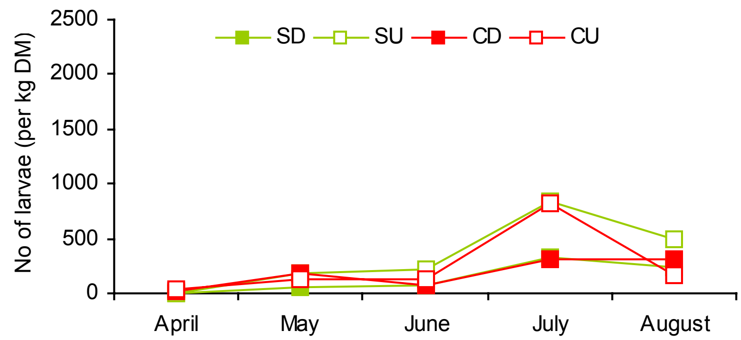


Figure 9: Number of infective "other trichostrongyle" larvae on pasture in Year 2 (Legend: see footnote Table 2).

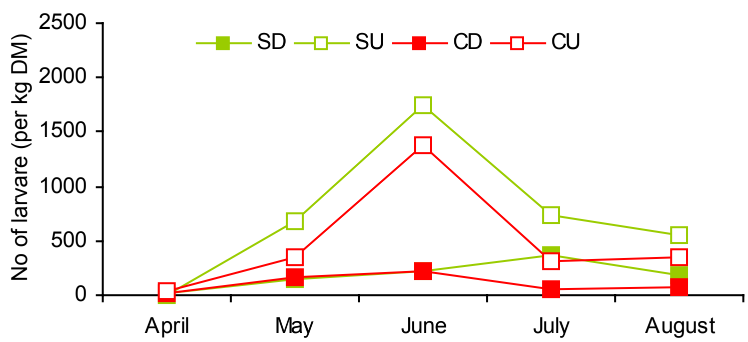


Figure 10: Number of infective "other trichostrongyle" larvae on pasture in Year 3 (Legend: see footnote Table 2).

Faecal egg counts in ewes: Results for both years are shown in Table 10. FEC was significantly higher in the third compared to the second year ($P<0.05$) (Table 11). This effect was associated with a higher midsummer rise of infective larvae on pasture as illustrated earlier in Figures 9 & 10. Ewes that were dosed had a significantly lower number of eggs than the undosed ewes grazing similar paddocks ($P<0.05$). A significant interaction between ewe treatment and year was observed at zero, 5, 10 and 14 weeks post-lambing which means that differences among treatment groups were affected by year ($P<0.05$). Pasture type ("safe" *vs* "contaminated") had no effect on the FEC at weeks 5, 10 and 14 post-lambing.

Table 11: Mean "other trichostrongyle" faecal egg count in ewes (e.p.g.).

Treatment*	Weeks post-lambing in 1999				Weeks post-lambing in 2000			
	0	5	10	14	0	5	10	14
CD	0	156	21	21	0	152	3	1
CU	404	200	43	21	709	414	129	56
SD	0	153	19	5	0	111	28	8
SU	427	112	16	10	1217	650	239	155

* See footnote (Table 2).

Faecal egg counts in lambs: Results for Years 2 and 3 are shown in Figures 11 and 12 respectively. Year had a significant effect on the FEC observed in lambs at weeks 10 and 14 weeks of age ($P<0.001$). Compared to Year 3, FEC was higher at 10 weeks post -lambing and lower at 14 weeks post-lambing in Year 2.

There was evidence for an interaction between year and ewe treatment at 10, 14 and 19 weeks of age which means that the differences among these ewe treatments depended on the year ($P<0.05$). In both years, at 10 weeks of age, FEC was lower in lambs grazing paddocks were ewes had been dosed (P<0.001). These results imply that dosing ewes delayed the build up of FEC in lambs. In contrast there was no consistent trend between ewe treatment and year in FEC observed at 14 and 19 weeks of age.

