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Effect of withholding anthelmintic treatment on autumn growth and internal parasitism of weaner deer grazing perennial ryegrass-based pasture or chicory

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ABSTRACT

Sixty-eight weaner deer were allocated to grazing perennial ryegrass-based pasture or chicory from 18 March to 20 May 2002, and within these groups were either regularly treated four-weekly with anthelmintic or treatment was withheld until weight loss or clinical signs of parasitism such as coughing was observed (trigger treatment). Liveweight gain was monitored fortnightly. Five sentinel deer from each of the four groups were slaughtered for nematode counts on 20 May. Deer grazing chicory grew faster than deer grazing pasture ($P < 0.001$). Thirty five percent of trigger-treated deer grazing pasture required treatment for clinical parasitism, but no anthelmintic was required for trigger-treated deer grazing chicory. There was no effect of anthelmintic treatment on average autumn growth of deer grazing chicory, but trigger-treated deer grazing pasture grew at half the rate of regularly treated deer ($P < 0.01$). Deer grazing chicory and treated four-weekly with anthelmintic grew 1.5x faster than deer grazing pasture and treated four-weekly with anthelmintic ($P < 0.05$). This difference in growth of deer grazing chicory and pasture increased to 2.9x when comparing trigger-treated deer grazing the two forages ($P < 0.01$). Sentinel trigger-treated deer grazing chicory had half the lungworm population of deer grazing pasture ($P = 0.13$) and 18% fewer gastrointestinal nematodes ($P = 0.06$). This study shows that grazing young farmed deer on chicory during autumn can increase their resilience to internal parasitism, reducing anthelmintic use whilst increasing deer growth.

Keywords: deer; chicory; lungworm; gastrointestinal nematodes; pasture; growth.

INTRODUCTION

Young deer are at greatest risk of internal parasitism, particularly lungworm, during the post-weaning autumn period when risk of mortality and reduced growth is increased (Audige *et al.*, 1998). Anthelmintic drenches at regular intervals during the first year of life are relied upon for endoparasite control in weaner deer (Charleston, 2001). A significant liveweight increase is associated with each autumn anthelmintic treatment for deer calves grazing conventional ryegrass-based pastures (Audige *et al.*, 1998).

It is important for economic viability and market access that New Zealand (NZ) deer farmers seek to improve both the level of production and the quality of products produced in a sustainable manner. A key aspect of sustainability is the relationship between animal health, welfare, production and product quality. In particular, widespread control of internal parasites using synthetic chemicals may be unsustainable in the long term, due to the increasing risk of anthelmintic resistance and the risk or perception of chemical residues in deer products. There is a growing consumer awareness of, and demand for, low-chemical input or 'naturally produced' deer products (Loza, 2001).

Chicory (*Cichorium intybus* or *Grasslands Puna*) appears to be the alternative forage species most suitable for deer production on a range of soils types across NZ, given its persistence and ease of establishment relative to other alternative high feeding value forages for deer (Kusmartono, 1996; Barry, 1998). A previous study indicated that grazing weaner deer on chicory compared with perennial ryegrass-based pasture during autumn increased liveweight gain whilst reducing the requirement for anthelmintic treatment (Hoskin *et al.*, 1999). Chicory contains sesquiterpene lactones (SL; Visser and Blair,

1992) and low concentrations of condensed tannins (CT), both at 3.5-4.0g/ kgDM, and both these secondary compounds extracted from chicory have been shown to directly inhibit the viability of endoparasite larvae of deer *in-vitro* (Molan *et al.*, 2000a,b; Schreurs *et al.*, 2002).

The aim of this experiment was to further investigate the effect of withholding anthelmintic treatment whilst grazing weaner deer on perennial ryegrass-based pasture and chicory during the post-weaning autumn period. Preliminary data (not statistically validated) from this experiment has been presented elsewhere (Hoskin *et al.*, 2003).

