ANTHELMINTICS AGAINST LUNGWORM *(DICTYOCAULUS VIVIPARUS)* IN RED DEER *(CERVUS ELAPHUS)*

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Introduction

Lungworms *Dictyocaulus viviparus* are currently the most important parasites of farmed red deer in New Zealand. Young deer in their first autumn and wild captured deer are particularly susceptible to infestation while adult stock often carry light burdens of no clinical significance. Cross-infection with *D. viviparus* between cattle and deer in this country may occur (Mason, 1981) and it is assumed that in both cases the life cycle is very similar. The most important features of the life cycle are:

(i) The first stage larvae (L1) in the faeces develop into third stage infective larvae (L3) and migrate onto grass in as little as 5 days under optimal conditions of warmth (15-20°C) and moisture.

(ii) The migration from the gut to the lungs takes 1 to 7 days.

(iii) The minimum prepatent period is around 20 days.

There is good evidence that deer generally develop immunity to lungworm as do cattle and this is probably related to age, exposure to lungworm and nutritional status (Corrigall *et al.*, 1980; Mason, 1981; Mason and Gladden, 1983). In trials conducted at Invermay in which weaners were left undrenched for 2 to 3 months in autumn, older heavier calves tended to "self-cure" (i.e. faecal larval counts reached a moderate peak and then spontaneously declined in the late autumn) whereas younger lighter deer tended to get heavier burdens which did not decline before treatment with anthelmintics. Wild captured adult deer which may not have experienced *D. viviparus* challenge and are under stress can become heavily infested unless drenched regularly for a few months after capture while their immunity develops. Adult farmed stock in good condition rarely develop heavy clinical burdens of lungworm. However, if they are allowed to carryover lungworm from one season to the next they will infect their calves.

The faecal larval output of deer appears to be directly related to the number of adult *D. viviparus* in the lungs, at least in red deer calves. This was demonstrated in 2 trials when 11 untreated calves were slaughtered and complete lung counts of adult worms and faecal larval counts were compared (Mason, Mackintosh, Cairns, Beatson, in prep.). Thus monitoring faecal larval counts is a reasonable means of assessing lungworm burdens and measuring the efficacy of anthelmintic treatments.

Anthelmintics: In the early days of treatment and prevention of lungworm in deer it was assumed that anthelmintics which were efficacious in cattle would be equally effective in deer (Mason, 1979). A 1979 survey of 72 veterinary practices servicing deer farms (Wilson and Collier, 1981) showed that oxfendazole and fenbendazole were the most popular anthelmintics for prophylactic control, closely followed by levamisole and diethylcarbamazine.

A survey of 130 farms 3 years later showed that the 3 new generation benzimidazoles oxfendazole, albendazole and fenbendazole accounted for over 75% of anthelmintic used in deer (Mason and Gladden, 1983). The popularity of levamisole and diethylcarbamazine had fallen to a low level, presumably due to a subjective assessment of their lack of efficacy, the difficulty of administration and the poor results of these anthelmintics in trials. One such pilot trial (Mason, unpub.) indicated that the commonly used anthelmintics fell into 3 categories: diethylcarbamazine, levamisole and cambendazole had low activity; mebandazole, albendazole, oxfendazole, fenbendazole and febantel had moderate to good activity; and ivermectin had excellent activity. Unfortunately there were only small numbers of animals available per group and it was not possible to use control animals. Further trials were therefore undertaken. Mason (unpub.) took frequent blood samples from deer immediately after treatment with levamisole and found a much lower, more transient plasma levamisole level than in cattle and sheep, suggesting that at the cattle dose rate levamisole does not produce therapeutic levels in deer. Some years previously, in Australia, Presidente *et al.* (1973) had found it necessary to double the cattle dose rate (i.e. from 7 to 14 mg/kg) of levamisole in black-tailed deer fawns to reduce the faecal larval counts, which then returned to predosing levels 13 days after treatment suggesting that this dose rate only removed adult and not immature lungworms in deer. Presidente *et al.* (1973) also found that 40 to 50 mg/kg cambendazole (twice the cattle dose rate) reduced faecal larval counts of these black-tailed deer fawns from 275 L1/g to zero 6 days later, but the counts had risen again 15 days after treatment. A small trial by Wilson (1981) showed that cambendazole at the cattle dose rate (25 mg/kg) failed to control faecal larval shedding in a group of 35 weaner red deer, while albendazole (7.5 mg/kg) reduced faecal larval counts to a low level.

