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The effects of grazing chicory (*Cichorium intybus*) and birdsfoot trefoil (*Lotus corniculatus*) on venison and velvet production by young red and hybrid deer

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Abstract The effects of grazing chicory, *Lotus corniculatus*, and perennial ryegrass/white clover pasture on growth, voluntary feed intake (VFI), and venison and velvet production was studied in red and hybrid deer from weaning to slaughter at one year of age. Twenty five percent of red and 75% of hybrid stags attained the target slaughter weight (50 kg carcass or greater) when grazing pasture and spiker velvet antler weight was low (approximately 0.2 kg/stag). Mean carcass weight of deer grazing chicory was higher than for deer grazing pasture ($P < 0.05$), due to increased liveweight gain (LWG) in both autumn and spring, and to higher dressing-out percentage at slaughter. Carcass weights for red and hybrid stags were 56.0 and 59.3 kg, respectively, when grazed on chicory and 48.6 and 53.3 kg, respectively, when grazed on pasture ($P < 0.01$). Hybrid hinds grazing chicory had a significantly higher carcass weight ($P < 0.05$) and dressing-out percentage ($P < 0.01$) than those grazing pasture.

Chicory had a higher organic matter digestibility (OMD) than pasture, and VFI was higher than on pasture during autumn but was similar in spring. Relative to pasture, chicory grazing increased total spiker velvet antler production (323 v 225 g/stag) by advancing the dates of pedicle initiation, antler initiation, and of first velvet cutting and increasing the rate of velvet antler length growth. Initiation of velvet growth was correlated with liveweight (LW), with each 10 kg increase in LW advancing the dates of pedicle initiation, commencement of velvet growth, and first velvet cutting by 10, 18, and 13 days, respectively. Earlier velvet growth in deer fed chicory could thus largely be explained by the higher liveweight of deer grazing this forage.

Observations from deer grazing lotus were limited due to problems with lotus establishment. Grazing lotus increased LWG of stags during autumn compared with perennial ryegrass/white clover pasture (248 v 176 g/day) and increased the efficiency of growth in spring, with LWG being similar to deer grazing pasture, but VFI being lower (1.53 v 2.00 kg OM/day). OMD of lotus was higher than pasture during autumn, but not in spring. Stags grazing lotus produced similar velvet antler weight to stags grazing pasture.

Total condensed tannin (CT) concentration in hand plucked and oesophageal fistulae (OF) extrusa samples, respectively, were 48 v 13 g/kg OM for lotus, 3.1 v 5.8 g/kg OM for chicory, and 0.3 v 1.5 g/kg OM for pasture. It was concluded that chicory was of high feeding value for increasing venison and velvet production from young deer. Results suggest that the CT content of lotus may improve the efficiency of growth in young deer.

Keywords: Chicory; *Lotus corniculatus*; deer; venison; velvet

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INTRODUCTION

A production target of deer farmers in New Zealand is to achieve premium carcass weights (50–65kg) by November (spring), preferably by one year of age. Under current perennial ryegrass/white clover pasture management, young red deer stags usually reach this carcass weight when 15 months old (Drew 1989), when venison schedule prices usually have declined. A contributing cause is the poor alignment between pasture production and feed requirements of lactating hinds and young weaners, caused by late calving (Nov/Dec). In order to reach premium carcass weights by one year of age or less, superior nutritional strategies such as the input of specialist crops are desirable.

'Grasslands Puna' chicory (*Cichorium intybus*) is a perennial herb of the Asteraceae family that has been evaluated as a bulk summer green feed (Hare et al. 1987) and as a special purpose forage for increasing the growth of male and female deer from 3 to 12 months of age (Kusmartono et al. 1996a). Puna chicory establishes well and has good drought resistance characteristics, with excellent summer dry matter (DM) production (25 t DM/ha) from December to May in NZ, due to its deep roots (Hare & Rolston 1987; Hare et al. 1987). Chicory is one of the forages most preferred by red deer (Hunt & Hay 1990) and can produce weaner stag autumn liveweight gains (LWG) of over 300 g/day (Kusmartono et al. 1996a).

The presence of condensed tannin (22 g extractable CT/kg DM) in birdsfoot trefoil, commonly known and refered to in this paper as lotus (*Lotus corniculatus*), is believed to be beneficial in sheep diets by reducing protein degradation in the rumen and increasing amino acid absorption from the small intestine, without depressing rumen fibre digestion and VFI (Barry et al. 1986; Waghorn et al. 1987a). Lambs grazing lotus (22.3–34.0 g CT/kg DM) compared with lambs grazing lucerne (0.5–0.3 g CT/kg DM) had slightly lower VFI, but higher LWG (196 v 181 g/day), carcass weight gain, and wool growth (11.5 v 10.5 g/day) (Wang et al. 1996). However, there is no information available on the effect of CT on the efficiency of venison production from tannin-containing forage diets.

This study was designed to compare the feeding value of chicory and lotus with that of perennial ryegrass/white clover pasture for growth of red deer and 0.25 elk: 0.75 red deer (hybrid) calves from weaning to slaughter at one year of age, and to study the effects of these diets upon the initiation and growth of velvet antler in young stags.

MATERIALS AND METHODS

Experimental design

The experiment involved growth from weaning to slaughter at one year of age, and took place between 7 March and 8 December 1995, at Massey University Deer Research Unit. The experiment was a 3 × 2 × 2 factorial design, with three types of forage namely chicory (*Cichorium intybus* cv. Grasslands Puna), birdsfoot trefoil (*Lotus corniculatus* cv. Grasslands Goldie) and perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) pasture, two deer genotypes (pure red deer vs elk hybrid), and two sexes (male vs female) The animals were rotationally grazed on chicory, perennial ryegrass/white clover pasture, and lotus.

