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Growth and carcass production of young farmed deer grazing sulla (*Hedysarum coronarium*), chicory (*Cichorium intybus*), or perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) pasture in New Zealand

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Abstract Liveweight gain, voluntary feed intake, and carcass production were compared for pure red and hybrid (0.75 red: 0.25 elk) deer calves grazing sulla (*Hedysarum coronarium* cv. Necton), chicory (*Cichorium intybus* cv. Grasslands Puna), or perennial ryegrass (*Lolium perenne* cv. Nui)/white clover (*Trifolium repens* cv. Huia) pasture from weaning in March to slaughter in December of the same year, at approx one year of age.

Organic matter digestibility (OMD) of diet selected was similar for all forages during autumn, but OMD of chicory (88.4%) was greater than both sulla (78.3%) and pasture (83.8%) during spring ($P < 0.05$). Sulla diet selected contained 5.1% condensed tannin (CT) in autumn and 8.4% CT in spring ($P < 0.05$); pasture and chicory contained 0.14–0.26% CT. VFI of deer grazing sulla was greater than for deer grazing chicory in autumn (2027 versus 1014 g OM d^{-1}; $P = 0.07$), but not spring (2029 versus 2251 g OM d^{-1}). In autumn, deer gained 293 g d^{-1} on sulla, 218 g d^{-1} on pasture ($P < 0.01$), and 183 g d^{-1} on chicory ($P < 0.001$). In winter, deer gained 150 g d^{-1} on sulla and 133 g d^{-1} on pasture. Final liveweight of deer grazing sulla was 106 kg, which was significantly higher than 97 kg for deer on pasture or 95 kg for deer on chicory ($P < 0.01$). Deer grazing sulla had greater carcass weights (59.9 kg) than deer grazing pasture (52.3 kg) or chicory (52.1 kg) ($P < 0.01$ hinds; $P < 0.05$ stags).

Hybrid stags had significantly greater carcass weights than red stags (64.1 kg versus 56.3 kg; $P < 0.01$) and hybrid hinds (52.8 kg; $P < 0.001$). It was concluded that the increased growth and carcass weight of young deer grazing sulla was caused by a higher feeding value of sulla, with a component of this being increased utilisation of digested nutrients.

Keywords red deer; hybrid deer; sulla; chicory; perennial ryegrass/white clover pasture; post-weaning growth

INTRODUCTION

One of the New Zealand deer industry aims is to produce quality-assured, tender, farm-raised venison from young deer all year round. A premium is paid for carcasses in the range 50–65 kg. Most New Zealand farmers achieve optimum carcass weights for venison production at an age of 15–24 months (Drew 1985; Barry & Wilson 1994) through grazing perennial ryegrass/white clover (PRG/WC) pastures. However, it is more efficient to produce carcass weights of 50–65 kg before 12 months of age, during August–November (spring), which

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attract an additional seasonal premium related to market demand.

Red deer exhibit seasonal patterns of voluntary feed intake (VFI) and liveweight gain (LWG) (Kay 1979; Suttie et al. 1987), making achievement of optimum carcass weights before 12 months of age difficult (Audigé 1995). Most PRG/WC pastures are unable to produce the quality and quantity of feed required for high deer growth rates during summer and autumn, the period of inherent maximum potential VFI and LWG in deer.

Special purpose forages such as red clover (*Trifolium pratense*) (Niezen et al. 1993; Semiadi et al. 1993) and chicory (*Cichorium intybus*) (Kusmartono et al. 1996), which produce high dry matter (DM) yields of high nutritive value particularly during summer and autumn, enable 100% of red deer stags to reach 92 kg liveweight (50 kg carcass weight) by one year of age, compared with 73% (range 25–90%) of those grazing PRG/WC pasture of 10 cm surface height (Barry et al. 1998).

Sulla (*Hedysarum coronarium*) is an erect, tap-rooted, biennial forage legume adapted to semi-arid areas, and is the main forage legume in Italy, where it is used for hay, silage, and greenfeed (Watson 1982). Sulla was introduced into New Zealand for soil conservation purposes but was subsequently recognised as a palatable, high quality herbage capable of producing high lamb growth rates (Terrill et al. 1992a). Sulla contains condensed tannins (30–70 g kg^{-1} DM) and significantly increases the growth rate of parasitised lambs compared with grazing non-tannin containing forages (Niezen et al. 1994, 1995). Sulla is of interest for deer production because of its tall growth habit, high summer growth rates, drought tolerance, high annual DM production (Rys et al. 1988; Krishna et al. 1990) and ready acceptance by grazing deer (Hunt & Hay 1990). Unlike other forage legumes, sulla exhibits some winter growth (Krishna et al. 1990), but current cultivars exhibit poor persistence under grazing.