In the 1979 survey (Wilson and Collier, 1981), veterinary practices were asked to comment on the success or failure of the anthelmintics they used to treat deer clinically affected with lungworms. The results were a confusing mass of subjective opinions. All the anthelmintics were reported to be satisfactory by some practices but unsatisfactory by other practices. Some of these failures may have been due to incorrect dosing, poor condition of the animals, asphyxiation of deer by dead adult worms blocking the trachea or adverse local reactions in the lungs. It would seem that the treatment of clinically affected animals is a poor risk, and that prevention is better than cure.

Over the last 3 years a number of trials have been undertaken to investigate the efficacy of the anthelmintics which appeared to have good activity in preliminary trials, so that recommendations on drenching intervals could be made.

Trials 1A and B

These farm trials have been reported and discussed elsewhere (Mason and Beatson, 1984) and only a summary will be presented here. The trials compared the effects of diethylcarbamazine, levamisole, albendazole, fenbendazole, and three dose rates of oxfendazole on both the faecal larval output and weight gain of newly weaned red deer calves in 2 successive seasons. The results confirmed that diethylcarbamazine and levamisole were significantly less effective than the other three benzimidazole drenches which produced good reduction in faecal larval counts for 3 weeks after dosing and significantly better weight gains (Figs 1 & 2).