MATERIALS AND METHODS

Animals and treatments

On 18 March 2002, following weaning on the 28 February 2002, 68 weaner deer (mean live weight \pm SD = 53.1 \pm 6.51kg) comprising 10 red deer hinds, 22 red deer stags and 18 hybrid (0.25 elk: 0.75 red deer) hinds and stags were randomly allocated to forage type ($n=34$) and anthelmintic treatment groups ($n=17$) based on liveweight and faecal egg count and balanced as far as possible for sex and genotype. The treatments consisted of grazing perennial ryegrass-based pasture or chicory until 20 May, and within these forages to either treated four weekly with anthelmintic or treatment was withheld until trigger-treatment criteria such as weight loss or clinical signs of parasitism were observed. Regular four-weekly treatment was initially ivermectin given orally (0.2mg/kg; Ivomec oral; Merial New Zealand Ltd), but was switched on 29 April to moxidectin given topically (0.5mg/kg; Cydectin Pour-on for cattle and deer; Fort Dodge NZ Ltd). Trigger treatment was ivermectin given orally (0.2mg/kg; Ivomec oral; Merial New Zealand Ltd) + oxfendazole (5mg/kg; Systemex; Schering Plough

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Animal Health Ltd), on an individual animal basis. This occurred when clinical signs of parasitism (coughing, and/or laboured breathing at rest) were observed during daily monitoring, and/or a significant weight loss was observed (≥ 3 kg bodyweight loss over a 2-week period), together with either: a) lungworm larvae/g faeces exceeding 500, and/or b) strongylid eggs/g faeces exceeding 800). The number and date of anthelmintic treatments required in the trigger-treated groups was recorded.

Deer were yarded fortnightly for live weight measurement and faecal sampling for faecal gastrointestinal egg and lungworm larvae counts.

Five sentinel deer, selected at random from each of the four groups, but balanced as far as possible for sex and genotype were blood sampled and commercially slaughtered on 20 May at Venison Packers Feilding, with lungs and the gastrointestinal tracts recovered for nematode counts. Carcass weight and grade was recorded and dressing out percentage calculated from the final liveweight recorded when animals were transported to the slaughterhouse.

Forages and grazing management

Chicory (*Cichorium intybus* cv Grasslands Puna) comprising 2.3 ha in 5 paddocks (mean age of stand \pm range = 2.3 ± 2 years) was used. Permanent perennial ryegrass-based pasture (*Lolium perenne* cv Grasslands Nui)/white clover (*Trifolium repens* cv Grasslands Huia) comprising 3.3 ha in nine paddocks was used. On the two forages, both trigger-treated and regularly-treated animals were rotationally grazed together with the dry matter allowance (excluding dead matter) for all animals set at 6 kg DM/deer/day. Pre-grazing herbage mass (mean \pm SD kgDM/ha: pasture 3414 \pm 733.0, chicory 2950 \pm 748.2) was measured by taking random cuts to soil level from six quadrats (1.8 m²) from each paddock for DM determination (100°C, 18h) and botanical composition (proportion dead vs 'green') to enable calculation of grazing days (Semiadi *et al.*, 1993). Rotation length was 3–8 weeks and grazing periods were 4–8 days for chicory and 5–10 days for pasture. Grazing of pasture by mature hinds following the weaners was employed to maintain pasture quality as is normal commercial deer farm management practice. Chicory was mechanically topped in mid February to remove excess reproductive stem material and maintain the vegetative state prior to trial initiation. Nitrogen fertiliser (Urea; 46%N, 50 kgN/ha) was applied to chicory and pasture in late March.

Parasitology

Faecal samples were refrigerated within 2 hours of sampling. Faecal egg counts were performed using a modified McMaster technique with saturated NaCl solution (Stafford *et al.*, 1994), where a count of one egg was equivalent to 50 eggs/g faeces. Faecal lungworm larval counts were determined using a modified Baermann technique (Hendriksen, 1965) using 4g of faeces before refrigeration.

Counts of adult lungworm recovered from the lungs, and gastrointestinal nematodes recovered from the abomasum, small and large intestines of sentinel deer were

conducted using the methods described by Hoskin *et al.* (2000).

