Responses in deer production to alternative pasture species

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Abstract

Grazing systems are described for producing venison carcasses weighing 50-65 kg (92-120kg liveweight) in the spring by one ear of age, using red and hybrid (0.25 elk : 0. 75 red) deer stags. Grazing perennial ryegrass/white clover pasture at 10cm surface height during autumn, winter and spring resulted in 73% of young stags attaining the desired slaughter target, but variation between years was large (range 25-100%). When red clover and chicory were grazed during autumn and spring, with pasture grazing during winter, the proportion of young stags attaining the desired slaughter target was consistently increased to 90-100% and mean carcass weights were increased by 11 & 17% respectively. Largest responses in deer growth to red clover (26%) and chicory (47%) were seen during autumn. Both voluntary feed intake (VFI) and digestibility of the diet selected were higher for deer grazing chicory and red clover than perennial ryegrass-based pasture, with the largest effects seen during summer and autumn, when perennial ryegrass was of lowest nutritive value. In indoor studies, both the rates of ruminal degradation and outflow of chicory were greater than for perennial ryegrass, with similar results found for red clover. It was concluded that the faster breakdown and clearance of red clover and chicory from the rumen than perennial ryegrass explained their higher digestibility and VFI by grazing deer. Management of red clover and chicory to increase persistence on commercial deer farms is discussed, with key recommendations being to graze from an initial height of 30 cm to a final height of 10 cm, rotational grazing at 3-5 week intervals, mechanical topping to remove reproductive growth during summer and not grazing during prolonged periods of wet weather. To achieve these objectives, both crops should be sown on a small area of the farm and receive specialised management; they should not be set stocked and grazed like perennial ryegrass/white clover pasture.

Introduction

Most deer production in New Zealand (NZ) occurs from the grazing of perennial ryegrass (0.80)/white clover (0.20) pasture. This is generally grazed on a year round basis, with some supplementation as hay, silage or cereal grains in times of low pasture growth. Earlier studies with sheep grazing pure species plots in NZ showed that rates of body growth were higher on legumes than on grasses, with highest growth rates obtained on white clover (Ulyatt 1981). This paper reviews work carried out with deer at Massey University, mainly evaluating red clover and chicory as alternative forages for deer production, but also briefly mentions work with the condensed tannin - containing legumes *Lotus corniculatus* and sulla. These were selected for evaluation because of their high summer and autumn dry matter (DM) production, which coincides with high animal feed requirements in deer fanning, their deep tap rooting system to withstand drought and their perceived high nutritive value and that both are highly preferred by deer (Hunt and Hay 1990).

The review will concentrate upon venison production. Under NZ conditions, venison production is most efficient if 50-65 kg carcasses (corresponding to 92-120 kg liveweight) can be produced in the spring by 12 months of age or less (Barry and Wilson 1994). In a survey of 15 commercial deer farms, Audige\ (1 995) found that on average 8 - 15% of young red stags attained 92 kg liveweight by one year of age over two consecutive years, with values for individual farms ranging from 0 to 42%. This review will concentrate on how grazing technology, including inputs of red clover and chicory, can be used to improve this situation.

Growth on perennial ryegrass - based pastures

Previous work has defined 5 cm and 10 cm as appropriate surface heights to maximise sheep and cattle production from grass-based pastures, whilst also maximising rates of pasture production (Hodgson 1990). Table 1 shows that growth of young red deer in NZ was restricted when grazed under set stocking at 5 cm compared with 10 cm surface height (Ataja *et al* 1992).

Similar conclusions can be drawn from the data of Hamilton *et al* (1995) in the UK, which shows that the growth of the young deer was maximised when sward surface height was maintained at 8 - 10 cm. However, even when grazed under these conditions, only 42 - 50% of young red deer stags attained the minimum slaughter criteria by 12 months of age. A follow up investigation using rotational grazing (initial height 1 0 cm; final height 8 cm) produced similar results, with 41 and 60% of young red stags grazing perennial ryegrass/white clover and annual ryegrass/white clover pastures during winter and spring attaining 92 kg liveweight by 12 months of age (Ataja *et al* 1992).