The objectives of this study were to compare the growth, VFI, and carcass weight of red and hybrid deer (0.75 red: 0.25 elk) calves grazing sulla with those grazing chicory and perennial ryegrass/white clover pasture, from weaning to slaughter at one year of age, when internal parasites were controlled by regular anthelmintic treatment. This study was conducted at the same time and on the same experimental area as the study reported by Hoskin et al. (1999a), hence the same chicory and pasture were used in both investigations.

MATERIALS AND METHODS

Trial design

A rotational grazing experiment was conducted with 33 weaner deer (3–4 months old) grazed on either PRG/WC pasture, chicory, or sulla (n = 11 on each forage). Deer grazing each forage were balanced for genotype (pure red versus 0.75 red: 0.25 Elk hybrid), sex, and liveweight. Measurements included LWG, VFI, and carcass characteristics at slaughter. The trial was carried out at the Massey University Deer Research Unit (DRU), Palmerston North, New Zealand from 17 March to 28 November 1994, and was divided into autumn (71 days), winter (116 days), and spring (68 days) periods.

Forages

The forages grazed were: established perennial ryegrass (cv. Nui)/ white clover (cv. Huia) pasture; chicory (cv. Grasslands Puna), sown December 1992; and sulla (cv. Necton) sown November 1993. Potassic superphosphate (9% P: 10% S: 7% K) was applied onto all forages in late April 1994 at 250 kg ha^{-1}. Nitrogen fertiliser (Urea; 46% N) was applied to chicory (76 kg N ha^{-1}), pasture (56 kg N ha^{-1}), and sulla (53 kg N ha^{-1}) in late March, and to pasture (60 kg N ha^{-1}) and chicory (76 kg N ha^{-1}) in early August. In autumn, chicory paddocks were mechanically topped following initial grazing to remove reproductive stem material to maintain the vegetative state. In winter 1994, the chicory and one sulla paddock were sprayed with herbicide (Galant; Dow-Elanco, NZ Ltd; 3 litres ha^{-1}) to control grasses.

Animals

Seven pure red hinds, eight pure red stags, ten (0.75 red: 0.25 elk) hybrid red hinds, and eight (0.75 red: 0.25 elk) hybrid stags were used. Mean initial liveweight (± SD) was 51.0 (± 6.19) kg. On 28 February 1994, the calves were weaned, weighed, sexed, vaccinated against clostridial infections (Clostridial 5 in 1; "Ultravac" CSL Ltd, NZ) and yersiniosis (Yersiniavax; AgVax Develpoments Ltd, NZ) by subcutaneous injection into the anterior of the neck, and treated orally with ivermectin ("Ivomec" 0.4% w/v at 200 μg kg^{-1} liveweight; Merck, Sharp and Dohme, NZ). Booster vaccinations were given 30 days later. The calves were ear tagged and reweighed on 15 March, then randomly assigned to the three forages on 17 March with the three groups balanced for liveweight, sex, and genotype. On 3 October, all deer were given 12 g cupric oxide per animal orally (Copper Needles, Bayer NZ Ltd) and a 3 ml injection of vitamin B12 (Prolaject 1 mg vit B12 ml^{-1}; Bomac Laboratories Ltd, NZ) subcutaneously in the anterior of the neck. All deer were treated three-weekly with ivermectin as above until six weeks before slaughter and were weighed at three-weekly intervals and immediately prior to slaughter.

Grazing management

Deer were rotationally grazed throughout the trial, with allowances (excluding dead matter) set at 5 kg DM per head d^{-1} from 17 March to 1 September (autumn and winter), 6 kg DM per head d^{-1} from 1 September to 19 September (late winter), and 7 kg DM per head d^{-1} from 19 September to slaughter on 28 November (spring). Rotation length was 4–7 weeks, with grazing periods of 4–7 days for chicory and 5–10 days for pasture and sulla.