Statistics

Non-parasitological data was statistically analysed by ANOVA (GLM, SAS Institute Inc, USA) with forage type, anthelmintic treatment, animal genotype and sex and interactions as factors. Liveweight gain and live weight at fortnightly intervals throughout the experiment were also analysed using repeated measures analysis. Initial weight was used as a covariate for liveweight and liveweight gain data, however the covariate was not significant and was subsequently removed from the model. As the parasitology data were not normally distributed, log n+1 transformation was performed prior to ANOVA.

RESULTS

Liveweight gain

Main effects on average autumn liveweight gain (Table 1) were forage type, anthelmintic treatment (both $P < 0.001$) and genotype ($P < 0.05$). Growth was higher for deer grazing chicory compared with perennial ryegrass-based pasture, higher for four-weekly anthelmintic treatment than trigger-treatment for deer grazing pasture, but not chicory, and was higher for hybrid deer than pure red deer. Regularly treated deer on chicory grew 1.5 times faster on average than regularly treated deer on pasture ($P < 0.05$). The increase in liveweight gain whilst grazing chicory increased to 2.9 times when comparing average autumn liveweight gain of trigger-treated deer grazing the two forages ($P < 0.01$). Liveweight gain, of regularly and trigger-treated deer on pasture was initially similar, but from mid April onwards the growth of those regularly treated with anthelmintic was between 2.3 and 14.7 times higher than that of trigger-treated deer ($P < 0.05$; Table 1). No significant difference in liveweight gain between regularly- and trigger-treated deer grazing chicory was found, except during one fortnightly period from 15 to 29 April when liveweight gain of regularly treated deer exceeded that of trigger-treated deer ($P < 0.05$; Table 1). Repeated measures analysis showed a significant time*forage interaction on liveweight gain.

Final autumn live weight (Table 1) was greater for stags than hinds ($P < 0.05$), greater for hybrids than red deer ($P < 0.001$), greater for chicory than pasture-fed deer ($P < 0.001$) and was greater for regularly treated than trigger-treated deer on pasture ($P < 0.05$), but not chicory, with a significant forage by anthelmintic treatment interaction ($P < 0.05$).

Internal parasitism and anthelmintic treatment

Clinical parasitism was not observed in deer grazing chicory resulting in a zero requirement for anthelmintic input for the trigger-treated group. Thirty-five percent of trigger-treated deer on pasture developed clinical parasitism requiring trigger anthelmintic treatment (Table 1). Faecal lungworm larval counts (data not shown) peaked from mid to late April for deer on chicory and from early to mid-May for deer on pasture, whereas faecal egg counts peaked in early April for both groups. There

TABLE 1: Fortnightly liveweight gain (LWG), average autumn liveweight gain, final live weight and incidence of clinical parasitism requiring trigger anthelmintic treatment in trigger-treated groups of deer grazing either perennial ryegrass-based pasture or chicory and treated four-weekly with anthelmintic (treated) or anthelmintic was withheld until trigger-treatment criteria were reached (trigger).

Forage Anthelmintic treatment	Pasture		Chicory		SEM (n=17)
	Treated	Trigger	Treated	Trigger	
Liveweight gain (g/d)					
18 March -	18 ^a	10 ^a	154 ^b	136 ^b	31.7
2 April -	213 ^a	172 ^a	366 ^b	355 ^b	22.6
15 April -	148 ^a	65 ^{ab}	130 ^a	45 ^b	29.7
29 April -	133 ^a	9 ^b	119 ^a	85 ^a	25.7
14 May - 20 May	237 ^a	58 ^b	405 ^c	442 ^c	59.1
Average autumn LWG	134 ^a	60 ^b	208 ^c	175 ^c	11.8
Final live weight (kg)	62 ^a	57 ^b	66 ^c	64 ^{ac}	0.8
Clinical parasitism (%)	-	35	-	0	-

^{abc} for rows letters designate differences between treatments (P<0.05 or better). DF=32.

was no difference in faecal egg counts between deer grazing the two forages, but lungworm larval counts tended to be higher in deer grazing pasture compared with chicory (P=0.06).