Animals

Twenty six red deer (14 stags, 12 hinds) and 27 hybrids (hybrid = (*Cervus canadensis* × *Cervus elaphus*) × *Cervus elaphus*), 13 stags, 14 hinds) were randomly allocated to three groups after weaning on 7 March 1995. Groups were allocated to graze either chicory, perennial ryegrass/white clover pasture, or lotus, with each group balanced for genotype and sex. Animals were eartagged and vaccinated against clostridial infections (Coopers, Animal Health Ltd, NZ) at the start of the trial (7 March) and against *Yersinia pseudotuberculosis* (Yersiniavax; AgResearch, Upper Hutt, NZ) on 1 and 28 March. Copper needles (Bayer NZ LTD, Petone) were given orally (12 g/head) on 7 March. Animals were drenched orally with Ivermectin (IVOMEC–0.4% w/v at 200 (g/kg liveweight: Merck, Sharp and Dohme, NZ) at 3-week interva until the end of June, and then 6-weekly until slaughter.

Forages

The chicory (1.95 ha; 7 paddocks) was three years old, while the perennial ryegrass/ white clover pasture (7.16 ha; 9 paddocks) was several years old and the lotus newly sown. The area for lotus (1.57 ha; 4 paddocks) was ploughed, disk harrowed, and power harrowed in December 1994. Seed was drilled during the summer of 1994 at the rate of 10 kg/ha. After the lotus emerged, MCPB (Mecoprop phenoxy butyric; active ingredient 400 g/l as the sodium salt; Shell Chemicals Ltd.) was sprayed at

4 l/ha to control white clover and other weeds. However, in two paddocks the lotus subsequently died, thus providing no autumn grazing. They were re-sown and were available for spring grazing. Urea was applied at 37 kg N/ha to both the chicory and the perennial ryegrass/white clover pasture in early autumn (February) and late spring (October) 1995.

Grazing management

Each group of deer was rotationally grazed on its allocated forages from 7 March to 6 June during autumn (91 days), and during spring from 22 September to 8 December (77 days). Deer were combined and grazed on perennial ryegrass/white clover pasture (7.16 ha; 9 paddocks) over winter (107 days). They were split into their groups again in spring. Pasture allowances were 6 kg DM/deer/day in autumn and winter, and 7 kg DM/deer/day in spring. Pasture post-grazing residual mass was 1500 kg DM/ha during autumn and spring, and 1300 kg DM/ha during winter when 1.51 kg DM/animal/day of hay supplementation was given from 10 July to 11 August. Feed allowance in the lotus group was 6 kg DM/deer/day for 20 days in autumn (May) and 7 kg DM/deer/day for 50 days in spring (October to November), due to the shortage of lotus.

The time the deer grazed each paddock, based on the specified allowances, was calculated as follows:

$$\text{Total days} = \frac{\text{Herbage mass (kg DM/ha)} \times \text{total area of paddock}}{\text{(Total animals/group)} \times \text{(Pasture DM allowance/hd/day)}} \quad (1)$$

Pasture measurements

Pre- and post-grazing herbage mass (kg DM/ha) was measured at the beginning and end of grazing each paddock. On each occasion eight random quadrats (0.1 m^2) per paddock were cut to soil level using a hand-clipper. The herbage samples were then washed, oven-dried at 90°C for 18 h, and weighed.

For laboratory analysis, eight quadrats (0.1 m^2) of herbage on offer were cut to ground-level from each paddock pre-grazing. Samples were combined for each paddock, mixed, and divided, with the first part used for botanical composition assessment and the second part stored at –20°C for later nutritive value analysis.

Diet selection was simulated by hand-plucking plants in the areas that were grazed by deer. The samples were collected daily, pooled for each paddock, and then divided for nutritive value analysis and for botanical composition. In autumn and spring the diet selected was also determined using two oesophageal fistulated (OF) red deer, which allowed a second sampling procedure for nutritive value and digestibility. Forage samples were washed, stored at –20°C, and then freeze dried and ground, whereas OF extrusa samples were stored at –20°C, and then freeze dried and ground.

Animal measurements

Animals were weighed at 3-weekly intervals. In order to estimate faecal organic matter output, chromium (Cr) slow-release capsules (CRD, Cr_2O_3 matrix, Captec Ltd., Auckland, NZ) were given into the rumen of the deer. Faeces were sampled at 2 day intervals from day 8 to day 22 after CRD administration, with one sample taken per day, and with the daily sampling time progressively moved at 2 h intervals from 07.00 to 21.00. Faecal samples were collected in plastic bottles and oven-dried at 90°C for 72 hours. Each sample was then crushed, and equal amounts of each sample were pooled for each weaner over the two week sampling period for later analysis.

Two hand-reared, rumen-fistulated, castrated red deer stags in autumn and three in spring were grazed on each forage for 27 days, to measure the Cr release rate of capsules suspended in the rumen. Measurements started on day 5 after CRD insertion, and proceeded at 3-day intervals until day 27.

Pedicle development and velvet antler removal

Pedicle initiation was measured by thumb palpation, using two independent operators, twice per week from 14 April 1995 to 25 May 1995. When the pedicle reached 4 cm long this was regarded as velvet antler initiation. The length of the spiker (i.e., yearling stag) velvet antlers was measured from the skull to the top of the antler using electronic calliper twice per week from 26 May to 3 October. Velvet was removed when it reached 20 cm long using the procedures of Ministry of Agricultue and Fisheries (1992). Velvet antler was weighed, and date of removal, velvet length, and cross-sectional area of the cut section were recorded. Cross-section areas were measured using a Tamaya Digiting Area-line Meter (Planix 5000, Japan).