In autumn and spring, the deer grazed chicory (1.20 ha), pasture (1.20 ha), or sulla (1.25 ha autumn; 0.84 ha spring). In winter, the chicory and pasture-grazing groups were combined on pasture (3.66 ha) because chicory is dormant during winter. Deer were only able to graze sulla for 26 days during winter despite adequate available forage, because of wet soil conditions causing pugging damage to the crop. They grazed pasture (0.90 ha) during the remaining winter.

In spring, the chicory group returned to chicory and the sulla group to sulla, and the pasture group returned to paddocks they had grazed in autumn. The above periods of grazing on each forage were determined by the growth characteristics of the different forages and by weather conditions, as would be normal in any grazing system.

Forage sampling and measurements

Pre- and post-grazing herbage mass was measured by taking random cuts to soil level from six quadrats (0.1 m^2) from each paddock for DM determination (100°C, 18 hr) to enable calculation of grazing days (Semiadi et al. 1993) according to the allowance set. Samples of feed on offer were taken from each paddock at the commencement of grazing, mixed and divided into two 200-g parts, and stored at −20°C. Samples for botanical composition were dissected into grasses, clover (red and white together), dead matter, and weed (PRG/WC pasture), and for sulla and chicory, stem and leaf (separately), clover, dead matter, and weed. Each component was separately oven-dried (100°C, 18 hrs) and weighed. During autumn and spring, hand-plucked samples estimating deer diet selected were taken daily (Kusmartono et al. 1996), pooled per paddock, and stored at −20°C for chemical analysis. Previous studies by us have shown that with deer fed these high forage allowances, the hand plucking procedure gives similar values for organic matter digestibility (OMD) to samples obtained from deer fistulated in the oesophagus under most conditions, and gives more realistic values of condensed tannin (CT) content in the diet selected (Semiadi et al. 1993; Min et al. 1997).

Voluntary Feed Intake (VFI)

In late autumn and spring, intra-ruminal, slow-release chromium capsules (CRDC, Cr_2O_3 matrix, Nufarm, NZ) were administered to all deer to estimate faecal organic matter output (Parker et al. 1989). Rectal faecal samples were collected at 2-day intervals from Days 8 to 22 post CRDC insertion. Samples were oven dried (100°C, 36 hrs; minimum 2 g dry weight per animal), pooled per animal, and ground for chromium analysis. Faecal output and VFI were calculated as described by Kusmartono et al. 1996.

Slaughter

Twenty-six deer were slaughtered at the Feilding Deer Slaughter Premises (Venison Packers NZ Ltd) on 28 November 1994, with seven red hinds remaining at Massey University Deer Research Unit as breeding replacements. Final liveweight was measured before transport. Hot carcass weight, carcass grade, and carcass GR, an indirect measure of subcutaneous fat depth measured as soft tissue depth over the 12th rib, 16 cm from the dorsal midline, were recorded for each animal.

Laboratory analysis

Samples of feed on offer and estimated diet selected were freeze-dried and ground to pass a 1 mm sieve (Wiley Mill, USA). Organic matter (OM) content was determined by ashing overnight at 555°C. *In vitro* OMD was determined by incubation with fungal cellulase and hemicellulase enzymes (Roughan & Holland 1977). Total nitrogen (N) was determined by the Kjeldahl method (Kjeltec Auto 1030 Analyser, Tectator, Sweden). Extractable and bound CT were determined by the modified butanol-HCl procedure of Terrill et al. (1992b), and extractable CT was also determined by the vanillin-HCl procedure of Broadhurst & Jones (1978). Extractable CT values (% OM; Butanol-HCl procedure) were deducted from *in vitro* OMD determinations because extractable CT would be solubilised in the initial *in vitro* steps but is known to be indigestible *in vivo* (Terrill et al. 1994). Faecal chromium concentration was determined by atomic absorption spectrometry, as described by Costigan & Ellis (1987).

Data analysis

Liveweight gain and VFI were compared within each season using Generalised Linear Models (GLM: SAS 6.11; SAS institute Inc. USA), with forage type, animal genotype, sex, and any interaction as factors. Other factors analysed were final liveweight and carcass weight. Carcass weight was used as a covariate for carcass GR measurements. There were no interactions involving forage, sex, and genotype for liveweight, liveweight gain, or for any of the carcass measurements; hence only main effects are presented.