The anthelmintic used for regularly treated animals was changed on 29 April from ivermectin to moxidectin because ivermectin given orally at 0.2mg/kg did not eliminate the presence of nematode eggs in faeces. Although post-treatment faecal egg counts in treated deer were lower following a change to moxidectin, low numbers of strongylid eggs remained in the faeces of treated deer.

Slaughter of sentinels

Random selection of sentinel animals for slaughter resulted no trigger-treated animals on pasture that had received anthelmintic treatment being selected. However two of the animals slaughtered in the trigger-treated group on pasture achieved trigger treatment criteria at the point of slaughter, but were not actually treated. These two animals were included in the 35% of animals in the trigger-treated group grazing pasture recorded as having developed clinical parasitism.

Slaughter of sentinel deer in mid May (Table 2) showed no effect of anthelmintic treatment on carcass weight for either forage. However deer grazing chicory had significantly heavier carcasses than deer grazing pasture (P<0.05). Trigger-treated deer grazing chicory had twice the lungworm population of trigger-treated deer grazing pasture and harboured 18% fewer gastrointestinal parasites (P<0.10). The majority, (>95%) of GI nematodes were found in the abomasum. A significant forage by anthelmintic treatment interaction was found for gastrointestinal parasite counts.

DISCUSSION

Most forage evaluations for grazing deer have employed routine three or four-weekly anthelmintic treatment to eliminate the potentially confounding effect of internal parasites. When trigger anthelmintic treatment was first used on a group basis by Hoskin *et al.* (1999), weaner deer grazing chicory did not require treatment during autumn whereas clinical signs of lungworm, reduced voluntary feed intake and liveweight gains were observed in pasture-grazed weaners. The current study has confirmed the earlier finding that continuous grazing of chicory throughout the post-weaning autumn period can increase growth whilst reducing the incidence and effects of endoparasitism that occurs when conventional perennial ryegrass-based pastures are grazed. Therefore, chicory grazing can negate the requirement for anthelmintic treatment for control of clinical parasitism during the post-weaning autumn period.

So how might grazing chicory have reduced internal parasitism in weaner deer? Aside from differing macro- and micro-nutrient content of chicory and pasture, there are both direct and indirect mechanisms by which forages containing secondary compounds may potentially reduce infection or ameliorate internal parasitism in ruminants. Condensed tannins extracted from a range of forage legumes and chicory have exhibited direct inhibitory effects on the developmental first (L1) and infective third (L3) stages of deer lungworm and the infective third (L3) stage of deer gastrointestinal nematode larvae cultured from deer faeces (Molan *et al.*, 2000a). There was no difference in the hatching of eggs from faeces of deer grazing chicory compared with perennial ryegrass-based pasture (Schreurs *et al.*, 2002), but *in vitro* research using

TABLE 2: Carcass weight, dressing-out percentage and numbers of nematodes recovered from the lungs and gastrointestinal tract of deer grazing either perennial ryegrass-based pasture or chicory and treated four-weekly with anthelmintic (treated) or anthelmintic was withheld until trigger-treatment criteria were reached (trigger).

Forage Anthelmintic treatment	Pasture		Chicory		SEM (n=5)
	Treated	Trigger	Treated	Trigger	
Carcass weight (kg)	31 ^a	30 ^a	37 ^b	37 ^b	2.3
Dressing %	53 ^a	54 ^a	58 ^b	58 ^b	0.8
Lungworm (No) ¹	1	643	0	311	115.2
GI nematodes (No) ¹	0	2642	52	2240	373.7

^{ab} for rows letters designate significant differences between treatments (P<0.05). DF = 8.

SL extracted from chicory has shown similar inhibitory properties against deer parasite larvae to CT (Molan *et al.*, 2000b). Schreurs *et al.* (2002) showed that faeces, rumen and abomasal fluid of deer grazing chicory contained compounds that inhibited the motility of deer L1 lungworm larvae, while compounds from the same sources from deer grazing ryegrass-based pasture did not.