Slaughter

Stags and hybrid hinds attaining 92 kg liveweight (LW; 50 kg carcass) or greater were sent for slaughter at the Deer Slaughter Premises in Feilding on 8 December 1995. Red deer hinds were retained for breeding. Hot carcasses were weighed, and the carcass GR (soft tissue depth over the 12th rib 16 cm from the dorsal mid line) measured as an indirect measure of fatness (Kirton 1989). Carcass dressing percentage was then calculated as hot carcass weight divided by LW × 100.

Laboratory analysis

Prior to laboratory analyses, herbage samples were stored at −20°C, freeze-dried, and ground to pass a 1 mm mesh diameter sieve (Wiley mill, USA). Dry matter was determined by oven-heating at 100°C for 16 h. Organic matter content was measured by ashing the samples in a furnace at 500 °C for 16 h.

Forage digestibility was estimated *in vitro* using the enzymic method of Roughan & Holland (1977). Total nitrogen (N) was determined by the Kjeldahl method using a selenium catalyst and sulphuric acid digestion. Chromium analysis of faeces was by the method of Costigan & Ellis (1987). Extractable and bound condensed tannins (CT) were determined by the modified butanol/HCl procedure of Terrill et al. (1992a).

Pasture on offer and hand-plucked samples used for botanical composition were separated into grasses, clover (red or white), chicory, lotus, dead matter, and weed. Each component was separately oven-dried at 90°C for 17 h, and weighed.

Data calculation and statistical analysis

Faecal output (FO) was calculated as:

$$\text{FO (g OM/Day)} = \frac{\text{Cr release rate (RR) (mg/day)}}{\text{Faecal Cr concentration (mg/g OM)}} \quad (2)$$

Voluntary feed intake (VFI) was calculated as follows using organic matter digestibility (OMD) from estimated diet selected (OF samples).

$$\text{VFI (g OM/Day)} = \frac{\text{FO (g OM/day)}}{1-\text{OMD}} \quad (3)$$

LWG, pedicle development, velvet length, velvet weight, carcass weight, GR measurement, and VFI data were analysed using a General Linear Model Procedure (SAS 1987). Age was used as a covariate for all LW data, and carcass weight was used as a covariate for carcass GR measurements. There were no forage × genotype interactions and no forage × genotype × sex interactions for any of the measurements made; hence only main effects are reported in the results section.

RESULTS

Herbage mass and botanical composition

Pre- and post-grazing herbage masses were generally higher for pasture than for chicory (Table 1), with the lowest post-grazing herbage masses being 1184 and 1444 kg DM/ha for pasture during winter and spring, respectively. Pre-grazing herbage masses during spring were higher for lotus than for either pasture or chicory.

Table 1 Seasonal mean (SE) pre- and post-grazing herbage mass (kg DM/ha) for perennial ryegrass/white clover pasture (PRG), chicory, and *Lotus corniculatus*.

Herbage mass	PRG			Chicory			Lotus[2]		
Season	N[1]	Pre-	Post-	N[1]	Pre-	Post-	N[1]	Pre-	Post-
Autumn (91 days)	11	2487	1971	12	2158	1326	2	2043	1493
SE		343.6	212.7		563.6	328.5		94.0	25.4
Winter[3] (107 days)	13	1594	1184		–	–		–	–
SE		402.1	225.2						
Spring (77 days)	9	2260	1444	17	2030	1466	4	2786	1736
SE		68.4	257.2		241.4	138.9		510.7	203.1

[1]Number of samples taken per season.
[2]Lotus was grazed for 20 days in autumn and for 50 days in spring, due to limited lotus establishment.
[3]Deer on pasture, lotus, and chicory were combined and grazed together on pasture during winter, with 1.5 kg/animal/day of hay supplementation from 10 July to 11 August 1995.

Pasture on offer (Table 2) contained predominantly perennial ryegrass with 4–11% of white clover. Dead matter was at a maximum of 9% in autumn and was lower in winter and spring (2%). The chicory forage on offer contained 80–85% chicory (Table 3), interspersed with white clover and weed ranging from 6 and 3%, respectively, in autumn to a maximum of 11 and 9%, respectively, in spring. Dead matter ranged from 6% in autumn to 0% in spring. Lotus content of feed on offer was 92–94% (Table 3). Forage samples of "diet selected" were of similar botanical composition to "feed on offer", except that the weed and dead matter contents were lower.

Table 2 Seasonal mean (SE) botanical composition (% DM) of perennial ryegrass/ white clover pasture.

Season	N[1]	Perennial ryegrass	White clover	Dead matter	Weed
Forage on offer					
Autumn	11	80.9	6.9	9.4	2.8
SE		3.6	0.5	0.5	0.1
Winter	8	91.3	4.0	2.5	2.2
SE		1.4	0.2	0.1	0.1
Spring	8	85.5	11.1	2.0	1.4
SE		1.5	0.4	0.1	0.1
Diet selected (hand-plucked)					
Autumn	10	88.7	5.8	3.4	2.1
SE		4.1	0.2	0.2	0.1
Winter	8	94.9	3.0	2.2	0
SE		1.0	0.1	0.1	0
Spring	6	89.2	7.6	1.8	0.8
SE		0.6	0.3	0.1	0.1

[1]Number of samples taken per season

Nutritive value of forages

Mean nutritive values for forage during autumn and spring are given in Tables 4 and 5. OMD of chicory was higher than for perennial ryegrass/ white clover pasture (Table 4) in autumn ($P < 0.001$) and spring ($P < 0.001$), for both forage on offer and hand-plucked samples, but similar for the oesophageal fistula (OF) samples.