RESULTS

Herbage mass and botanical composition

The pre- and post-grazing herbage mass of sulla was higher than for chicory and pasture, particularly during spring when sulla became reproductive and produced thick stems up to 1 m tall (Table 1). However, the average daily DM allowance per animal was constant for all forages. The pre- and post-grazing herbage mass of chicory was slightly lower than that of pasture in autumn and spring.

The sulla sward increased in purity during the trial, and the ratio of sulla leaf:stem decreased from 8.2:1 in autumn to 1.1:1 in spring (Table 2), with the sward reaching 10–15% flowering by late spring. The white plus red clover components of the sulla sward decreased from autumn to spring, and the dead matter content decreased from autumn to winter and spring.

The chicory sward decreased in purity from autumn to spring. This was accompanied by an increase in the white and red clover content of chicory. The ratio of chicory leaf:stem increased from 1.9:1 in autumn to 20:1 in spring. The dead matter content of chicory decreased from autumn to spring, and the maximum weed content of both sulla and chicory was c. 10%.

Perennial ryegrass constituted 60% of the pasture sward in autumn, increasing to 80% in winter and spring. The white clover decreased from autumn to winter and spring, but dead matter content remained relatively constant.

Nutritive value of forages

For all forages, diet selected was generally higher in total N, organic matter (OM), and organic matter digestibility (OMD) than the feed on offer (Table 3). There were no significant differences in OMD of estimated diet selected in autumn between the three forages. Sulla estimated diet selected in autumn was significantly higher in extractable-CT (Butanol-HCl, $P < 0.05$; Vanillin-HCl, $P < 0.01$), protein and fibre-bound CT ($P < 0.01$) and total CT ($P < 0.05$) than either chicory or pasture, which contained only trace levels of CT (Table 4). There were no significant differences in total N, OMD, or OM content of feed on offer of pasture and sulla grazed during winter.

The OM content of diet selected in spring did not differ significantly between sulla and pasture, both of which had a higher OM content than chicory ($P < 0.01$). The OMD of diet selected in spring for chicory was greater than sulla and pasture ($P < 0.05$), but there was no difference in OMD of spring diet selected between sulla and pasture. Sulla diet selected in spring was significantly higher in extactable-CT (Butanol-HCl, $P < 0.001$; Vanillin-HCl, $P < 0.01$), protein and fibre-bound CT

Table 1 Seasonal pre- and post-grazing herbage mass (kg DM ha^{-1} ± s.e.) of perennial ryegrass/white clover pasture, chicory, and sulla.

Season	Pasture			Chicory			Sulla		
	n	Pre-grazing	Post-grazing	*n*	Pre-grazing	Post-grazing	*n*	Pre-grazing	Post-grazing
Autumn	6	2960 ± 352.9	1852 ± 128.4	8	2852 ± 160.1	1777 ± 79.4	8	4008 ± 258.7	2626 ± 183.0
Winter	28	2377 ± 80.8	1413 ± 40.3	–	–	–	4	5225 ± 1486.4	3588 ± 663.4
Spring	6	3130 ± 332.6	2185 ± 413.0	11	2819 ± 95.4	1801 ± 62.8	3	9658 ± 1235.9	4664 ± 1311.7

($P < 0.05$), and total CT ($P < 0.01$) than chicory and pasture (Table 4). The total CT content of sulla increased from 5.1% in autumn to 8.4% in spring, associated with a rise in extractable-CT.

Voluntary Feed Intake

During autumn, VFI (Table 5) of deer grazing sulla was greater than for deer grazing chicory ($P = 0.07$), with the pasture group being intermediate

Table 2 Seasonal botanical composition (% DM ± s.e.) of perennial ryegrass/white clover pasture, chicory, or sulla on offer. Clover for pasture = white clover; clover for chicory/sulla = white + red clover.