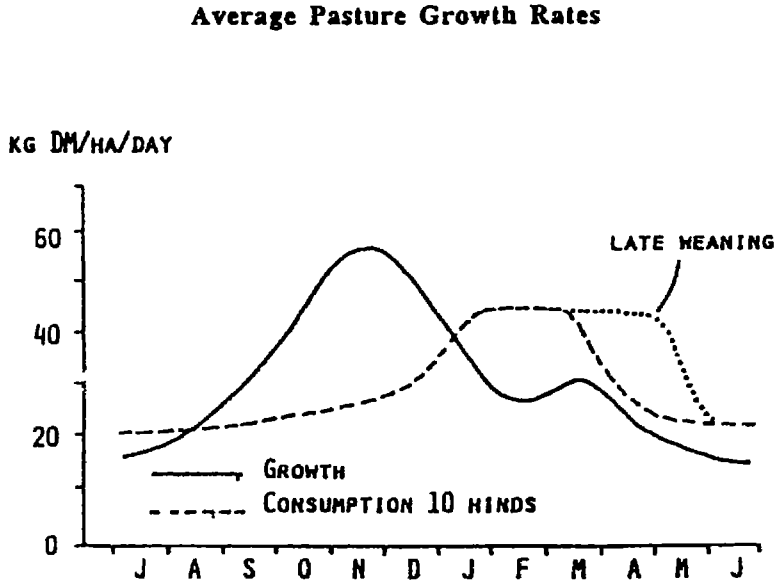
Table 1: Growth of young red deer during their first winter (W) and spring (S)when grazing ryegrass-based pastures maintained at 5 and 1O cm sward surface heights.

		10 cm		5 cm	
Ryegrass		Perennial	Annual	Perennial	Annual
Herbage Mass	W	1840	1694	1236	1148
(kg DM/ha)	S	2251	2022	1731	1690
LWG (g/d)	W	153	131	74	79
	S	234	209	147	211
Stags attaining 92 kg LW (%)		42	50	0	21

From Ataja *et al*, 1992

Another problem with perennial ryegrass/white clover pastures is the mis-match between feed production and deer feed requirements (Fig 1), with peak pasture production occurring in mid spring but deer not calving until late spring/early summer. Consequently, feed quality is lowest during summer and autumn when the potential for deer growth is highest. For these reasons, a research programme was initiated at Massey University in 1987 to develop grazing systems for deer production based upon special forages.

Figure 1: *The mis-match between rates of pasture DM production (Manawatu) and deer feed requirements.*



Red clover and chicory as specialist forages for venison production

Deer Production

In the experiments reviewed here, deer grazing red clover and chicory forages were compared with similar deer grazing perennial ryegrass/white clover pasture, when both were grazed under optimum conditions. Rotational grazing was used in all instances, with rotation length being ')-5 weeks. Deer were offered all three forages at the same DM allowance/animal in each season. These corresponded to mean pre- and post- grazing forage masses of 3,500 & 2,100 kg DM/ha for chicory and 2655 and 1770 kg DM/ha for perennial ryegrass/white clover and pasture. This corresponded to red clover and chicory being grazed from an initial height of approx 30 cm to a final height of approx 10cm, with the corresponding values for perennial ryegrass/white clover pasture being 1 0 cm & 8 cm.

Further details of forage management are given by Barry (1998) and Barry *et a]* (1998). The experiments were divided into a lactation phase to weaning (January & February) and a post weaning to slaughter phase (early March to 30 November of the same year). Because red clover and chicory are dormant during winter, animals allocated to these forages were grazed on pasture during winter. Red deer and hybrid (0.25 elk : 0.75 red) deer were used as specified in each experiment. All were regularly drenched with anthelmintic from weaning (end Feb) to the end of winter.

During lactation, growth of deer calves grazing perennial ryegrass/white clover pasture was 331-399 g/d (Table2). Grazing red clover, chicory or *Lotus corniculatus* further increased calf growth by approx 20%, with the response being similar for all forages.