OMD of lotus on offer was significantly higher than that of pasture during autumn ($P < 0.05$), whilst that of lotus for hand-plucked samples was similar to that of pasture. OMD of lotus was similar for both feed on offer and hand-plucked samples. OF samples in deer grazing lotus were significantly lower in OMD than that of pasture during spring ($P < 0.001$).

Hand plucked and OF samples were generally of higher OMD than samples of feed on offer, for all three forages, with the differences being largest when diet selected was measured using OF deer, especially when grazing pasture in autumn.

The OMD of chicory showed little change between seasons, but pasture changed with season, being of lowest OMD in autumn and highest in spring. Feed on offer and diet selected on lotus were relatively similar in terms of total N content and OMD in autumn and spring.

Organic matter (OM) contents of pasture, chicory, and lotus were much lower for OF samples than hand-plucked samples due to saliva contamination (Table 5). Consequently, total N and CT values were expressed per 100 g OM. Total N content was generally higher for OF samples than hand-plucked samples. Total CT in the lotus was

Table 3 Seasonal mean (SE) botanical composition (% DM) of chicory and *Lotus corniculatus* forages.

		Chicory					Lotus[2]			
Season	N[1]	Chicory	White clover	Dead matter	Weed	N[1]	Lotus	White clover	Dead matter	Weed
Forage on offer										
Autumn	14	84.7	5.9	6.3	3.1	2	94.1	1.5	0.1	4.4
SE		6.1	0.6	0.4	0.4		0.4	0.1	0.1	0.1
Spring	11	80.1	11.0	0	8.9	4	92.0	3.1	0.1	4.9
SE		0.8	0.4	0	0.6		1.7	0.4	0.1	0.1
Diet Selected (hand-plucked)										
Autumn	13	89.6	7.1	0.7	2.6	2	96.4	1.7	0.1	1.9
SE		2.6	0.3	0.1	0.2		1.6	0.1	0.1	0.1
Spring	10	91.2	7.4	0	1.4		91.5	4.1	0	4.4
SE		1.1	0.4	0	0.1		1.9	0.4	0	0.4

[1]Number of samples taken per season.
[2]Lotus was grazed for 20 days in autumn and for 50 days in spring 1995.

Table 4 Seasonal mean (± SE) total nitrogen (N; %DM) and organic matter digestibility (OMD;%DM) of forage on offer and diet selected by deer grazing perennial ryegrass/white clover, chicory, and *Lotus corniculatus*.

	Pasture (n = 6)	Chicory (n = 6)	Lotus (n = 6)
Forage on offer			
Total N:			
Autumn	3.87 ± 0.11	3.49 ± 0.11	3.77 ± 0.15[a]
Winter	4.07 ± 0.15	–	–
Spring	2.70 ± 0.24	3.49 ± 0.22	3.22 ± 0.27
OMD:			
Autumn	66.59 ± 1.85	81.87 ± 1.85	75.27 ± 2.61[a]
Winter	77.60 ± 1.14	–	–
Spring	80.24 ± 1.44	85.34 ± 1.33	75.28 ± 1.58
Diet selected (hand–plucked)			
Total N:			
Autumn	4.22 ± 0.11	3.61 ± 0.11	3.56 ± 0.20
Winter	4.39 ± 1.00	–	–
Spring	3.14 ± 0.24	3.64 ± 0.24	3.59 ± 0.28
OMD:			
Autumn	69.5 ± 1.85	84.63 ± 1.84	71.74 ± 2.61
Winter	80.1 ± 1.45	–	–
Spring	80.7 ± 1.44	86.31 ± 1.44	76.71 ± 1.58
Diet selected (oesophageal fistulae)			
Total N:	(n = 4)	(n = 6)	(n = 6)
Autumn	3.46 ± 0.36	3.03 ± 0.30	–
Winter	–	–	–
Spring	3.31 ± 0.10	2.97 ± 0.11	3.64 ± 0.10
OMD:			
Autumn	86.9 ± 0.65	85.9 ± 0.53	–
Winter	–	–	–
Spring	85.67 ± 0.81	83.63 ± 0.89	80.47 ± 0.81

[1] Number of samples taken per season. The same samples were used for total N and OMD.
[a]n = 3.

Table 5 Mean (n = 3) chemical composition (g/kg OM) of the perennial ryegrass/white clover (pasture), chicory, and *Lotus corniculatus* during spring.

	Pasture		Chicory		Lotus	
	HP[a]	OF[b]	HP	OF	HP	OF
Organic matter	908.9	716.6	862.1	727.4	913.4	761.0
SE	9.13	14.56	3.58	16.99	2.11	11.84
Total N	34.5	45.9	42.1	40.7	39.3	47.8
SE	3.17	1.00	2.22	2.39	2.12	0.80
Condensed tannin[c]						
Extractable	0.11	ND	1.70	ND	36.10	ND
Protein-bound	ND	1.15	1.16	4.12	10.90	10.60
Fibre-bound	0.14	0.32	0.19	1.65	1.20	2.50
Total	0.25	1.47	3.05	5.77	48.20	13.10
SE	0.06	0.23	0.83	0.48	7.11	0.25

[a]HP = hand plucked. [b]OF= oesophageal fistulae
[c]Butanol/HCl method. ND = Not detectable

48.2 and 13.1 g/kg OM in hand plucked and OF samples, respectively. Most CT in the lotus hand-plucked samples was readily extractable, with much smaller amounts being protein-bound or fibre-bound. In lotus OF extrusa, extractable CT was not detectable, with similar concentrations of protein-bound or fibre-bound CT compared with hand-plucked samples. Thus, after chewing during eating, the largest component of CT was not detected in lotus OF samples. Small amounts of total CT were detected in both chicory and perennial ryegrass/white clover pasture, with chicory being higher in total CT concentration than pasture, and extractable CT being negligible in OF samples.