	Pasture	Chicory	Sulla
Autumn			
No. samples	6	8	8
Ryegrass	58.9 ± 3.53	–	–
Leaf	–	46.0 ± 3.51	50.1 ± 3.71
Stem	–	24.5 ± 4.55	6.1 ± 1.97
Clover	27.6 ± 2.04	4.1 ± 1.21	12.8 ± 2.57
Weed	3.5 ± 1.49	5.9 ± 1.57	9.0 ± 2.25
Dead matter	10.0 ± 4.94	19.5 ± 2.79	22.0 ± 3.70
Winter			
No. samples	28	–	4
Ryegrass	78.1 ± 1.50	–	–
Leaf	–	–	57.8 ± 6.17
Stem	–	–	19.8 ± 7.03
Clover	7.2 ± 0.98	–	6.8 ± 1.82
Weed	1.1 ± 0.34	–	9.9 ± 2.68
Dead matter	13.6 ± 1.26	–	5.7 ± 1.85
Spring			
No. samples	6	11	3
Ryegrass	81.8 ± 1.92	–	–
Leaf	–	53.2 ± 3.10	41.6 ± 4.28
Stem	–	2.7 ± 1.06	38.6 ± 4.67
Clover	6.6 ± 0.27	24.1 ± 2.24	3.2 ± 1.37
Weed	2.4 ± 0.71	9.4 ± 2.41	10.0 ± 1.59
Dead matter	9.2 ± 1.44	10.6 ± 2.74	6.6 ± 0.59

Table 3 Chemical composition (mean ± s.e.) of forage on offer and diet selected by deer grazing either perennial ryegrass/white clover pasture, chicory, or sulla. Chicory was dormant during winter. n = 5, 12, 4 for pasture on offer during autumn, winter, and spring, respectively; n = 7, 8 for chicory on offer in autumn and spring, respectively; n = 5, 3, 4 for sulla on offer during autumn, winter, and spring, respectively; n = 4, 3 for diet selected in autumn and spring, respectively, for all forages.

	Pasture		Chicory		Sulla	
Season	On offer	Selected	On offer	Selected	On offer	Selected
Total nitrogen (% DM)						
Autumn	3.02 ± 0.27	4.16 ± 0.17	3.01 ± 0.11	3.79 ± 0.11	3.29 ± 0.61	4.00 ± 0.19
Winter	3.69 ± 0.11	–	–	–	3.91 ± 0.27	–
Spring	2.35 ± 0.25	3.08 ± 0.11	2.91 ± 0.12	3.36 ± 0.23	2.17 ± 0.10	3.27 ± 0.22
Organic matter (% DM)						
Autumn	89.0 ± 0.67	90.1 ± 0.55	83.1 ± 0.55	82.1 ± 0.55	85.7 ± 0.60	87.4 ± 0.55
Winter	86.5 ± 0.79	–	–	–	87.0 ± 1.29	–
Spring	87.6 ± 1.12	91.6 ± 0.38	86.3 ± 0.85	87.0 ± 0.38	89.3 ± 1.13	91.0 ± 0.38
Organic matter digestibility (%OM)						
Autumn	67.7 ± 4.03	82.7 ± 0.54	83.1 ± 0.55	85.2 ± 1.05	72.0 ± 2.80	81.9 ± 0.98
Winter	79.0 ± 0.95	–	–	–	77.0 ± 2.38	–
Spring	78.4 ± 1.06	83.8 ± 2.34	86.3 ± 0.85	88.4 ± 0.03	73.9 ± 1.30	76.7 ± 0.20

and not significantly different from either sulla or chicory. In spring, there were no significant differences in VFI between the forage groups. There was no effect of genotype on VFI in either season. VFI of stags was greater than hinds, but this effect only reached significance during spring ($P = 0.07$).

Liveweight and liveweight gain

Liveweight gain (LWG; Table 5) of stags was higher than that of hinds during winter and spring ($P < 0.001$), and the growth of hybrid deer was greater than that of pure red deer during winter ($P < 0.05$) and spring ($P < 0.001$). During autumn, LWG of deer grazing sulla was significantly higher than that of deer grazing chicory ($P < 0.001$) or pasture ($P < 0.01$). In spring, LWG of deer grazing all three forages was similar. At the end of winter and spring the sulla group had a higher liveweight than both the pasture and chicory groups ($P < 0.01$), with the latter two groups being similar. Stags were heavier than hinds at the end of both winter and spring ($P < 0.001$) and hybrid deer were heavier than pure red deer at the end of spring ($P < 0.05$).

Carcass production

All deer grazing sulla reached the target of 92 kg liveweight (50 kg carcass weight) by one year of age, whereas 88% and 89% of deer grazing chicory and pasture, respectively, met this target (Table 6). Deer grazing sulla had greater carcass weights than deer grazing chicory or pasture ($P < 0.01$ hinds; $P < 0.05$ stags). Hybrid stags had significantly

Table 4 Condensed tannin concentration (% DM ± range) of diet selected by deer grazing perennial ryegrass/white clover pasture, chicory, or sulla. $n = 2$ for all forages in both seasons. † = Vanillin-HCl. ‡ = Butanol-HCl.

