Chicory as an alternative forage for deer health

T. N. Barry, A. L. Molan, P. R. Wilson, N. Lopez-Villalobos, N. M. Schreurs and A. J. Duncan

Abstract

Investigations were carried out to determine if chicory contained compounds that inhibited deer-origin parasitic larvae and also whether feeding chicory could improve the trace element status of weaner deer The motility of L1 lungworm larvae and their development from L2 to L3 larvae was less for larvae extracted from the faeces of undrenched weaner deer grazing chicory than from the faeces of comparable deer grazing perennial ryegrass/white clover pasture The factors responsible for reduced motility could be transferred through rumen and abomasal fluid Adding condensed tannin and crude sesquiterpene lactones extracted from chicory to *in vitro* incubations reduced the motility of lungworm larvae

Chicory contained higher concentrations of most minerals than perennial ryegrass/white clover pasture. After 10 weeks of grazing during autumn, liver copper concentration was significantly higher for weaners grazing chicory than pasture, but there was no significant difference between forages for liver vitamin B12 or blood Selenium concentration

In addition to increasing deer growth rates, feeding chicory may also confer benefits in that less anthelmintic drench and less copper supplementation is required Further field experimentation on these aspects is justified

Introduction

Chicory (*Chicorium intybus*) is a herb which produces forage of high nutritive value A high proportion of its annual DM production is during summer/autumn, so its annual pattern of feed production is well aligned with deer feed requirements. Relative to animals grazed on perennial ryegrass/white clover pasture, grazing on chicory has substantially increased growth during summer and autumn, for both young red deer and for lambs (Barry 1998, Barry *et al.* 1998). A feature of chicory is its very rapid rate of disintegration in the rumen and hence its high digestibility and voluntary feed intake (VFI).

Two grazing trials have shown that high growth rates on chicory can be achieved with reduced anthelmintic drench input, relative to similar animals grazed on perennial ryegrass/white clover pasture, both for lambs (Scales *et al.* 1995) and for weaner deer (Hoskin *et al.* 1999). This could be due to the taller growth habit of chicory reducing the consumption of infective L3 larvae or to the presence of secondary compounds in chicory having anti-parasite effects. Chicory contains the secondary compounds condensed tannin (CT) and sesquiterpene lactones (SL), both at about 4 g/kg plant DM (Barry 1998). Their effects upon deer-origin internal parasites is reported in the work reviewed here.

Chicory also contains a high ash (i e , mineral) content (160 g/kg DM), relative to normal grazed forages (100 g/kg DM) A second objective was to study the concentration of individual major and trace minerals in chicory and to measure the effects of grazing weaner deer on chicory upon liver concentrations of copper and Vitamin B12 and upon blood selenium concentration Results from the initial phase of this work are reported here

Parasitology

Two approaches were used to study effects of grazing weaner deer on chicory during autumn upon the development and motility of internal parasite larvae In the first approach, faeces were collected using bags and harnesses from undrenched weaner deer grazing either chicory or perennial ryegrass/white clover pasture and the eggs of gutworm larvae and L1 lungworm larvae extracted from the faeces. Differences in egg hatching, larval development and larval migration inhibition (LMI) between the

two sources of faeces were then determined, using the *in vitro* methods described by Molan *et al.* (1999, 2000a) and Rabel *et al* (1994)

In the second approach, CT and crude SL extracts were made from chicory using the methods of Jackson *et al* (1996) and Visser & Blair (1992) respectively, with some modifications CT and crude SL were then added to deer-origin larvae in *in vitro* assays and their effects upon LMI determined Polyethylene glycol (PEG, MW 3,350) was also added to some CT incubations, as a means of binding and inactivating the CT (Jones and Mangan 1977)

In both sets of experiments, incubations were done in high-speed centrifuged rumen fluid and in high speed centrifuged abomasal fluid