Voluntary feed intake

The VFI of deer grazing chicory was significantly higher than that of deer grazing pasture in autumn ($P < 0.05$) but not spring (Table 6). The VFI of lotus was significantly lower than that of both perennial ryegrass/white clover pasture and chicory ($P < 0.001$) in spring. For the deer grazing chicory, VFI was higher for hybrid than for red deer in autumn ($P < 0.05$; 1.47 v 1.30 kg OM/day).

Table 6 Mean (SEM) organic matter intake (kg OM/animal/day) of deer grazing perennial ryegrass/white clover (PRG), chicory, and *Lotus corniculatus* forages during autumn and spring.

Forage	PRG	Chicory	Lotus	SEM
Autumn	1.26	1.39	–	0.042
Spring	1.99	2.10	1.53	0.075

Liveweight change

The growth of hybrid deer was higher than that of pure red deer and the LWG of stags was higher than for hinds, during autumn, winter, and spring ($P < 0.01$; Table 7). During autumn, LWG was significantly higher in weaners grazing chicory than perennial ryegrass/white clover pasture ($P < 0.001$) and LWG of stags grazing lotus was significantly higher than that of stags grazing pasture ($P < 0.001$). The LWG of hinds grazing lotus was not significantly different compared with those grazing pasture during autumn.

In winter, when all three groups grazed pasture, growth rates were reduced to −4 to 89 g/day with no differences between the three groups. In spring, LWG was higher for deer grazing on chicory than deer grazing on pasture ($P < 0.05$). LWG was similar for deer grazing lotus to those grazing pasture.

Hybrid deer were on average four days younger than red deer and stags were on average four days younger than hinds ($P < 0.07$; Table 7). All LW data in this experiment were therefore adjusted to a constant age (Table 7). Animals grazing chicory had higher LW than those deer grazing perennial ryegrass/white clover pasture (end autumn, $P < 0.05$; end spring, $P < 0.01$). Hybrid deer (especially stags) were heavier than pure red deer

Table 7 Seasonal mean liveweight (kg) and liveweight gain (g/day) of red and hybrid weaner deer grazing perennial ryegrass/white clover pasture, chicory, and *Lotus corniculatus.*

Forage	Pasture				Chicory				Lotus				
Sex	Stag		Hind		Stag		Hind		Stag		Hind		
Genotype	R[a]	H[b]	R	H	R	H	R	H	R	H	R	H	SEM
No. of animals	5	4	4	5	5	5	4	5	4	4	4	4	4.7
Mean initial age (10.3.95)	103	102	113	104	100	104	108	99	108	101	105	109	2.6
Mean liveweight (kg)[1]													
Initial (10.3.95)	45.0	51.8	42.9	47.1	46.3	50.3	43.0	48.0	45.1	49.0	44.3	49.2	2.40
End autumn (6.6.95)	60.6	69.7	54.0	64.9	67.8	74.2	58.9	69.4	60.4	72.5	56.2	64.9	1.70
End winter (8.9.95)	67.9	77.9	57.9	67.7	72.8	80.7	64.1	70.6	65.7	77.7	58.2	67.5	2.01
End spring(8.12.95)	89.2	99.9	71.8	84.7	97.3	105.4	80.7	89.7	87.4	97.9	75.0	85.4	2.20
Liveweight gain (g/d)													
Autumn (91 days)	152	199	145	201	235	271	188	232	235	260	138	189	11.4
Winter (107 days)	72	89	34	34	53	86	39	21	63	79	–4	28	12.2
Spring (77 days)	285	298	185	227	335	331	218	267	283	275	191	233	18.6

[1]Adjusted to equal age.
[a]R = pure red deer.
[b]H = hybrid (0.25 elk: 0.75 red deer).

at the end of all seasons ($P < 0.001$), and stags were significantly heavier than hinds at the end of all seasons ($P < 0.01$). Deer grazing lotus were of similar LW to deer grazing pasture in all three seasons.

Carcass production

More hybrid stags attained the target of 92 kg slaughter LW or over 50 kg carcass weight than red stags (Table 8). Stags grazing chicory had higher carcass weights and dressing-out percentage ($P < 0.05$) than those grazing pasture. Hybrid stags had a significantly higher carcass weight ($P < 0.01$) than pure red deer stags. Stags grazing lotus were of similar carcass weight to stags grazing pasture, but the dressing-out percentage was higher for hybrid stags ($P < 0.05$). Carcass subcutaneous tissue depth (GR) was significantly higher for deer grazing chicory than pasture ($P < 0.05$), but after being adjusted to equal carcass weight, there was no difference in GR measurement.

Hybrid hinds grazing chicory had a significantly higher carcass weight ($P < 0.05$) and dressing-out percentage ($P < 0.01$) than those grazing pasture. Hybrid hinds grazing lotus were similar in carcass weight and dressing-out percentage to those grazing pasture. After being adjusted to an equal carcass weight, there was no difference in carcass GR.