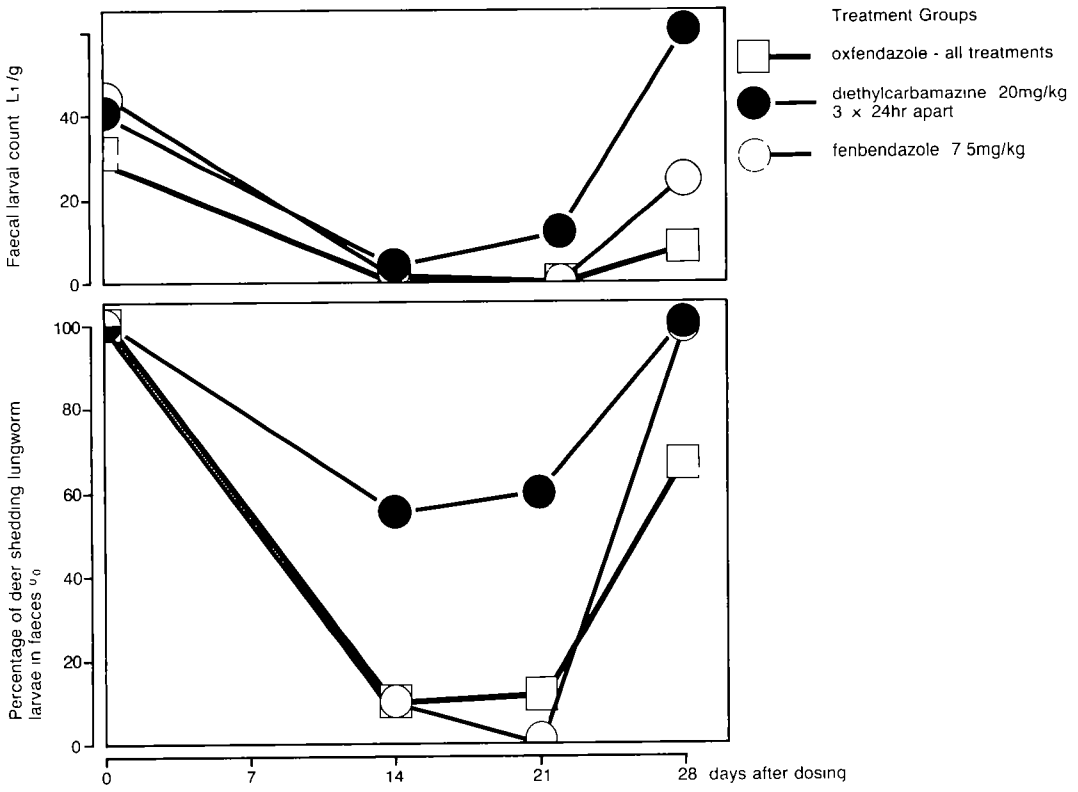

Fig. 1: Percentage of deer shedding lungworm larvae in faeces and the mean faecal larval counts of deer before and after treatment with various anthelmintics (Trial 1A).

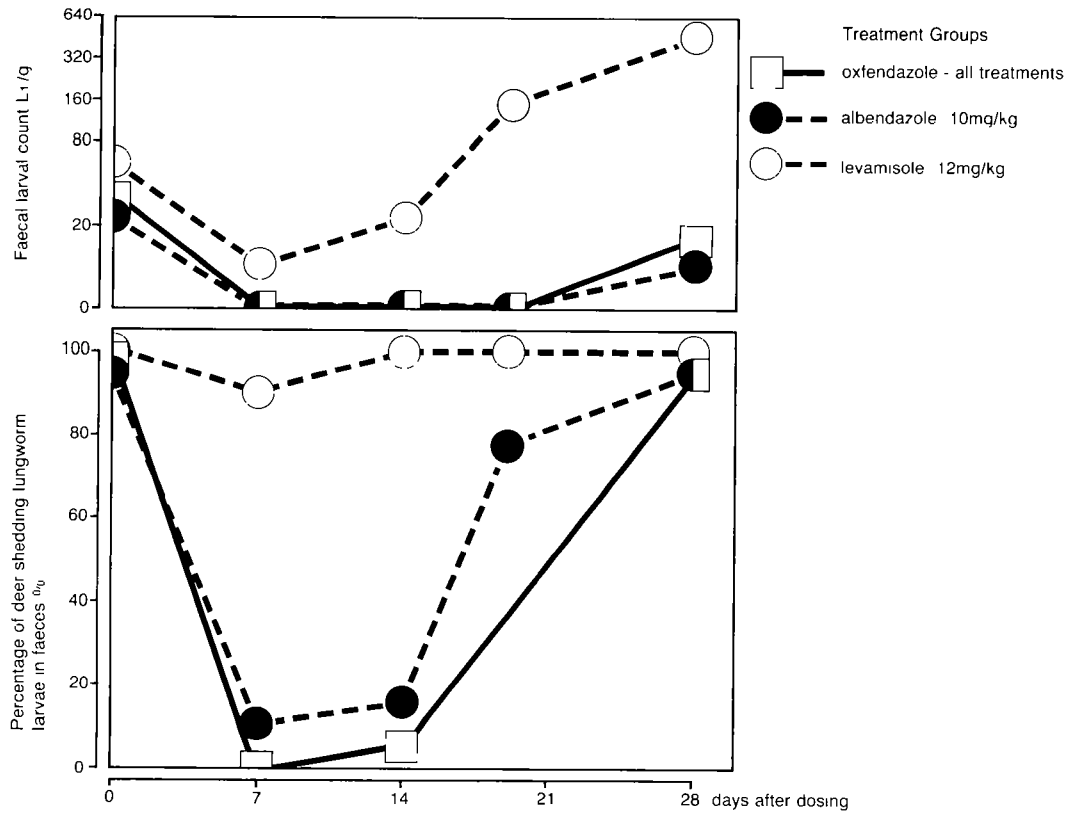

Fig. 2: Percentage of deer shedding lungworm larvae in faeces and the mean faecal larval counts of deer before and after treatment with various anthelmintics (Trial 1B)

Trial 2

This was an investigation of the effectiveness of three weekly drenching intervals with oxfendazole and injectible ivermectin. Thirty-three calves were randomly divided into two treatment groups; 17 received ivermectin injection (Ivomec) 200 ug/kg and 16 received an oral dose of oxfendazole (Synanthic) 4.5 mg/kg. These calves were weighed and faecal sampled at three weekly intervals from mid-March to June and again in early and late August. They were given anthelmintic on the first 3 sampling occasions (mid-March, early April and late April) and then in order to investigate the rate of development of lungworm burdens in late autumn early winter they were not treated again until late August.