Table 12 (see earlier) shows the average FEC in lambs when results are pooled for both years. It is clear that there is no significant difference in FEC in lambs grazing undosed paddocks is compared to the FEC observed in lambs grazing dosed ewe paddocks (756, 759 respectively). This is contrary to what might be expected given the differences in the levels of challenge on pasture between these two treatments. Depressed lamb growth rates of 24 to 37% following trickle infection of 1500 *Teladorsagia circumcincta* larvae per day have been reported (Coop *et al* 1985). These results suggest therefore that some factor(s) may be masking the benefit of the lower challenge on pasture e.g. the frequent dosing regime. Pasture type had no effect on FEC (Figure 13)

Table 12: Mean "other trichostrongyle" faecal egg counts in lambs (average of 1999 and 2000) (e.p.g.).

	Weeks post-lambing				Total
	5	10	14	19	
CD	0	91	355	330	776
CU	1	243	222	273	739
SD	0	76	463	203	742
SU	0	173	231	369	773

* See footnote Table 2; †Weeks 10 to 19.

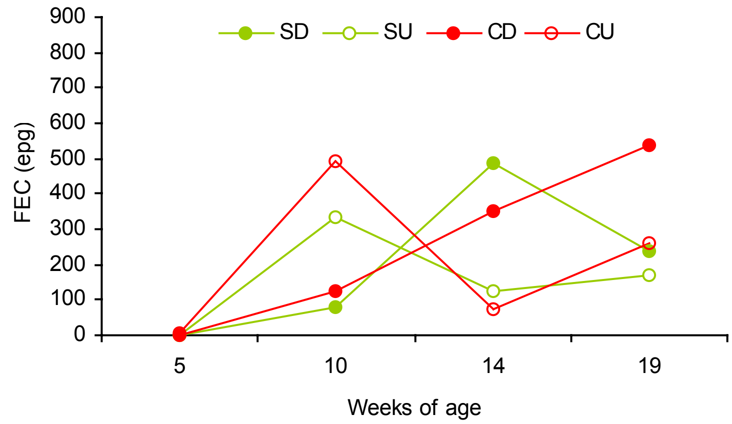


Figure 11: "Other trichostrongyle" faecal egg counts in lambs in Year 2 (Legend: see footnote Table 2).

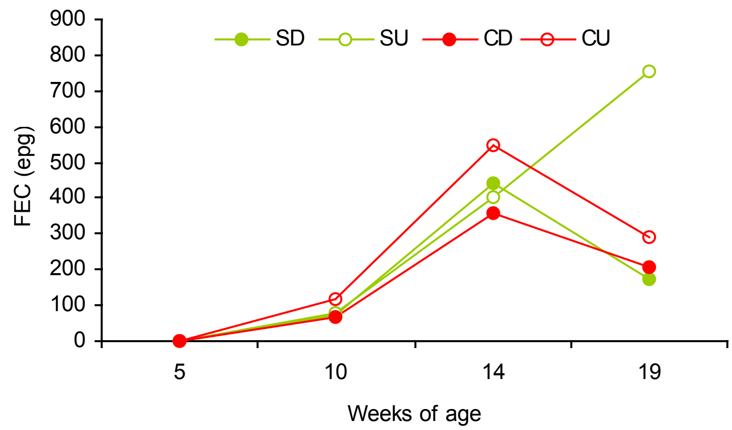


Figure 12: "other trichostrongyle" faecal egg counts in lambs in Year 3 (Legend: see footnote Table 2).

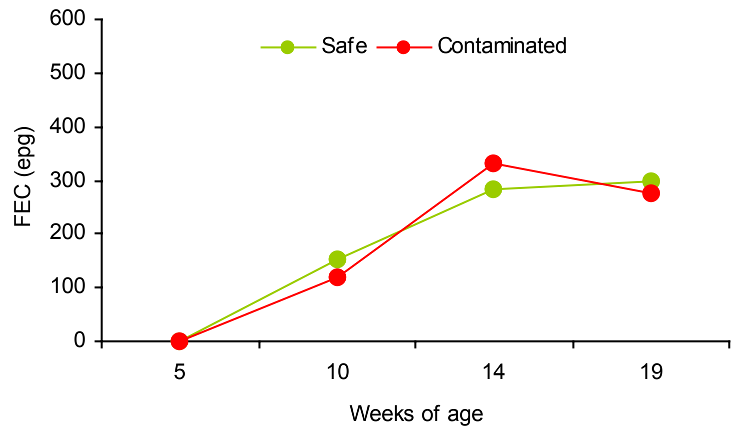


Figure 13: Average “other trichostrongyle” faecal egg counts in lambs on “safe” or “contaminated” paddocks (Legend: see footnote Table 2).