Table 2: **Growth of deer calves during lactation (g/day) in summer (January & February). Values in brackets are % increases relative to grazing perennial ryegrass/white clover pasture.**

Author	Perennial ryegrass/white clover pasture	Red Clover	Chicory	*Lotus corniculatus*
Niezen *et al.*, (1993)[1]	333	433 (30)		
	331	410 (24)	385 (16)	
Kusmartono *et al.*, (1996a)[2]	351		404 (16)	
Adu *et al.*, (1997)[2]	399			485 (22)
Mean % increase		(27)	(16)	(22)

[1] Calves all red deer.

[2] Half calves were red deer & half were 0 25 elk: 0 75 red deer hybrid.

From weaning to slaughter, growth of young deer grazing perennial ryegrass/white clover pasture was approx 200g/day during autumn and 300 g/day during spring (Tables 3 & 4). Grazing red clover increased growth by an average of 26% during autumn and 14% during spring. Corresponding increases for chicory were 47% in autumn and 1 0% in spring (Table 4).

Table 3: **Growth of red stags from weaning to one year of age (g/day) on red clover, compared with perennial ryegrass/white clover pasture. Values in brackets are % increases relative to grazing perennial ryegrass/white clover pasture.**

Author	Perennial ryegrass/white clover pasture	Red Clover
	AUTUMN	
Semiadi *et al.*, (1993)	192	263 (37)
Soetrisno *et al.*, (1994)	207	237 (14)
Mean % increase		(26)
	SPRING	
Semiadi *et al.*, (1993)	341	354 (4)
Soetrisno *et al.*, (1994)	281	346 (23)
Mean % increase		(14)

Table 4: **Growth of weaner red (R) hybrid (H) stags (g/d) to one year of age on chicory, compared with perennial ryegrass/white clover pasture. Values in brackets are % increases relative to grazing perennial ryegrass/white clover pasture.**

Author	Perennial ryegrass/white clover pasture		Chicory	
	R	H	R	H
			AUTUMN	
Kusmartono *et al.*, (1996a)	178	203	246 (38)	318 (57)
Min *et al.*, (1997)	152	199	235 (55)	271 (36)
Mean % increase			(47)	
			SPRING	
Kusmartono *et al.*, (1996a)	260	271	255 (-2)	310 (14)
Min *et al*, (1997)	285	298	335 (18)	331 (11)
Mean % increase			(10)	

The proportion of young red stags grazing perennial ryegrass/white clover pasture which reached 92 kg liveweight (50 kg carcass) by one year of age averaged 73%, but showed great variation between years (Table 5). When red clover or chicory were grazed this was consistently increased to 90-1 00%, with little variation between years. Relative to deer grazing perennial ryegrass/white clover pastures, grazing red clover increased carcass weight by an average of 11% whilst grazing chicory increased carcass weight by 17%. Carcass weight responses were particularly high for hybrid stags grazing chicory. Grazing red clover or chicory did not affect mean carcass fatness, as measured indirectly by GR.

Table 5: **Percentage of red (R) and hybrid (H) stags reaching 92 kg liveweight (50kg carcass) by one year of age when grazing red clover, chicory or perennial ryegrass/white clover pasture.**

Author	Perennial ryegrass/white clover pasture		Red Clover		Chicory	
	R		R			
Semiadi *et al*, (1993)	75		100			
Soetrisno *et al*, (1994)	90		100			
	R	H			R	H
Kusmatono *et al*, (1996a)	100	88			100	100
Min *et al*, (1997)	25	75			80	80
Mean Values	73	82	100		90	90

Table 6: **Carcass weight (kg) of red (R) and hybrid (H) stags at one year of age from grazing red clover, chicory or perennial ryegrass/white clover pasture. Values in brackets are % increases relative to grazing perennial ryegrass/white clover pasture.**

Author	Perennial ryegrass/white clover pasture		Red Clover	Chicory	
	R		R		
Semiadi *et al*, (1993)	54 5		59 9 (10)		
Soetrisno *et al*, (1994)	53 3		58 9 (11)		
	R	H		R	H
Kusmatono *et al*, (1996a)	56 6	57 0		63 2 (12)	73 0 (28)
Min *et al*, (1997)	48 6	53 3		56 0 15)	59 3 (12)
Mean Values			11		17