Results (see Fig. 3)

Prior to treatment the calves had a mean faecal larval count of 20 L1/g. Twenty-two days after treatment all the invermectin treated calves and all but three of the oxfendazole treated calves had zero counts. All the calves had zero counts three weeks after the second and third treatments. However, 6 weeks after the third treatment 9 animals were sampled at random and the ivermectin calves had zero L1/g; the 4 oxfendazole calves had counts of 0, 1.5, 2.0 and 9.5 L1/g respectively. On the next sampling occasion, 15 weeks after treatment, the ivermectin group again had significantly fewer animals shedding larvae (19% versus 60%) and a lower group mean (1 L1/g versus 3.3 L1/g). Three weeks later there was no significant difference between the 2 group and all animals were treated and the trial ended.

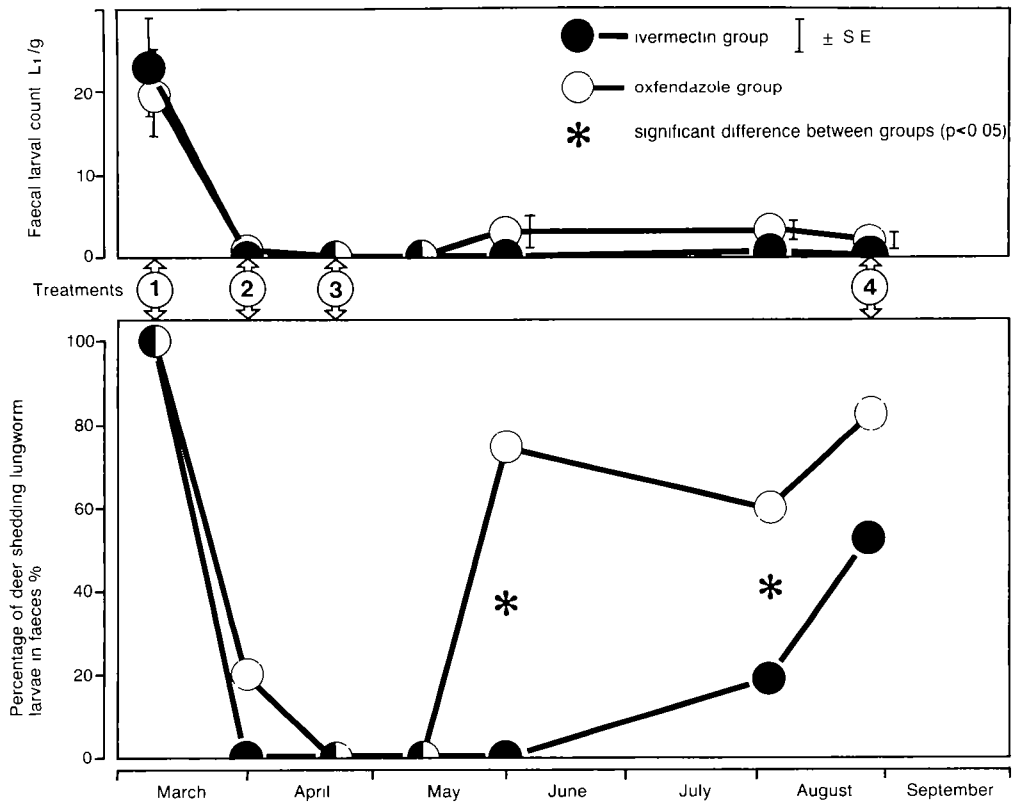

Fig. 3: Percentage of deer shedding lungworm larvae in faeces and the mean faecal larval counts of deer before and after treatment with ivermectin or oxfendazole (Trial 2).