Source of faeces (i.e , deer grazing pasture or chicory) had no effect upon hatching of gastrointestinal nematode eggs or upon the development of these larvae from L1 to L3 stages However, fewer L2 lungworm larvae developed into L3 larvae from the faeces of deer grazing chicory relative to deer grazing pasture (31.2 vs. 44 4%, $P < 0.05$)

L1 lungworm larval migration (Table 1) was less from the faeces of deer grazing chicory than from the faeces of deer grazing pasture ($P < 0.001$) and was less from rumen fluid than from abomasal fluid incubations ($P < 0.001$). Adding rumen or abomasal fluid from deer grazing pasture to larvae extracted from the faeces of chicory fed deer had no effect on migration, but adding rumen or abomasal fluid from deer grazing chicory to larvae extracted from the faeces of their counterparts grazing pasture markedly reduced L1 lungworm larval migration This indicated the presence of anti-larval compounds in the faeces of deer grazing chicory and showed that some of this activity could be transferred through rumen and abomasal fluids, suggesting it could be due to secondary compounds.

Table 1: The effect of source of faeces (chicory or pasture-grazed deer), source of fluid (chicory or pasture grazed) and type of fluid (rumen or abomasal) upon the viability of L1 lungworm larvae as measured by the Larval Migration Inhibition assay

Forage type deer grazed on to obtain:		Percentage of larvae not passing through sieves	
Faeces (larvae)	**Fluid**	**Rumen Fluid**	**Abomasal Fluid**
Chicory	Chicory	49.1	39 9
Chicory	Pasture	43 8	39 1
Pasture	Chicory	40.4	29 6
Pasture	Pasture	27.7	21 2
Standard Error		2 04	2 04

From Schreurs (2001)

Adding CT extracted from chicory reduced L1 lungworm larval migration in rumen fluid but not in abomasal fluid (Table 2), probably due to the well-accepted concept that CT bind to proteins much more effectively at rumen pH than at abomasal pH Adding PEG reversed the effect of CT in rumen fluid but as might be expected had no effect in abomasal fluid

Table 2: The effect of adding condensed tannin (CT) extracted from chicory to incubations containing rumen or abomasal fluids in the presence or absence of polyethylene glycol (PEG, MW 3350) upon the viability of L1 lungworm larvae as measured by the Larval Migration Inhibition assay

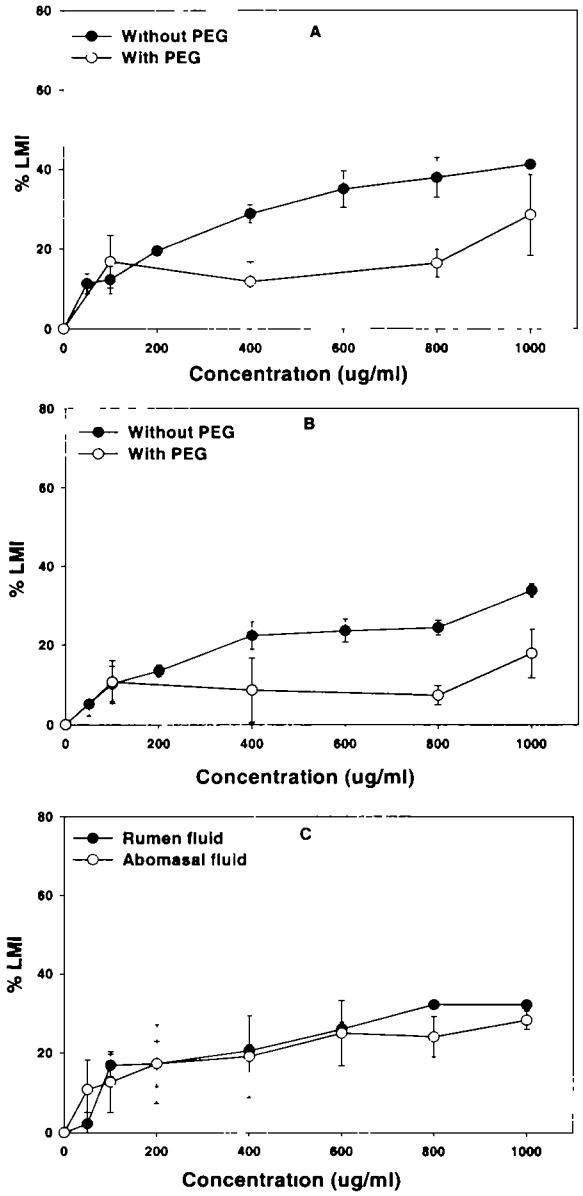
Treatment	Percentage of larvae not passing through sieves	
	Rumen Fluid	**Abomasal Fluid**
Fluid Only	40 7	34 3
+CT	54 3	34 8
+CT +PEG	33 5	35 7
+PEG	32 5	25 1
Standard Error	2 03	2 03

