# Development of specialist forage systems for deer production

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## ABSTRACT
Red clover (RC) (*Trifolium pratense* L.) and chicory (C) (*Cichorium intybus* L.) were evaluated in 3 experiments as alternative forages to perennial ryegrass (*Lolium perenne* L.) (0.85)-white clover (*Trifolium repens* L.) (0.15) pasture (PRG) for deer production. During lactation (summer), fawns grazed with their hinds on RC grew faster (410-433 g/day) than their contemporaries reared on PRG (322/g/day). Fawns reared on C during lactation were intermediate. From weaning to 12 months of age, young deer were consistently heavier when grazing RC than PRG, with the advantage at 12 months being 7 kg for stags and 3 kg for hinds. During the post-weaning phase, 100 and 75%, respectively, of stags grazing RC or PRG attained the target slaughter criterion of 92 kg live weight (50 kg carcass) by 1 year of age. It is concluded that RC offers considerable potential as a special purpose forage for deer production.

KEYWORDS: *Cichorium intybus*, deer production, lactation, post-weaning growth, Red deer, *Trifolium pratense*, venison production

## INTRODUCTION
Red deer (*Cervus elaphus*) are late calvers (November-December) and hence have their lactation during summer, when perennial ryegrass (*Lolium perenne* L.)-white clover (*Trifolium repens* L.) (PRG) pastures may be of low nutritive value due to moisture stress. Lactation is the time of peak nutrient demand, and lactation performance and fawn growth over this period may therefore be limited when grazing PRG. Both red clover (*Trifolium pratense*;RC) and chicory (*Cichorium intybus*; C) are highly preferred by red deer (Hunt & Hay 1989, 1990), are relatively drought resistant, with high dry matter (DM) production over summer-autumn, and can therefore be considered as alternatives to PRG for deer production.

Principal markets for New Zealand's venison are in the Northern Hemisphere and require a carcass of at least 50 kg (92 kg live weight) in their autumn-winter, which corresponds to spring in New Zealand. Hence, for most efficient venison production, it is essential to grow young stags to attain at least 92 kg live weight by 1 year of age. Early attempts, using pastures maintained at 10 cm surface height during winter and spring, showed respectively 40 and 60% of young stags could attain this objective when grazing perennial or annual (*Lolium multiflorum*) ryegrass-based pastures (Ataja et al. 1992). The aim of the present research was to investigate RC and C as special purpose forages for deer production, with the objective of increasing growth over lactation (summer) and during the post-weaning phase (autumn, winter and spring) before slaughter at one year of age.

## METHODS
Three experiments were conducted with Red deer, two involving lactation and one involving post-weaning growth. Calving was in November-December (late spring-early summer) and weaning took place at the end of February (late summer). Areas of RC (three experiments) and C (one experiment) were established as single sown species, and the performance of deer grazing these was compared with that of similar animals grazing PRG.

In Experiment 1, groups of 8 hinds grazed RC during lactation at allowances of 5, 11 and 16 kg DM/head/day and PRG at 10 kg DM/head/day. In Experiment 2, groups of lactating hinds grazed RC (n=16), C (n=15) and PRG (n=12) at an allowance of 12 kg DM/head/day.

Groups of 10 weaner hinds and 10 weaner stags were allocated to either RC or PRG in Experiment 3, commencing in March. Allowance was 7 kg DM/head/day in autumn and 8 kg DM/head/day in spring. As RC is dormant over winter, the groups were joined on PRG over this period, which was grazed to a residual of 1100 kg DM/ha. 0.5 kg DM/head/day of meadow hay was also provided over winter. All stags were slaughtered at the end of November, when aged approximately 1 year.

All forages were rotationally grazed, the length of rotation generally being about 4 weeks. The RC and C areas received applications of herbicide during winter, to control invading grasses. All areas received annual application of single superphosphate (220 kg/ha) and C received 3 applications of urea (100 kg/ha) during each year. Samples of estimated diet were hand plucked, freeze dried and ground to pass a 1 mm sieve. Total nitrogen (N) was then determined by the Kjeldahl method and *in vitro* digestibility by the method of Roughan & Holland (1977).

## RESULTS
### Lactation
Organic matter digestibility (OMD) and total N content (%DM) of the diets in Experiment 1 were respectively 82.9 and 3.60, 82.0 and 3.33, and 79.7 and 2.69 for the high, medium, and low RC allowances, and 72.1 and 2.61 for PRG. Corresponding values in Experiment 2 were 80.4 and 3.97 for RC, 84.8 and 3.03 for chicory, and 78.2 and 3.37 for PRG.

In deer grazing PRG, fawn growth was consistent between Experiments 1 and 2 (322 g/day). In Experiment 1 (Table 1), fawn growth and weaning weights were significantly greater on all RC treatments than on PRG ($P<0.05$), and fawns grazed at high and medium allowances grew faster than those grazed at low allowance ($P<0.05$). In Experiment 2 (Table 2) fawn growth rates and weaning weight were respectively 80 g/day and 4 kg greater for fawn-hind pairs grazing RC than PRG ($P<0.05$). For fawn-hind pairs grazing C, fawn growth was intermediate to that of fawns reared on either RC or PRG. Hind live-weight change in both experiments was greater on RC than on PRG ($P<0.05$), while hind live-weight change on C was similar to that on pasture.