Trial 3

Details of this trial have been published elsewhere (Mackintosh and Mason, 1984; Mackintosh *et al.*, in prep.) and only a summary is presented here. A controlled trial was conducted to determine the efficacy and pharmokinetics of febantel and ivermectin in 6 month old red deer calves. Three groups of 5 calves received febantel (7.5 mg/kg), injectible ivermectin (200 ug/kg) or no anthelmintic respectively. All calves were killed 7 days later (Fig. 4). Febantel was 99.8% and 85% efficient in removing mature and immature *D. viviparus* respectively, and ivermectin was 100% efficient in both cases. Full details of plasma levels of ivermectin and febantel metabolites (febandazole, oxfendazole and sulphone) are to be published elsewhere (Mackintosh *et al.*, in press), but in summary it was estimated that plasma levels of ivermectin persisted for up to 15 days after injection and febendazole and oxfendazole levels persisted for up to 30 and 72 hours respectively.

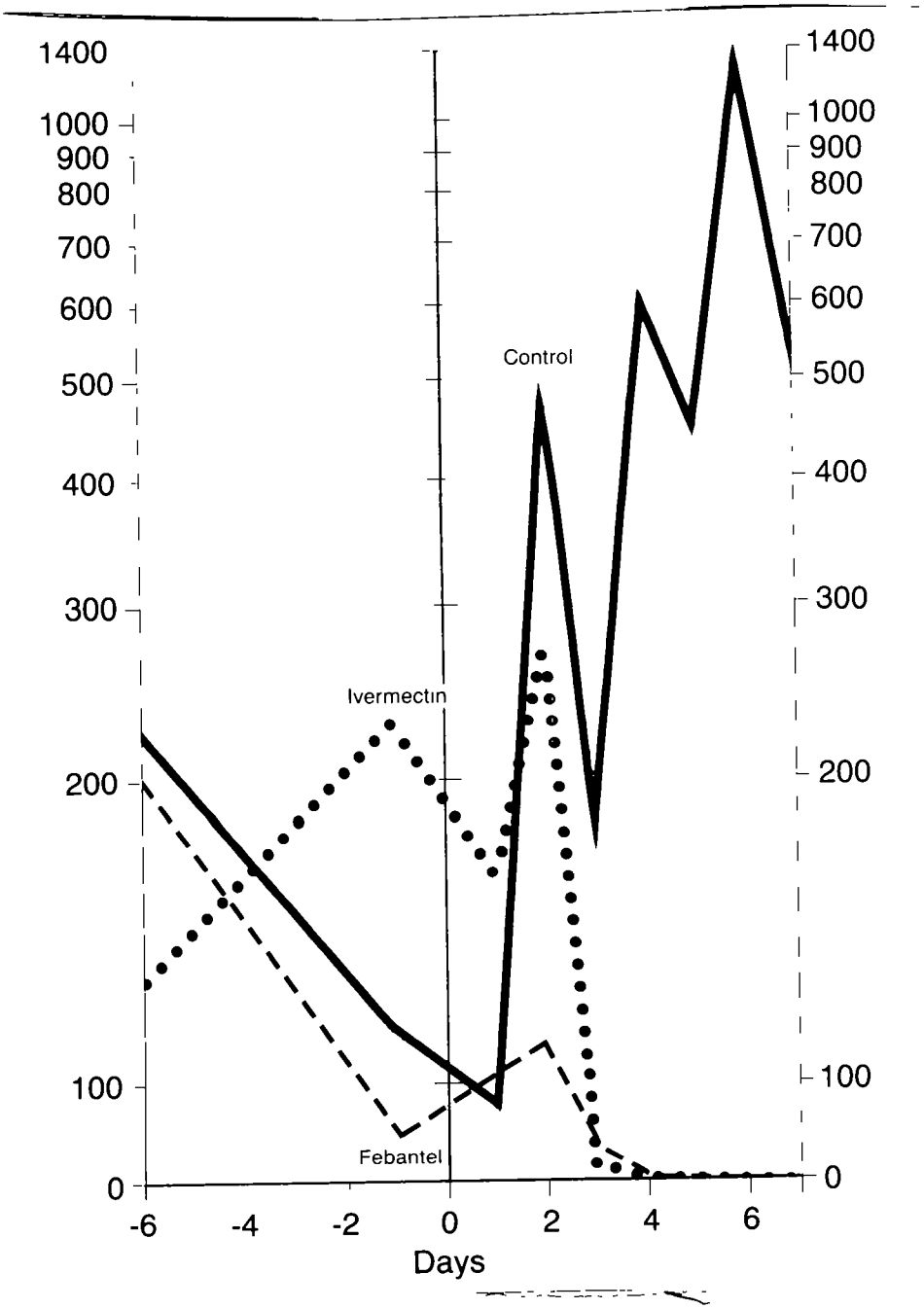

Fig. 4: Faecal larval counts (L1/g) of *D. viviparus* prior to and during the trial.

Trial 4

The object of this farm trial was to determine the time taken for weaner calves on pasture to develop significant *D. viviparus* burdens after one dose of oxfendazole or oral ivermectin. Thirty-eight newly weaned red hind calves were randomly divided into 2 equal groups; one received oral ivermectin (200 ug/kg) and the other oxfendazole (4.5 mg/kg) in late March and faecal samples were taken 3, 4, 5, 6, 7, 10 and 14 weeks later. At the 14 week sampling they were treated a second time and sampled 3, 8 and 14 weeks after that. Following a third treatment they were sampled at 4 and 7 weeks (see Fig. 5).