Establishment

Establishment can be either by direct drilling or by drilling after conventional cultivation, but as the seeds are small sowing depth needs to be no more than 1 0 mm. Chicory is sown at 4 - 5 kg/ha with 'i kg/ha white clover seed. Without clover to provide a source of nitrogen for the chicory, regular applications of nitrogen fertiliser (20 kg N/ha) are needed monthly. Red clover is sown at 6 - 8 kg/ha. Both species can be established in either early autumn or spring, but require warm temperatures (>10'C) while the seedlings are establishing, or the seedlings grow too slowly to compete with weeds. Spring sowing is preferred. Well established crops of red clover or chicory have from 60 - 80 seedlingS/M2 (Figure 1, Li *et al.* 1997a). Grasses can be readily removed from both crops with herbicides.

Grazing Management

The key to the grazing management of both chicory and red clover is to maximise leaf mass without excessively decreasing the persistency of the plants. This is achieved by starting grazing when the plants are 'JO cm high and grazing down to 10 cm. Grazing the plants to less than 1 0 cm high decreases the subsequent regrowth and increases the incidence of fungal rots in the plants. The recommended grazing management results in chicory and red clover being rotationally grazed every ') - 5 weeks depending on the weather conditions. Reproductive stems that grow above 'JO cm during sununer should be mechanically topped; under NZ conditions we normally top twice in summer. Grazing either red clover or chicory in winter, particularly when the soil is wet, can result in the death of twenty percent or more of the plants present and was avoided in the deer experiments reported here (Li *et al.* 1997b).

Production and Persistence

Red clover and chicory both typically produce from 8 - 12t DM/ha over their eight month growing season from spring to autumn (Soetrisno *et al*., 1994, Ll *et al.*, 1997a). They are dormant or very slow growing over winter, but produce well over dry summer and autumn conditions.

Over time the plant density of both forages declines regardless of the grazing management used, but this is compensated for by an increase in the number of shoots per crown until the plant reaches its maximum size for the prevailing environmental conditions (Ficrure 2). Once the plants have reached their maximum size the foraae production decreases as the plant density decreases. Therefore, one objective of management is to minimise the rate of plant death. The main causes of plant death are physical damage from severe treading or crraziner, exhaustion of plant reserves from too frequent errazing, and funeral diseases.

When grazed as a specialist forage crop red clover usually has a productive life of 2 - 3 years, whereas chicory remains productive for 3 - 5 years (Figure 2, see p.7). The productive life of red clover or chicory when used in a mixed pasture is only 1 - 2 years. The persistency of both species is largely determined by the plant density obtained at establishment, and the use of grazing management practices that minimise plant death. Once plant density of both red clover and chicory has declined to less than 25 plants/m^2 forage production is halved (Li *et al* 1997a).

Nutritional reasons for differences between forages

The chemical composition of vegetative perennial ryegrass, red clover & chicory is shown in Table 7. Chicory contains a higher concentration of ash than either perennial ryegrass or red clover. Relative to perennial ryegrass, both red clover and chicory contain higher concentrations of readily fermentable carbohydrate (soluble sugars & pectin) and lower concentrations of structural carbohydrate (cellulose & hemicellulose). Hence the ratio readily fermentable carbohydrate: structural carbohydrate is higher for red clover and chicory than for perennial ryegrass. The consequences of this are that both rate of ruminal particle breakdown and rate of rumen outflow are faster for chicory than for perennial ryegrass (Table 8), whilst ruminating time is much lower for chicory. As a result of this, both apparent digestibility (Table 8) and metabolisable energy (ME) concentration (Table 7) are considerably greater for chicory than for perennial ryegrass. The higher ash content of chicory probably also contributes to the very high fractional outflow rate (FOR) of rumen liquid in deer fed this

forage. Similar measurements of digestion kinetics show that red clover is also broken down faster in the rumen than perennial ryegrass (Freudenberger *et al* 1994).