Pedicle development and velvet antler production

The mean date of antler pedicle initiation (DPI) was 18 days earlier for stags grazing chicory ($P < 0.05$) than for stags grazing pasture (Table 9)

Table 8 Mean (SEM) carcass measurements from stags and hinds grazing perennial ryegrass/white clover, chicory, and *Lotus corniculatus* forages and attaining slaughter liveweight (92 kg or greater) by one year of age.

Sex	Stags							Hinds			
Forage	Pasture		Chicory		Lotus			Pasture	Chicory	Lotus	
Genotype	R[a]	H[b]	R	H	R	H	SEM	H	H	H	SEM
No. of animals	4	4	5	5	3	4	4.2	4	5	3	4.0
No. of animals attaining target	1	3	4	4	1	4		1	3	1	
slaughter LW (%)	(25)	(75)	(80)	(80)	(33)	(100)		(25)	(60)	(33)	
Carcass weight (kg)	48.6	53.3	56.0	59.3	51.5	55.6	2.40	48.5	54.5	51.0	2.40
Dressing-out percentage (%)	52.6	53.7	57.6	56.2	55.8	56.9	1.2	55.2	60.9	58.5	2.3
GR tissue depth	2.7	3.0	5.6	5.6	4.0	4.7	1.2	4.2	5.4	5.6	2.6
GR tissue depth[1] (mm)	3.8	3.2	5.3	4.8	4.5	4.5	1.3	5.4	4.3	5.9	1.5

[1]Adjusted to equal carcass weight.
[a]R = pure red deer.
[b]H = hybrid (0.25 elk: 0.75 red deer).

Table 9 The effect of nutrition and body weight on initiation of the pedicle and velvet antler growth of stags grazed on perennial ryegrass/white clover (PRG), chicory or *Lotus corniculatus*.

Forage	Pasture		Chicory		Lotus		
Genotype	R[a]	H[b]	R	H	R	H	SEM
No. of animals	5	4	5	5	4	4	
Pedicle-initiation							
- uncorrected	19 Apr	28 Apr	5 Apr	6 Apr	14 Apr	23 Apr	8.68
- corrected[1]	7 Apr	1 May	4 Apr	18 Apr	3 Apr	4 May	7.52
Antler-initiation							
- uncorrected	28 Sep	26 Sep	7 Sep	28 Aug	26 Sep	15 Oct	14.20
- corrected[1]	11 Sep	2 Oct	7 Sep	16 Sep	9 Sep	27 Oct	12.86
Body weight (kg)							
End of autumn	60.4	69.2	67.0	74.1	61.0	71.9	2.50

[1]Corrected by analysis of co-variance to equal liveweight at the end of autumn.
When the pedicle reached 4 cm long, this was regarded as velvet antler initiation.
[a]R = pure red deer. [b]H = hybrid deer (0.25 elk: 0.75 red deer).

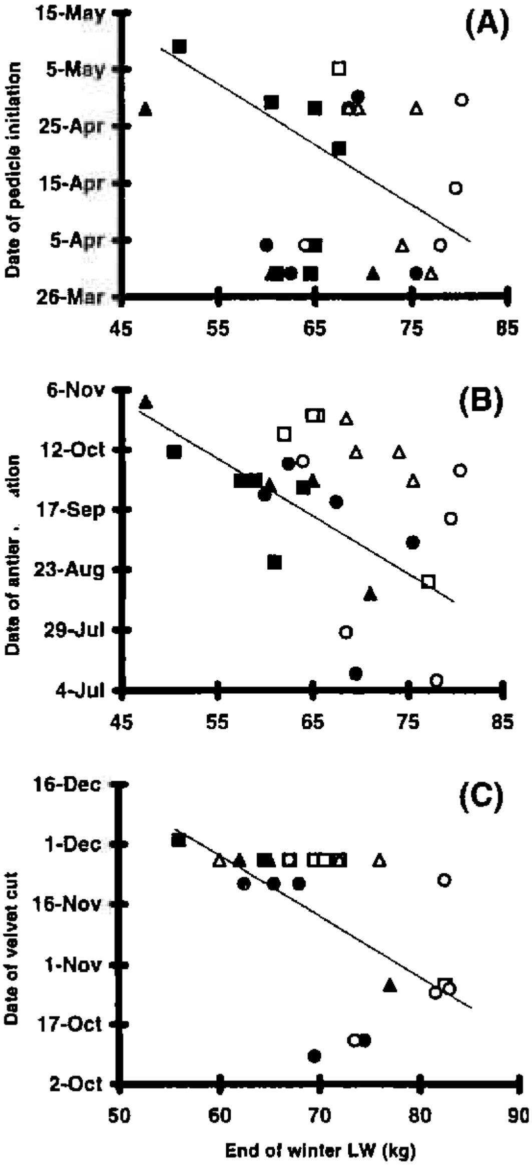

Fig. 1 The effect of liveweight at the end of autumn on A, date of pedicle initiation; **B**, date of initiation of velvet growth; and C, the relationship between date of first cut velvet antler and liveweight at the end of winter. ■ red deer pasture; □ hybrid deer pasture; • red deer chicory; ○ hybrid deer chicory; ▲ red deer lotus; △ hybrid deer lotus.

The relationship between DPI and LW (kg) is shown in Fig. 1A. The DPI (days) was found to be best correlated with LW at the end of autumn described by the equation

DPI (days) = **83.7–1.00 LW** (SE ± 0.183; $P < 0.01$) (4)

Each 10 kg increase in LW at the end of autumn advanced the DPI by an average of 10 days. When LW at the end of autumn was used as a co-variate, there was no difference between the three forage groups in DPI.