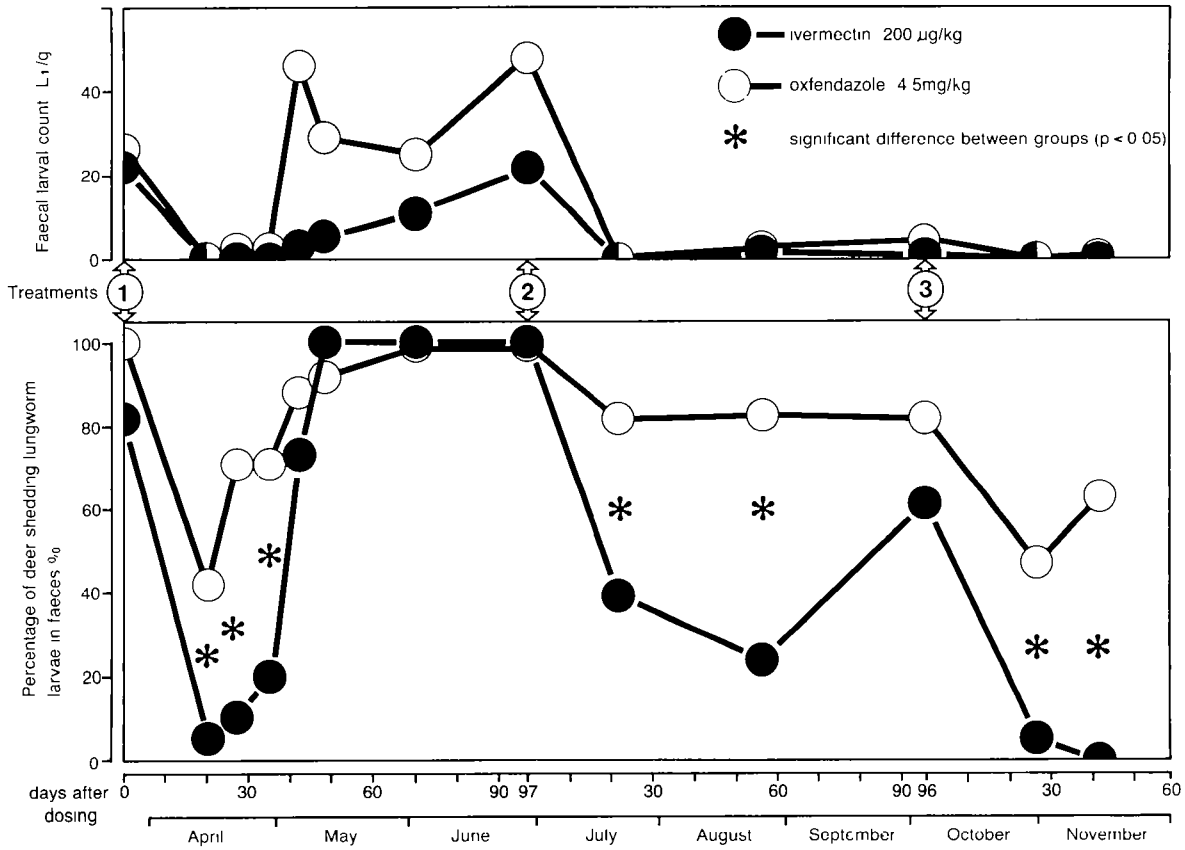

Fig. 5: Percentage of deer shedding larvae in faeces and the mean faecal larval counts of deer before and after treatment with ivermectin or oxfendazole (Trial 4).

Results (Fig. 5)

Both anthelmintics reduced faecal larval counts to low levels (<0.5 L1/g) 21 days after the first treatment. However, while the ivermectin treated calves remained <0.5 L1/g for 5 weeks after dosing the oxfendazole treated calves rose to 2.69 L1/g 4 weeks after dosing and 2.42 L1/g 5 weeks after dosing.

Throughout the trial significantly more ivermectin treated than oxfendazole treated calves were free of faecal larvae on 7 sampling occasions and the mean faecal larval counts remained lower for longer after each treatment. One calf in the ivermectin group, which was the youngest and was only 34.5 kg at the start of the trial compared with the group mean of 45.7 kg, developed a count of 1450 L1/g 10 weeks after the first treatment and was treated and excluded from the trial.

After the second treatment in late June the prevalence of faecal shedding remained relatively constant until the third treatment in early October and over this time the faecal larval counts remained low in both groups indicating very little reinfection over the winter. There were no significant weight gain differences between groups.

General Discussion

In trials 1A and 1B diethylcarbamazine and levamisole achieved only short-lived, moderate reductions in faecal larval counts, suggesting that they were only partially effective at eliminating adult *D. viviparus* and were ineffective against immature lungworms. In contrast the trials demonstrated that fenbendazole, oxfendazole and albendazole reduced faecal larval counts to a very low level for 3 weeks after dosing, although counts had risen again by 4 weeks after dosing. Febantel, which is metabolised into fenbendazole and oxfendazole in the body, probably achieves similar reductions for a 3 week period after treatment. Therefore a 21 day dosing interval is recommended for these new generation benzimidazoles and related anthelmintics such as febantel.