Figure 2 *The change in plant density (a) and plant size (b) of a crop of chicory over three years starting from spring of its second year The units are the number of months since measurements began The arrows show the predicted month for 50 and 75% of plants to have died From Li et al (1997)*

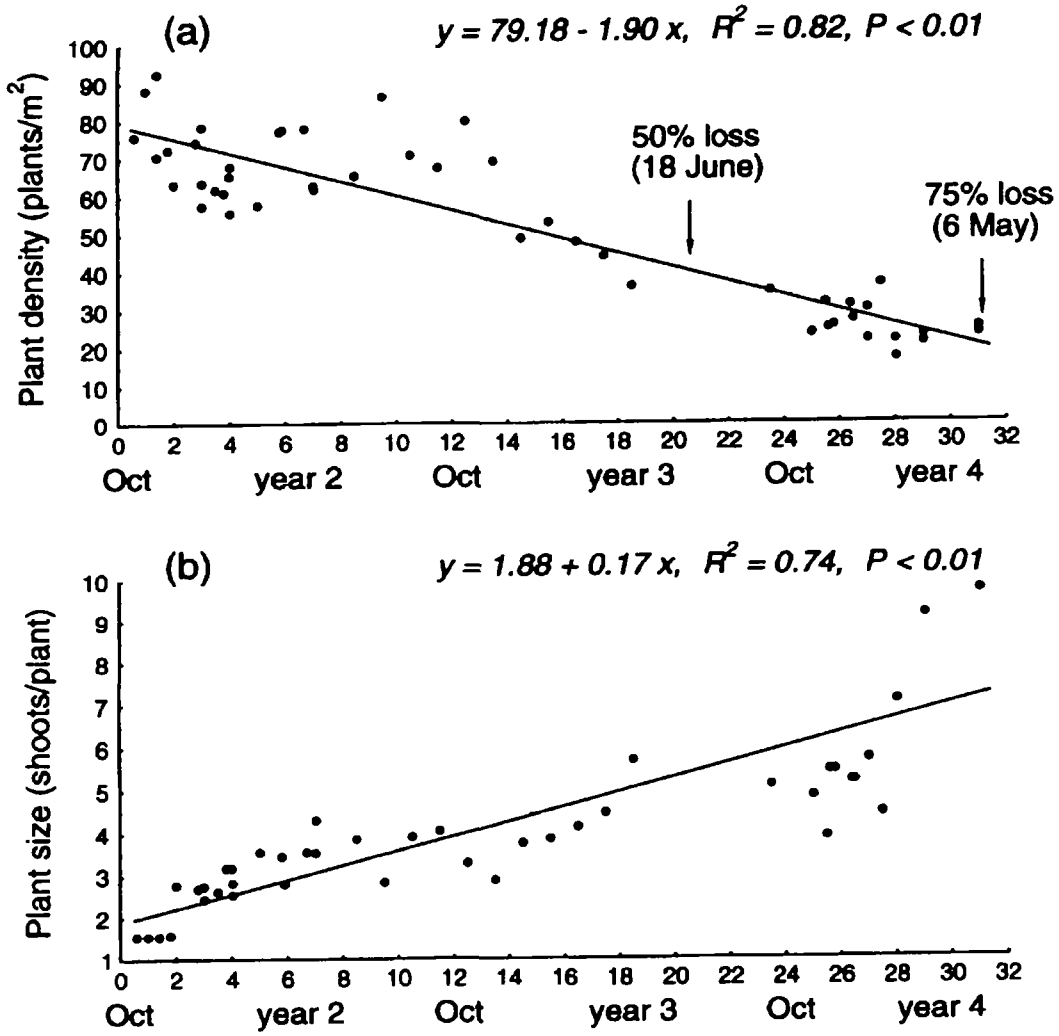


Table 7: **The chemical composition (g/kg DM) of vegetative perennial ryegrass, red clover and chicory.**

	Perennial ryegrass	Red Clover	Chicory
Ash	105	104	149
Total N	45 2	46 9	19 7
Soluble sugar (a)	74	95	111
Pectin (a)	10	39	98
Cellulose (b)	184	115	104
Hemicellulose (b)	212	54	44
Ratio (a b)	0 21	0 79	1 41
Lignin	10	12	20
Metabolizable energy (MJ/kg OM)	12 3	13 4	13 7