The indirect effects of secondary compounds such as CT in improving the protein status of the host could increase the animal's tolerance of endoparasites over and above other nutritional effects. Further, plant morphology and sward structure may also influence the free-living stages of the nematodes (Moss & Vlassoff, 1993). The relative contribution of these possible mechanisms to the reduced parasitism and increased growth effects seen in deer grazing chicory has not been elucidated, but it is likely that several mechanisms are responsible.

In comparison to the previous study (Hoskin *et al.*, 1999), which used trigger-treatment on a group basis where all animals in the group were treated if one animal reached the trigger criteria, the current study used trigger anthelmintic treatment on an individual animal basis. This allowed the relative proportions of trigger-treated animals on the two forages that developed clinical parasitism and required treatment to be compared. The current study's methods showed that 35% of deer grazing pasture developed clinical parasitism and that these animals only required one treatment each during the study period to prevent reappearance of clinical parasitism in the given time frame. However, what both studies have not shown is whether or not animals that exhibited sub-clinical parasitism in autumn later develop clinical parasitism in winter or whether those animals that are treated for clinical parasitism in autumn require further treatment in winter. As chicory is dormant and cannot be grazed during the winter period when internal parasitism remains a risk on perennial ryegrass-based pastures (Hoskin *et al.*, 1999), it is likely that weaner deer management strategies aiming to minimise anthelmintic input will require use of an additional alternative forage or crop species for grazing of deer during winter if anthelmintic treatment is to be avoided altogether.

Given the lack of deer-specific information on the epidemiology of internal parasitism and understanding of the relationship between diagnostic parameters and sub-clinical or clinical effects of parasites in deer, the trigger-treatment criteria used were based on those used by Hoskin *et al.* (1999), despite low liveweight gain or liveweight loss not coinciding well with high faecal egg or larval counts in that study. In the current study, group mean peak faecal lungworm larval counts coincided with lower liveweight gain for deer on pasture, but for deer on chicory group mean peak lungworm larval counts occurred 3-4 weeks after low liveweight gains were recorded. This may indicate that the effects of immature vs mature parasite infections on animal growth differed between forages, and/or that development of immunity to the endoparasites present may have differed with forage grazed. Although liveweight gain of trigger-treated deer on chicory was significantly lower than that of treated deer during mid to late April, probably due to sub-clinical

parasitism, by mid May growth of trigger-treated deer did not differ significantly from treated deer, indicating resistance to the effects of endoparasitism may have developed. In comparison, during late April and May, trigger-treated deer on pasture continued to exhibit reduced liveweight gain, indicating that adequate immunity to endoparasites had not developed. Both faecal egg and larval counts in the present study greatly exceeded the counts observed by Hoskin *et al.* (1999), making diagnosis of clinical parasitism easier.

The apparent efficacy of anthelmintics used in this experiment against gastrointestinal parasites under the field conditions employed appear to be a cause for concern. However, it should be clear that ivermectin given orally is not licensed for use in deer, hence the change to a licensed anthelmintic when moderate numbers of strongylid eggs remained in faeces following use of the initial anthelmintic. Although the moxidectin product appeared to be more efficacious than the ivermectin product against gastrointestinal parasites, based on faecal egg counts, gastrointestinal nematodes were recovered from treated sentinel deer slaughtered in May. Little or no published information is available on the efficacy of anthelmintics licensed for use in deer, under NZ field conditions, therefore research of this type is urgently needed.

Research into effects of forage chicory, containing CT and SL, on internal parasites has highlighted an important potential role in sustainable deer production systems. Improved health and productivity, and reduced chemical input provide more ecologically sustainable and consumer-friendly deer management practices. However, further research is needed to evaluate the relative contributions of secondary-compound-mediated direct anthelmintic effects, compared with indirect nutritional, plant morphological and sward structure effects on reduction of production losses attributable to internal parasitism in deer fed alternative forage species.

Chicory can be used in weaner deer systems to increase growth whilst reducing the effects of endoparasitism during autumn. However, greater understanding of the epidemiology of internal parasitism of NZ's grazing farmed deer, efficacy of anthelmintics under field conditions and research into alternative forages for winter grazing of weaner deer is required for advancement of low chemical deer finishing systems.

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