	Season	Pasture	Chicory	Sulla
Extractable	Autumn†	0.89 ± 0.015	0.78 ± 0.070	4.35 ± 0.680
	Spring†	0.64 ± 0.025	0.49 ± 0.105	7.41 ± 0.670
	Autumn‡	0.06 ± 0.000	0.05 ± 0.005	3.51 ± 0.101
	Spring‡	0.06 ± 0.010	0.07 ± 0.015	7.34 ± 0.535
Protein–bound ‡	Autumn	0.17 ± 0.030	0.14 ± 0.015	1.35 ± 0.110
	Spring	0.05 ± 0.010	0.07 ± 0.025	0.91 ± 0.180
Fibre–bound ‡	Autumn	0.04 ± 0.005	0.07 ± 0.005	0.24 ± 0.025
	Spring	0.02 ± 0.000	0.04 ± 0.005	0.18 ± 0.050
Total ‡	Autumn	0.26 ± 0.020	0.26 ± 0.015	5.10 ± 1.145
	Spring	0.14 ± 0.005	0.17 ± 0.025	8.42 ± 0.770

Table 5 Voluntary feed intake, liveweight (kg), and liveweight gain of deer grazed on perennial ryegrass/white clover pasture, chicory, or sulla. Means ± s.e. averaged over red and hybrid deer.

	Pasture		Chicory		Sulla		S.E.
	Stags	Hinds	Stags	Hinds	Stags	Hinds	d.f.= 27
Number of deer	5	6	5	6	6	5	
Voluntary feed intake (g OM d^{-1})							
Autumn	1900	1494	1029	1011	2224	1831	282.4
Spring	2408	1868	2365	2173	2556	1763	225.1
Mean liveweight (kg)							
Initial (15/3/94)	50.9	50.8	54.8	48.3	51.7	50.1	1.08
End autumn (25/5/94)	66.5	62.1	64.3	61.8	69.2	66.8	1.33
End winter (19/9/94)	87.1	73.5	84.5	71.6	94.3	80.6	1.83
End spring (27/11/94)	106.2	87.5	105.8	85.8	116.3	95.1	2.48
Liveweight gain (g d^{-1})							
Autumn (71 days)	224	214	154	203	315	268	11.4
Winter (116 days)	172	95	166	66	196	106	9.5
Spring (68 days)	289	211	344	236	333	220	13.6

higher carcass weights than hybrid hinds ($P < 0.001$), and carcass weights of hybrid stags were higher than for pure red stags (64.1 versus 56.3 kg; $P < 0.01$). After being adjusted to equal carcass weight, there were no differences in carcass GR measurement due to forage, sex, or genotype. Carcass dressing out percentage (DR) was greater for stags grazing sulla than those grazing chicory ($P < 0.05$) or pasture ($P < 0.01$), with hybrid stags on all forages having a higher DR than pure red stags ($P < 0.05$). Carcass DR of hinds was greater on sulla than on pasture ($P < 0.05$).

DISCUSSION

This is the first report of production from farmed deer grazing sulla. The most significant result from this experiment was the greater autumn LWG and carcass weight achieved from weaner deer grazing sulla compared with deer grazing pasture or chicory. In addition, 100% of red and hybrid stags and hybrid hinds grazing sulla reached the target of at least 92 kg carcass weight (50 kg carcass weight or greater) by one year of age, compared with 89% of deer grazing chicory and pasture. The increased carcass production on sulla came mostly from higher LWG during autumn and early winter. The advantage of sulla in increasing deer LWG during late autumn and winter is in part agronomic, in that it has capacity for cool season growth relative to chicory which is dormant during winter.

Increased animal productivity or feeding value of a forage can result from increased VFI, higher digestibility, or improved utilisation of digested nutrients (Ulyatt 1973). Terrill et al. (1992a) reported greater VFI in lambs grazing sulla than perennial ryegrass/white clover pasture, and there was some indication of this during autumn in the present study (Table 5) although it was highly variable and did not reach statistical significance. Feed intakes of deer grazing pasture and sulla in spring were similar, and despite the high pre- and post-grazing herbage mass ha^{-1} of sulla caused by its large, fibrous, reproductive stem fraction, forage allowances were maintained at a constant level. It seems that OMD was not a factor in the superior feeding value of sulla in this study, as apparent digestibility of organic matter (OMD) of both pasture and sulla were similar in autumn, with digestibility of sulla slightly lower than pasture in spring.