From Jackson *et al* (1 996), Scales *et al* (1 995)

Table 8: **Kinetics of feed breakdown and outflow from the rumen in red deer fed chicory and perennial ryegrass under indoor conditions**

	Perennial ryegrass	Chicory	SE
Composition			
Dry matter (g/kg)	247	161	
Total N (g/kg DM)	30 4	26 9	
Ash (g/kg DM)	102	180	
Apparent digestibility			
Organic matter	0 744	0 820	0 0311
NDF	0 755	0 679	0 02311
Rumen pH	6 44	5 63	
Particle breakdown efficiency			
Eating	0 37	0 27	0 038
Ruminating	0 47	0 65	0 038
Chewing time (min)			
Eating	221	209	49 2
Ruminating	257	30	54 6
Rumen fractional outflow rate (%/h)			
Liquid	13 6	18 9	2 18
Particulate (Lignin)	2 78	4 08	0 551
Particulate (ADF)	2 02	4 30	0 506
Rumen mean retention time (h)			
Liquid	8 9	6 4	0 01
Particulate (lignin)	49 0	37 7	9 61
Particulate (ADF)	52 5	27 9	4 66

From Dryden *et al* (1 995), Kusmartono *et al* (1 996a, 1996b, 1997)

In grazing studies, both voluntary feed intake (VFI) and apparent digestibility of the diet selected have been consistently higher for young deer grazing red clover and chicory than for deer grazing perennial ryegrass/white clover pasture (Semiadi *et al* 1993; Soetrisno *et al* 1994; Kusmartono *et al* 1996; Min *et al* 1997). These differences have generally been largest at the time when the nutritive value of perennial ryegrass/white clover pasture is lowest (summer)

and least when the nutritive value of pasture is highest (spring). Kusmartono *et al* (1996) found that VFI of deer grazing chicory was 55%, 25% & 15% greater than that of deer grazing pasture during summer, autumn and spring, respectively.

These increases in VFI and apparent digestibility can be explained by the faster breakdown and clearance of red clover and chicory from the rumen (Table 8).

Animal health issues and substainable deer production

In addition to increasing growth and venison production, specialist forages can also be used to assist in control animal health problems. One of our earliest observations was that although feeding red clover is well known to induce rumen frothy bloat in cattle, deer grazing pure swards of red clover at Massey University never developed bloat. Bloat is caused by high solubility of forage proteins, leading to the development of a stable foam in the rumen (Mangan 1959). It is especially prevalent in cattle grazing pure legumes during spring. From first principles, the damage done by these foams in preventing gas eructation from the rumen is going to depend on the rumen outflow rates shown in Table 8. Rumen fractional outflow rate (FOR) of liquid was 60% faster for red deer than for sheep and goats fed the same diet (Table 9), with the corresponding mean retention times (I/FOR) for liquid being 6.') and 10.0 hours respectively. Probably deer do not develop bloat on feeds with a high soluble protein content because the residence time of the foam in the rumen is too low. The proportionally faster rumen liquid outflow in deer can also be seen from the ratio FOR liquid : FOR particulate matter, which is normally close to for domestic ruminants but is 5 - 6 for red deer.

Table 9: **Fractional outflow rates (%/h) of liquid and particulate matter from the rumen in red deer, goats and sheep fed chopped lucerne hay at hourly intervals durinor summer (S) and Winter (W)**

	SEASON	DEER	GOATS	SHEEP
Liquid	S	15 8	10 8	10 4
	W	16 3	9 6	10 3
Particulate	S	2 8	3 7	3 3
Matter	W	3 5	3 5	3 3
Liquid	S	6 0	3 1	3 2
Particles	W	4 8	2 8	3 1

Domingue *et al* (1991)