Velvet antler initiation tended to be earlier in stags grazing chicory (24 days; $P = 0.08$) than for stags grazing pasture (Table 9). Grazing on lotus did not change the date of velvet antler initiation (DVI) compared with young stags grazing pasture. A number of LW relationships were examined. The DVI (days) was found to be best correlated with LW (kg) at the end of autumn (Fig. 1B) described by the equation

DVI (days) = **222.8–1.80 LW** (SE ± 0.215; $P < 0.01$) (5)

Each 10 kg increase in LW at the end of autumn advanced DVI by an average of 18 days. When LW at the end of autumn was used as a co-variate (Table 9), grazing on chicory appeared to advance DVI by 10 days, but this did not attain significance.

Velvet antler length (L; cm) was related to time after pedicle initiation (t; days) by the equation

$$L\ (\text{cm}) = Ae^{ct} \tag{6}$$

where A and c are constants. The relationship between length and time is shown in Fig. 2.

Table 10 gives values for the constants A and c for the prediction of velvet antler length. For stags grazing chicory, constant A ($P < 0.05$) and constant c ($P < 0.01$) were higher than for stags grazing pasture. Neither constant A nor constant c was affected by grazing lotus.

Relative to grazing on perennial ryegrass/white clover pasture, grazing on chicory advanced the mean date of first velvet cut (DVC) by 17 days ($P < 0.05$; Table 10). Deer grazing on lotus had a similar DVC compared with those grazing pasture. A number of LW (kg) relationships were examined, and the DVC was found to be best correlated with LW at the end of winter (Fig. 1C) described by the equation

DVC (days) = **251.8–1.32 LW** (SE ± 0.356; $P < 0.01$) (7)

Each 10 kg increase in LW at the end of winter advanced DVC by an average of 13.2 days. When LW at the end of winter was used as a co-variate (Table 10), there was no difference between the three forage groups in DVC. Relative to grazing on pasture, deer grazing on chicory tended to have

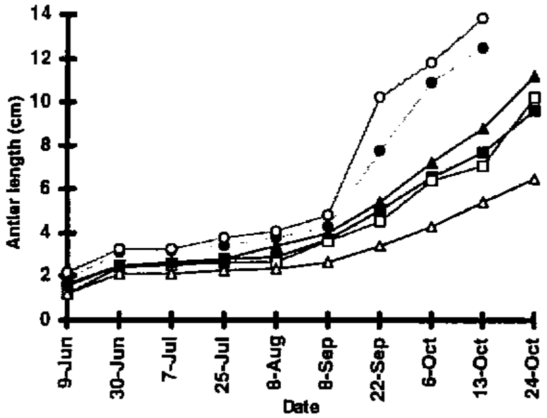

Fig. 2 Antler length in young stags grazing pasture, chicory, or lotus. ■ red deer pasture; □ hybrid deer pasture; • red deer chicory; ○ hybrid deer chicory; ▲ red deer lotus; △ hybrid deer lotus.

higher weight of the first velvet cut ($P = 0.09$) and total velvet ($P = 0.06$); Table 10), whilst grazing on lotus did not increase velvet weight.

The velvet cross-section area for pure red deer was larger than for hybrid deer (10.2 cm^2 v 8.1 cm^2; $P = 0.06$). Relative to grazing pasture, grazing deer on chicory or lotus did not increase velvet cross-section area (10.1 v 8.8; $P = 0.4$). A selection of velvet cross-section area relationships were examined, and the weight of first cut ($P < 0.05$) and regrowth velvet ($P < 0.05$) were found to be positively correlated with cross-section area.

DISCUSSION

The present study confirmed that when relying entirely on perennial ryegrass/white clover pasture for 12 month venison production, a low proportion of deer reached target slaughter LW (92 kg or greater) and carcass weights barely attained 50 kg, supporting earlier observations (Ataja et al. 1992; Semiadi et al. 1993). It also showed that spiker velvet antler production was low (0.2 kg/stag). This emphasises the needs for inputs of specialist forages in 12 month venison production systems

Relative to deer grazing on perennial ryegrass/white clover pasture, grazing chicory markedly increased carcass weight, due to increasing LWG and dressing out percentage at slaughter. Highest carcass weights were obtained from hybrid stags grazing chicory, as reported by Kusmartono et al. (1996a). Red clover also increased carcass dressing out percentage and increased LWG (Niezen et al. 1993; Semiadi et al. 1993). The evidence suggests that chicory and red clover had higher feeding value for deer than perennial ryegrass/white clover pasture.

Table 10 Mean (SEM) velvet antler measurements from red and hybrid yearling stags grazed on perennial ryegrass/white clover, chicory, and *Lotus corniculatus* forages.