Ivermectin demonstrated a high degree of efficacy against immature and mature *D. viviparus* and appears to persist in the animal for up to 2 weeks. This appears to prevent reinfection over this period, and the effect is equivalent to extending the prepatent period to about 5 weeks. In the trials, both oral and injectible ivermectin consistently achieved a higher percentage of animals free of larval shedding, the calves remained free for longer and the mean larval counts remained lower. Similar studies in cattle have also demonstrated a high degree of efficacy against lungworm and prolonged anthelmintic activity after treatment with ivermectin (Barth, 1983; Bremner *et al.*, 1983). It is therefore suggested that a safe dosing interval between ivermectin treatments is 4 to 5 weeks.

In these trials the newly weaned calves all had lungworm burdens of up to 80 L1/g in mid to late March, demonstrating the necessity of starting prophylactic anthelmintic programmes in February or March. The rapid rate of reinfection in April in Trial 4 shows that conditions were still dangerous. By July/August there appeared to be little reinfection, although there was a small rise in September/October by which time the deer had probably acquired some degree of immunity.

Recommendations

1. Start drenching programme in February/March.

2. New generation benzimidazoles (and febantel) should be given at 3 week intervals.

3. Ivermectin can be given at 4-5 week intervals.

4. Most dangerous period is March to May. Drenching at these intervals should be continued until June/July if conditions are mild. Drench weaners occasionally during the following spring and summer.

5. Yearlings and adults are relatively resistant to infection but treatment pre-calving should reduce exposure of their calves.

6. All stock should be moved onto clean pasture after drenching. Ideally calves should be grazed on "safe" spelled pasture, e.g. hay aftermath.

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