From Schreurs (2001)

Adding crude extracts of SL extracted from chicory to LMI assays involving larvae from deer grazing pastures decreased the motility of L1 lungworm larvae (Fig 1A), L3 lungworm larvae (Fig 1B) and L3 gutworm larvae (Fig 1C) This occurred in a dose-dependant manner, but the initial low concentrations often gave the greatest proportional inhibition. In marked contrast to the work with CT, larval motility inhibition caused by crude SL extracts was similar in rumen and abomasal fluid for all three larvae tested, showing that the effect was independent of pH.

Fig. 1 The effect of adding crude sesquiterpene lactone (SL) extracted from chicory on larval migration inhibition (LMI) measured in vitro A, L1 lungworm larvae, B, L3 lungworm larvae, C, gutworm larvae, I, SE From Duncan (2000).

Figure 1



Minerals

A pilot study was conducted at the Massey University Deer Research Unit, with deer grazing chicory or PRG/WC during autumn Deer were weaned late February and placed onto forage plots early March There were 24 deer per group comprising a mixture of red and red x 0.25 Wapiti hybrids,

including both sexes They were rotationally grazed until mid-May. Half of the weaners on each forage were treated with pour-on "Ivomec" at 30-day intervals The remainder received no anthelmintic

Liver biopsies were collected according to the procedure described by Wilson (2000). Twelve animals from the original pool of deer, but which were not allocated to the trial plots, were biopsied early March to assess their trace element status At the conclusion of the autumn grazing period, liver biopsies were collected from all animals on the grazing plots for copper and Vitamin B12, as sample size permitted A blood sample was collected from each animal for blood Selenium

At the commencement of each grazing interval during the autumn rotation a pluck sample of forage was collected and freeze dried for pasture trace element analysis

Chicory contained higher concentrations of most minerals than pasture (Table 3), with the difference being largest for sodium, calcium, copper and cobalt

In March, blood Selenium averaged 262 nmol/L (range, 110-330 nmol/L) Liver copper concentration averaged 238 µmol/kg (range 110-450 µmol/kg) Liver Cu concentration in mid-May (Table 4) was higher for weaners grazing chicory than pasture ($P < 0.01$) and was higher for drenched than for undrenched deer ($P < 0.01$), there was a significant forage x drench interaction ($P < 0.05$), explained by the difference between drenched and undrenched groups being greater in deer grazing chicory than pasture

There were no significant differences in liver Vitamin B12 concentration or blood Selenium concentration related to forage grazed or anthelmintic drenching

Table 3: Mean and range of chicory and PRG/WC minerals during the grazing period March – May (n = 3)

		Na[1]	K[1]	Mg[1]	P[1]	Ca[1]	S[1]	Fe[2]	Zn[2]	Mn[2]	Cu[2]	Co[2]	Se[2]	Mo[2]
Pasture														
	Mean	1 8	11 7	2 2	3 1	5 6	2 2	2513	45 2	183	7 6	0 55	0 10	0 23
	Min	0 9	11 1	2 0	2 7	4 5	1 8	1529	35.5	115	7 4	0 18	0 06	0.20
	Max	3 0	12 7	2 5	3 4	6 2	2 4	3549	54 8	248	7 8	1 03	0 12	0 25
Chicory														
	Mean	5 4	15 8	3 2	2 6	11 7	2 8	3836	55 8	201	10 5	1 38	0 10	0 18
	Min	3 1	15 4	2 4	2 3	8 8	2 0	2796	53 8	126	8.6	1 04	0 08	0 17
	Max	7 5	16 2	4 1	3 0	13 2	3 6	4815	59 2	243	10 8	1 83	0 14	0 22