The high feeding value for deer on sulla compared with pasture could be partly attributable to improved utilisation of digested nutrients. Condensed tannins in forage legumes (*Lotus* spp.) fed to sheep have been shown to reduce degradation of protein in the rumen, to increase amino acid absorption from the small intestine (Barry et al. 1986; Waghorn et al. 1987), and to increase utilisation of plasma cysteine for body synthetic reactions (McNabb et al. 1993; Wang et al. 1994). Hart & Sahlu (1993) reported greater LWG and mohair production, and reduced rumen ammonia concentration from young goats grazing sainfoin (medium CT content) compared with lucerne (containing traces of CT). Stienezen et al. (1996) found that CT in sulla reduced apparent N-digestibility and rumen ammonia and plasma urea concentration when fed to sheep, and it appears that similar effects could occur in deer. Wang et al. (1996a, 1996b) found that action of CT improved the efficiency of wool and milk production in sheep grazing *Lotus corniculatus* (35 g CT kg^{-1} DM) without affecting VFI. The CT in sulla may similarly have improved efficiency of the growth process in young deer (Hoskin et al. 1999b).

It is not known whether VFI of deer grazing sulla in spring was affected by the high total CT content (8.4%). Total CT concentrations of 5–

Table 6 Carcass production of red and hybrid stags and hybrid hinds grazed on perennial ryegrass/white clover pasture (P), chicory (C), or sulla (S). *dressing percentage calculated using final liveweight prior to slaughter. #adjusted to equal carcass weight.

	Stags (red + hybrid)			s.e.	Hinds (hybrid)			s.e.
	P	C	S	d.f. = 12	P	C	S	d.f. = 5
No. deer	5	5	6		4	3	3	
No. reaching target CW	5	4	6		2	3	3	
Carcass weight (kg)	57.9	57.1	65.6	2.29	50.0	50.1	58.2	1.45
Dressing percent (%)*	54.2	54.9	56.4	0.40	55.1	56.0	57.0	0.39
GR tissue depth (mm)#	5.9	6.5	9.7	1.72	4.0	4.3	8.7	1.42

10% in *Lotus pedunculatus* and mulga (*Acacia aneura*) have been shown to reduce VFI in sheep (Barry & Duncan 1984; Waghorn et al. 1990; Pritchard et al. 1992). However, the relationship between CT concentration and VFI of deer has not been established. Deer species such as mule deer and moose have adapted to consuming tannin-containing diets by the production of CT-binding salivary proteins (Austin et al. 1989; Hagerman & Robbins 1993). These CT-binding proteins are present in red deer saliva (Semiadi et al. 1995) at lower concentrations than in mule deer and sambar deer saliva, and may enable farmed red deer to tolerate a higher dietary CT concentration than sheep (which do not produce CT-binding salivary proteins). Therefore, any depression of VFI by high dietary CT concentrations in deer may not be as marked as in sheep and this needs to be determined in future studies.

There were no differences in production between deer grazing chicory and pasture in the present experiment, which is in contrast to the results of Hunt (1993) and Kusmartono et al. (1996). Those authors found that deer grazing chicory had superior carcass production and greater autumn and spring LWG and VFI than deer grazing pasture. The chicory swards and management used in this experiment differed from those used by Kusmartono et al. (1996). In this experiment the post-grazing herbage mass was 1789 kg DM ha^{-1} compared with 2386 kg DM ha^{-1}described by Kusmartono et al. (1996), and there was also a lower autumn forage allowance per animal (5 kg DM per deer d^{-1} versus 7 kg DM per deer d^{-1}. These factors probably combined to lower VFI for deer grazing chicory compared with pasture in autumn in the present experiment.

The effects of sex and genotype on LWG, VFI, and carcass production in this study are comparable with other reports (Semiadi et al. 1993; Kusmartono et al. 1996a), although there were no significant interactions between forage and sex or forage and genotype in this study.

Given the high carcass weights and DR% of deer grazing sulla, there is a place for it to be incorporated into commercial deer farms in New Zealand, especially in areas that experience dry summer conditions. However, sulla is slow to establish and only persists under grazing for one to two years. More research is required to investigate management strategies to increase persistency, before this new forage crop can be successfully used for deer production.

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