Forage technology also has the potential to be used to control problems of internal parasitism in grazing deer. This can be achieved using different plant morphology, using forages containing different chemical constituents (secondary compounds) or a combination of both approaches. An example of using the plant morphology approach is shown in Table 10 (Hoskin *et al* 1999), where weaner deer were grazed on either chicory or perennial ryegrass/white clover pasture from weaning to slaughter at one year of age. Groups of deer grazing each forage were either drenched 3 weekly for the duration of the study to suppress internal parasites or drenching was withheld until certain trigger criteria were met. Drenching could be withdrawn from deer grazing chicory without causing any problems of internal parasitism and without depressing growth and venison carcass production. However, withdrawing drenching from deer grazing perennial ryegrass/white clover pasture rapidly led

to the development of clinical lungworm infection during autumn and to considerable weight loss during this time (- 9 kg). Trigger drenching was required, but this did not prevent a reduction in carcass weight. Scales *et al* (1 995) observed similar beneficial effects in parasitised lambs grazing chicory. Moss & Vlassoff (1 99'J) seeded different herbage species with strongylate nematode eggs from sheep and recovered fewer ineffective larvae from chicory than from grasses and other herbage species. One of the reasons for reduced parasite problems with chicory is its taller growth habit relative to grasses and white clover, with fewer ineffective larvae reaching the stratum that is consumed by grazing animals.

In controlled indoor studies, involving trickle infections with mixed L') lungworm and GI nematode larvae, weaner deer fed the condensed tannin - containing legume sulla had less parasites established and greater growth than young deer fed lucerne, which does not contain condensed tannins (Hoskin 1998). This illustrates how chemical constitutes of forage can be used to control parasite problems, but current varieties of sulla only exist for about 1 1/2 years under grazing. Factors governing persistence in sulla are currently being researched.

Table 10: **Effect of withdrawing anthelmintic treatment upon the voluntary food intake (VFI), liveweight gain (LWG) and carcass weight of weaner deer grazing perennial ryegrass/white clover pasture and chicory.**

	PASTURE		CHICORY		SE
	Treated	Trigger treated	Treated	Trigger treated	
VFI (KgOM/d)					
Autumn	1920	835	1015	1150	127 3
Spring	1539	1739	1765	1631	55 2
LWG (g d)					
Autumn	217	125	184	212	8 7
Winter	133	138	115	95	7 4
Spring	249	238	288	291	12 4
Carcass Weight (Kg)	57 9	51 3	57 1	57 0	1 52

Hoskin *et al* (1 999)

Conclusions

With improved management of perennial ryegrass/white clover pasture these experiments have shown that growth of young deer can be increased, such that an average of 73% of animals reach the target liveweight (92kg) by one year of age. This is a considerable improvement over the figure of 40% found in the best commercial farms in the survey by Audige (1995). However, the mean figure of 73% was variable between years (range 25 - 1 00%) and carcass weight was only just over 50 kg. To achieve best deer growth rates, perennial ryegrass/white clover pastures should be maintained in the vegetative state and grazed at a height of 1 0 cm.

Inputs of red clover and chicory consistently increased the proportion of stags reaching the target liveweight to 90 - 100% and increased carcass weight by 11 - 17%, showing that the feeding value of these crops for deer is consistently higher than that of grass-based pastures, as also found for sheep (Barry 1998). With such superior feeding value, the key to specialist forages such as red clover and chicory being adopted by deer farmers is devising grazing management practices which will result in persistence of these plants being extended to 4 - 6 years. Key recommendations are rotational grazing at 5 week intervals, with initial and final heights being 30 and 10 cm, mechanically topping reproductive growth during summer and

not grazing during prolonged wet weather. The downside of these crops is that they are winter dormant; for this reason we recommend that no more than 20% of a deer farm be sown in these specialist crops.

These studies have shown that red deer and 0.25:0.75 elk:red hybrids showed similar advantages on chicory, with higher carcass weights consistently obtained for hybrids grazing chicory. It may be that the superior genetic potential of the hybrids for growth can best be expressed when grazing when grazing high nutritive value feeds such as chicory

An additional advantage of chicory is that it may be possible to reduce the use of anthelmintic drenches during autumn, thus reducing the chances of drench resistance developing and giving a more sustainable grazing system. Inputs of special purpose forages can therefore be used to simultaneously increase deer growth and to reduce the risk of parasitism developing.

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