[1] g/kg DM, [2] mg/kg DM (ppm)

Table 4: Mean (and range) of liver copper and Vitamin B_{12}, and blood Selenium at the end of the autumn grazing period in deer grazing chicory or PRG/WC

Group (Forage/anthelmintic)		Liver Copper (µmol/kg)	B_{12} (nmol/kg)	Blood Se (nmol/l)
Chicory				
No drench	Mean	205 (n=10)	577 (n=5)	192 (n=12)
	Range	35-380	450-690	110-300
Drench	Mean	461 (n=10)	516 (n=4)	164 (n=12)
	Range	140-690	419-590	100-210
PRG/WC				
No drench	Mean	143 (n=6)	469 (n=4)	187 (n=12)
	Range	81-220	410-610	110-360
Drench	Mean	175 (n=10)	487 (n=5)	173 (n=11)
	Range	93-610	370-520	110-280
Overall		**223**	**218**	**176**

Discussion

These results provide some explanations for the reduced anthelmintic need for anthelmintic in weaner deer and lambs grazing chicory, whilst also maintaining high growth rates (Hoskin *et al.* 1999, Scales *et al* 1995). Both CT and SL in chicory have been shown to reduce larval motility and in addition CT also reduced the development of lungworm larvae to the infective L3 stage These findings are especially important for lungworm, the most serious parasite of farmed deer (Wilson and Collier 1981, Mackintosh *et al* 1984), and offer a sustainable means of controlling lungworm Other studies have also shown that CT extracted from chicory reduced the motility of deer-origin L3 lungworm larvae and L3 gutworm larvae (Duncan 2000, Molan *et al* 2000b) Further large-scale experiments are now needed, spread over both research and commercial farms, to evaluate grazing on chicory as a means of reducing the requirement for anthelmintic drenching in grazing weaner deer

The effect of chicory on liver Cu stores may have clinical significance Data from other studies (Grace and Wilson, 2001, these Proceedings), show a large fall in liver copper concentration from autumn to spring Thus, the deer grazed PRG/WC would likely deplete liver Cu stores to levels that would put some at risk of deficiency, thus risking reduced growth and/or causing enzootic ataxia. In the present herd, copper levels measured in the PRG/WC group in the autumn could prompt prophylactic use of copper. At a stocking rate of 12 deer/ha, and $3/treatment, a cost of $36 plus labour could then be factored into the cost-benefit equation for chicory. If a chicory stand were to be managed to persist for 3-4 years, the total reduced animal remedy cost could escalate to $108-$144/ha Previous data suggests it is practically feasible to maintain chicory for 3-4 years (Barry *et al.* 1998), and even without trace element considerations, the cost benefit equation is positive

Mean liver Vitamin B12 concentrations in deer grazing chicory were higher than those of deer grazing pasture, although this difference was not statistically significant Since there were only a small number of samples available for Vitamin B12 analysis, further evaluation of Vitamin B12 status of deer grazing chicory is warranted, since chicory contained higher cobalt concentrations than pasture Similar mean blood selenium concentrations in animals on both forage species is consistent with similarity of pasture and chicory selenium concentrations

Further research is currently underway to evaluate the effects of grazing chicory on trace element status to repeat these observations, and extend them through winter, and through spring when deer will again be grazing chicory Thus, in addition to increasing deer growth rate, grazing chicory may result in reduced requirements for both anthelmintic drench and copper supplementation These aspects need to be studied in further field experiments

Acknowledgments

Funding for the parasitology work was provided by the NZ Game Industry Board Trace element analyses were funded by the Manawatu Branch of the NZDFA and the Massey University Veterinary Research Fund.