Effect of omitting 10-week does in lambs The results on Table 13 show that there was no significant difference in FEC at 14 weeks of age between siblings one of whom had received a dose at 10 weeks while the other lamb had not.

Table 13: Mean “other trichostrongyle” faecal egg count according to whether dose was omitted at 10 weeks (e.p.g.).

	Weeks post-lambing	
	10	14
Lambs dosed at 10 weeks	134	275
Lambs not dosed at 10 weeks	137	337

Effect of moving lambs to after-grass on FEC: Year or previous treatment did not significantly affect the FEC observed in lambs moved to after-grass at weaning. This is evident from the results in Table 14. Overall, at 19 weeks of age, FEC was lower in lambs that were dosed and moved to after-grass post-weaning compared to those that remained on their original paddocks

Table 14: Mean "other trichostrongyle" faecal egg count in lambs according to treatment groups from which they originated who were moved to after-grass at weaning (e.p.g.).

Treatment*	Weeks post-lambing in 1999		Weeks post-lambing in 2000	
	19	24	19	24
CD	199	311	169	219
CU	156	62	184	179
SD	215	445	144	195
SU	80	222	98	240

* See footnote Table 2.

Lamb growth rate

Pre-weaning growth rate: The results on lamb growth rate up to 14 weeks of age and live weight at 14 weeks of age (weaning) for Year 1, 2 and 3 are shown in Tables 15, 16 and 17 respectively.

As expected, treatment had no effect on growth rate to 5 weeks given the lamb's nutritional dependence on the ewe at this early stage rather than by grazing grass. Treatment had a significant effect on lamb growth rate between 0 and 14, 5 and 10, 10 and 14, weeks of age and liveweight at 14 weeks. Lambs grazing "contaminated" paddocks had a higher growth rate compared to lambs grazing "safe" paddocks between 10 and 14 weeks and 0 and 14 weeks of age. These results were contrary to expectations and may be explained by differences in pasture quality rather than parasitism. As discussed previously with respect to grass height, earlier emergence and flowering ('heading') occurred earlier in the "safe" pasture compared with the "contaminated" pasture. It is believed that the consistently lower lamb performance observed in these lambs over the three years was as a result of the poorer quality of grass available to them, especially in mid-season.

An interaction effect between year and treatment was significant with respect to growth rates between 0 and 14 and 5 and 10 weeks post-lambing ($P<0.001$) and approached significance for the 14 week weight ($P<0.06$).

Table 15: Lamb growth rates (g/day) and weaning weight (kg ± s.e.) in Year 1.

Treatment*	Growth rate				Liveweight
	0-5 weeks	5-10 weeks	10-14 weeks	0-14 weeks	14 weeks
CD	286	249	281	272	30.9 (0.56)
CU	315	269	253	281	32.0 (0.55)
SD	268	246	238	252	28.9 (0.54)
SU	276	254	206	249	28.5 (0.55)

* See footnote Table 2.

Table 16: Lamb growth rates (g/day) and weaning weight (kg ± s.e.) in Year 2.

Treatment*	Growth rate				Liveweight
	0-5 weeks	5-10 weeks	10-14 weeks	0-14 weeks	14 weeks
CD	336	251	249	281	31.9 (0.55)
CU	326	298	235	290	33.1 (0.55)
SD	314	256	197	260	30.2 (0.55)
SU	330	263	184	265	30.5 (0.54)

* See footnote Table 2.

Table 17: Lamb growth rates (g/day) and weaning weight (kg ± s.e.) in Year 3.

Treatment*	Growth rate				Liveweight
	0-5 weeks	5-10 weeks	10-14 weeks	0-14 weeks	14 weeks
CD	315	279	260	285	32.1 (0.54)
CU	322	263	266	284	32.2 (0.53)
SD	310	300	219	278	31.6 (0.53)
SU	315	317	201	281	32.2 (0.54)

*See footnote Table 2.

Post-weaning growth rate of lambs that remained on original paddocks: In years 2 and 3 core groups of lambs were retained on the original paddocks post-weaning, while a subsample from each of the 4 groups was grazed as one cohort on after-grass. The average growth rates for lambs that remained on their original paddocks are shown in Table 18 and show significant variation between years ($P<0.0001$). In general, the growth rates are in the range normally achieved on pasture post-weaning (Grennan, 1999).