Forage	Pasture		Chicory		Lotus		
Genotype	Red[a]	Hybrid[b]	Red	Hybrid	Red	Hybrid	SEM
Total no. of stags	5	4	5	5	4	4	
Length growth:							
Constant A	0.175	0.158	0.482	0.287	0.196	0.327	0.1463
Constant c	0.022	0.022	0.029	0.023	0.021	0.015	0.0010
Stags producing velvet (%)	100	75	100	100	75	75	
First cut (g)	257 (5)[1]	156 (3)	300 (5)	240(5)	266 (3)	187 (3)	31.3
Regrowth (g)	0	107 (1)	179 (1)	343 (1)	56(1)	0	34.5
First cut and regrowth (g)	257 (5)	192 (3)	336 (5)	309 (5)	285 (3)	187 (3)	61.2
Mean date of first cut							
-uncorrected	27 Nov	19 Nov	10 Nov	03 Nov	16 Nov	27 Nov	6.1
-corrected[2]	20 Nov	22 Nov	07 Nov	12 Nov	13 Nov	25 Nov	5.2
Cross-section area (cm^2)	9.0	8.6	11.4	8.7	10.6	7.1	1.10

[1]Number of stags per group.
[2]Corrected by co-variate to equal liveweight at the end of winter.
[a]Red = pure red deer. [b] Hybrid = hybrid deer (0.25 elk: 0.75 red deer).

Deer grazing chicory had higher VFI during autumn and chicory had a higher OMD than pasture (Tables 4 and 6), accounting for faster deer growth. Similar results were found by Kusmartono et al. (1996a). Deer grazing chicory spend slightly less time eating and significantly less time ruminating than those grazing pasture (Kusmartono et al. 1996a). Hoskin et al. (1995) showed that deer fed freshly-cut pure chicory indoors spent a similar time eating (361 v 379 min/24h) but markedly less time ruminating (33 v 270 min/24h) than those fed perennial ryegrass. Kusmartono et al. (1996b) showed that the reduced ruminating time was associated with faster rumen particle breakdown and faster disappearance of DM from the rumen in deer fed chicory, thus explaining the potential for greater autumn VFI in deer grazing this species.

Grazing deer on chicory also advanced the DPI by 18 days, advanced the DVC by 17 days, and increased the rate of velvet antler length growth. Relative to deer grazing on pasture, deer grazing on chicory tended to have higher total velvet antler production (323 v 225 g/stag; $P = 0.06$). Kusmartono et al. (1996a) obtained similar results, showing that young stags grazed on chicory rather than pasture increased spiker velvet production from 0.35 to 0.75 kg, due to two cuts being obtained in stags grazing chicory versus one cut in stags grazing pasture. Initiation of velvet growth was correlated with LW as reported by Fennessy & Suttie (1985), and correction of the data to equal LW removed the antler advancement, showing that the effects of feeding chicory on advancing date of antler growth could largely be explained by its effect in increasing LW.

If chicory is included in deer production systems under grazing conditions, it is important to maintain the plant in the vegetative state as the leaves are of higher feeding value than stems. Li et al. (1994) reported that the plant density (number of plants/m^2) of chicory grazed by deer decreased by about 33% each year, with the greatest decrease in spring. However, the decrease in plant density was compensated for by increases in shoot numbers/plant for the first two or three years of the crop. In order to increase the persistence of chicory, heavy grazing should be avoided, particularly in wet weather during late autumn and winter.

The animal results for lotus were undoubtedly influenced by the low number of grazing days that could be achieved, due to problems with the lotus establishment. Nevertheless, relative to grazing on perennial ryegrass/white clover pasture, grazing on lotus did increase LWG of stags during autumn and increased the efficiency of growth in spring, with the same LWG requiring a lower VFI on lotus. Wang et al. (1996) observed lower VFI but higher carcass weight gain and wool growth in lambs grazing *Lotus corniculatus* than lucerne, with part of the increased efficiency on lotus due to its CT content. In *Lotus corniculatus*, CT has been demonstrated to reduce dietary protein degradation in the rumen, and to increase amino acid absorption from the small intestine in sheep (Waghorn et al. 1987b; Wang et al. 1994). The small responses obtained in the present work give some indication that the CT content of *Lotus corniculatus* may have some value for improving the efficiency of growth in young deer and further experiments are needed in this area.

The CT content determined in *Lotus corniculatus*, before and after chewing by deer, can be compared with similar data from Terrill et al. (1992b) for sulla (*Hedysarum coronarium*) eaten by sheep. Total CT for both forages before chewing was approximately 52 g/kg OM, with most of this being readily extractable and low proportions bound to protein or fibre. Chewing both forages markedly reduced extractable CT concentration. However, this was counteracted by higher levels of protein-bound and fibre-bound CT in sulla chewed by sheep, whereas there was no increase in these components in *Lotus corniculatus* chewed by deer.

An explanation may be that red deer have produced tannin-binding salivary proteins, as found in the saliva of mule deer by Robbins et al. (1991). These proteins are not produced in sheep saliva (Austin et al. 1989). Deer salivary proteins may have bound a component of extractable CT in lotus during this study, that could not be extracted and detected in the analytical system used. Chewing by red deer did not reduce the CT content of perennial ryegrass/white clover pasture or chicory, but this may be due to the low concentration of extractable CT in these forages, which may have limited access for the salivary CT-binding proteins.

It can be concluded that perennial ryegrass/white clover pasture is of lowest feeding value during autumn, and that the nutritional advantages of either lotus or chicory over pasture are likely to be greatest during autumn. Future venison and velvet antler production research with lotus should use a longer time to expose deer to grazing on lotus.

These studies have shown that chicory can be used to dramatically increase venison production by one year of age, and have indicated a potential role for chicory in stimulating velvet antler growth in one-year-old stags. The present data and those of Kusmartono et al. (1996a) indicate that chicory may have a role to play in attaining velvet growth earlier, due to earlier development of the pedicle and faster antler length growth rate. Thus, one year old deer grazing chicory may produce two cuts of velvet in one season, compared with the one cut that is normally obtained from stags grazing perennial ryegrass/white clover pasture. This is an avenue for future research and may be particularly relevant to adult stag velvet antler production.

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