References

Barry, T N., Wilson, P.R. and Kemp, P D (1998) Management of grazed pastures and forages for optimum deer production, pp 141-157 Ed J Elliot In Proceedings of the 2nd World Deer Farming Congress Federation of European Deer Farmers' Associations, Reading, Berks, U K

Barry, T N (1998) The feeding value of chicory (*Cichorium intybus*) for ruminant livestock *Journal of Agricultural Science* **131**, 251-257

Duncan, A J (2000) The effects of secondary plant compounds extracted from chicory on the viability of deer internal parasites *in vitro* Dip App Sci Hons thesis Massey University, Palmerston North

Grace, N D and Wilson, P R (2001)

Hoskin, S O , Barry, T N , Wilson, P R , Charleston, W A G and Hodgson J. (1999). Effects of reducing anthelmintic input upon growth and faecal egg and larval counts in young farmed deer grazing chicory (*Cichorium intybus*) and perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) pasture *Journal of Agricultural Science, Cambridge* **132**, 335-345

Jackson, F S , McNabb, W C , Barry, T N , Foo, Y L and Peters, J S (1996) The condensed tannin content of a range of subtropical and temperate forages and the reactivity of condensed tannin with ribulose 1,5-bisphosphate carboxylase (Rubisco) protein *Journal of the Science of Food and Agriculture* **72**, 483-492

Jones, W T and Mangan, J L (1977) Complexes of the condensed tannins of sainfoin (*Onobrychis viciifolia* Scop) with fraction 1 leaf protein and with submaxillary mucoprotein, and their reversal by polyethylene glycol and pH *Journal of Science, Food and Agriculture* **28**, 126-136

MackIntosh, C G , Mason, P C , Bowie, J Y and Beatson, N S (1984) Anthelmintics against lungworm (*Dictyocaulus viviparus*) in red deer (*Cervus elapus*) *Proceedings of a Deer Course for Veterinarians Deer Branch of the New Zealand Veterinary Association* **1**, 69-77

Molan, A L , Waghorn, G C and McNabb, W C (1999) Condensed tannins and gastrointestinal parasites in sheep *Proceedings of the New Zealand Grassland Association.* **61**, 57-61.

Molan, A L , Hoskin, S O , Barry, T N , and McNabb, W C (2000a) Effect of condensed tannins extracted from four forages on the viability of the larvae of deer lungworms and gastrointestinal nematodes. *Veterinary Record* **147**, 44-48

Molan, A L , Duncan, A , Barry, T N and McNabb, W C (2000b) Effects of condensed tannins and sesquiterpene lactones extracted from chicory on the viability of deer lungworm larvae *Proceedings of the New Zealand Society of Animal Production* **60**, 26-29

Rabel, B , McGregor, R and Douch, P G C (1994) Improved bioassay for estimation of inhibitory effects of ovine gastrointestinal mucus and anthelmintics on nematode larval migration *International Journal for Parasitology* **24**, 671-676

Schreurs, N.M. (2001) Effect of grazing undrenched weaner deer on chicory or perennial ryegrass/white clover pasture on gastrointestinal nematode and lungworm viability B App. Sci. Hons thesis Massey University, Palmerston North

Scales, G H , Knight, T L and Saville, D J (1995) Effect of herbage species and feeding level on internal parasites and production performance of grazing lambs *New Zealand Journal of Agricultural Research* **38**, 237-247

Visser, F R and Blair, K A (1992) Changes in milk flavour effect of different feeds In *Milkfat Flavour Forum* (Ed New Zealand Dairy Research Institute), pp. 36-40 Palmerston North, New Zealand New Zealand Dairy Research Institute

Wilson, P R and Collier, A (1981) Lungworm in deer a survey of veterinary practices Deer Advisory Panel of the NZVA, Proceedings of a Deer Seminar for Veterinarians, 85-93

Wilson, P R (2000) A liver biopsy technique for red deer Liver Biopsy Workshop. Foundation for Veterinary Continuing Education, Massey University June 2000