The pre-weaning pattern observed in growth rate between lambs on the "safe" versus "contaminated" pastures was maintained post-weaning (i.e. lambs on "contaminated" pastures had higher growth rates than lambs on "safe" pastures ($P<0.001$)). Average growth rates were 176 g/day on the safe pasture and 201 g/day on the "contaminated" pasture and this is attributed to differences that emerged in pasture type and quality. The practice of dosing ewes had no effect on lamb growth in lambs that remained on their original paddocks. This may reflect the frequency of lamb dosing.

Table 18: Growth rate of lambs 0 to 19 weeks (g/day).

Treatment*	1999	2000
CD	192	227
CU	188	215
SD	150	220
SU	164	213

* See footnote Table 2.

Post-weaning growth rate of lambs moved to after-grass: As shown in Table 19, growth rates were higher in lambs that were dosed and moved subsequently to after-grass compared to lambs that remained on original paddocks. In years 2 and 3, growth rates were 14 and 10 % higher respectively in lambs that were removed to after-grass compared to lambs that were retained on their original paddocks. The enhanced performance of lambs moved to after-grass may be attributed to differences in pasture quality or supply as well as differences in the level of parasitic challenge on pasture.

Table 19: Growth rate of lambs post-weaning to 19 weeks (g/day).

Treatment*	Original Paddock	Aftergrass
CD	205	220
CU	198	210
SD	180	194
SU	172	220

* See footnote Table 2.

CONCLUSIONS

- Herbage larval counts demonstrated a clear seasonal pattern; *Nematodirus* was the predominant parasite encountered on spring pastures while *Teladorsagia* (Ostertagia) became the predominant genus of the "other trichostrongyles" observed later in the grazing season.

- There was a low level of residual over-wintered infection of other trichostrongyles" on pasture in spring under the conditions of this study. This may not be surprising given the fact that lambs post weaning continued to be dosed on a monthly basis, which would have resulted in reducing contamination on pasture.

- Results clearly show the merits of avoiding the practice of grazing ewes and lambs on the same pasture from lambing to weaning in successive years. This approach maintained *Nematodirus* at "safe" levels on pasture. The pattern of *Nematodirus* faecal egg counts in lambs was a reflection of the type of pasture that lambs were grazing. Higher FEC was observed in lambs grazing "contaminated" as opposed to "safe" pastures. Levels of *Nematodirus* on the "contaminated" pasture increased over the three years.

- Anthelmintic treatment of ewes prior to turnout in spring reduced the mid-summer build-up of infective larvae ("other trichostrongyles" excluding *Nematodirus*) on pasture. The timing of the mid-summer rise of infective larvae on pastures where ewes remained undosed was not constant from year to year (mid July Year 2, early June Year 3). Environmental factors which favour faster larval development combined with somewhat earlier lambing may have been contributory factors.

- While dosing ewes clearly had an effect on the faecal egg count of ewes and the numbers of larvae subsequently recovered on herbage and there were some effect as to when FEC was first observed and peaked in lambs, it was surprising that there was no overall difference in the total FEC observed in lambs from different treatments. This may reflect the dosing regime used in the study, which effectively controlled the build up of substantial parasite burdens in lambs, thus masking the impact of different levels of larvae on herbage

- While there were some differences with respect to faecal eggs observed between sibling lambs at 14 weeks, where one of each twin pair received a 10-week anthelmintic dose while the other did not, this was not reflected in growth rate.

- The significant and consistent differences in growth rate to weaning and to 4 weeks post-weaning observed between lambs that grazed the "contaminated" compared to "safe" pastures annually could not be attributed to parasite burdens. No difference in FEC between groups of lambs grazing similar swards but exposed to different levels of infection was observed. Differences in growth rate were attributed to the difference in pasture quality, particularly in mid-season.

- Faecal egg counts of lambs moved to after-grass at weaning (post-dosing) were lower at 19 weeks than those that remained behind on the original plots regardless of the experimental group.

- The growth rate of lambs that went to after-grass post-weaning was higher than that observed in lambs that remained on their original pre-weaning plots.

The benefits of a safe grazing system in terms of lamb growth may be clearer where anthelmintic treatment of lambs is less frequent than at monthly intervals used in this study. Faecal egg counts performed on a regular basis would aid decisions regarding the timing and necessity of anthelmintics.

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