Table 1 Experiment 1: Weight changes of Red deer hinds and fawns grazing red clover (RC) or perennial ryegrass-white clover pasture (PRG) during lactation*

| | PRG | RC | | | |
|---|---|---|---|---|---|
| | | Low | Medium | High | s.e.m. |
| Pasture mass (kg/ha): | | | | | |
| Pre-grazing | 3660 | 3420 | 3420 | 3420 | |
| Post-grazing | 1270 | 420 | 950 | 1390 | 107.1 |
| Live-weight gain (g/day): | | | | | |
| Hind | -52 | 5 | 58 | 53 | 14.2 |
| Fawn | 333 | 380 | 433 | 461 | 15.1 |
| Fawn weaning weight (kg) | 42.8 | 46.7 | 49.5 | 51.3 | 0.92 |

* January and February 1990 (summer)

Table 2 Experiment 2: Weight changes of Red deer hinds and fawns grazing red clover (RC), chicory (C) or perennial ryegrass-white clover pasture (PRG) during lactation*

| | PRG | C | RC | s.e.m. |
|---|---|---|---|---|
| Live-weight gain (g/day): | | | | |
| Hind | 27 | 7 | 70 | 13.2 |
| Fawn | 331 | 385 | 410 | 12.0 |
| Fawn weaning weight (kg) | 46.7 | 49.3 | 50.5 | 0.59 |

* January and February 1991 (summer)

### Post-weaning growth
Means of pre- and post-grazing herbage masses for the RC and PRG pastures in each season are shown in Table 3. The RC diet had a higher total N content than the PRG diet, during both autumn (4.9 v. 4.4% DM; $P<0.01$) and during spring (5.1 v. 3.6% DM; $P<0.001$). OMD was greater for RC during autumn (84.6 v. 82.6% DM; $P<0.05$), but was similar for both diets in spring (84.2%). In winter, total N content of the PRG herbage diet was 4.4% DM and OMD was 86.3%.

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Table 3 Experiment 3: Pre- and post-grazing herbage masses (kg DM/ha; s.e.) of both red clover (RC) and perennial ryegrass-white clover (PRG) pastures during autumn, winter and spring

| | PRG | | RC | |
|---|---|---|---|---|
| | Pre-grazing | Post-grazing | Pre-grazing | Post-grazing |
| Autumn | 2780 (147.3) | 2177 (122.5) | 3320 (137.7) | 2901 (122.9) |
| Winter* | 1539 (66.3) | 1128 (59.0) | | |
| Spring | 2360 (171.1) | 1848 (116.9) | 3542 (197.3) | 2779 (141.6) |

* Both PRG and RC animals were joined and grazed on PRG pasture during winter

Live-weight gain was greater in deer grazing RC than PRG, but only the difference in autumn attained significance ($P<0.05$) (Table 4). The interaction between treatment and sex was significant in autumn ($P<0.05$), indicating a greater response to RC in stags than hinds; the interaction was not significant in the other seasons. Animals grazing RC consistently had higher live weights than those grazing PRG (end autumn, $P<0.001$; end winter $P<0.01$ and end spring $P<0.01$). The interaction between group and sex was significant at the end of autumn ($P<0.05$), but not in the other seasons. At 1 year of age, stags grazing RC were 7 kg heavier and hinds were 3 kg heavier than animals grazing PRG. The percentage of stags reaching the target slaughter live weight (92 kg) by the end of November was respectively 100 and 75% for those grazing RC and PRG.

Table 4 Experiment 3: Live-weight gains and body weights of weaner Red deer grazing either red clover (RC) or perennial ryegrass-white clover (PRG) pasture, during autumn, winter and spring. Mean values adjusted to equal initial live weight

| | Stags | | Hinds | | s.e.m. |
|---|---|---|---|---|---|
| | PRG(n=8) | RC(n=9) | PRG(n=10) | RC(n=10) | |
| Live-weight gain (g/d): | | | | | |
| Autumn | 192 | 263 | 173 | 198 | 11.8 |
| Winter | 106 | 101 | 53 | 52 | 6.7 |
| Spring | 341 | 354 | 218 | 242 | 16.8 |
| Body weight (kg): | | | | | |
| Initial (7/3/90) | 48 | 47 | 48 | 50 | 2.3 |
| End autumn (19/5/90) | 62 | 67 | 61 | 62 | 0.9 |
| End winter (11/8/90) | 74 | 79 | 67 | 68 | 1.3 |
| End spring (29/11/90) | 101 | 108 | 84 | 87 | 1.9 |

## DISCUSSION

As judged by its relatively high OMD, PRG was maintained in a state of high nutritive value in all three experiments, and pasture height-mass should not have been limiting deer production (Ataja et al. 1992). Despite the relatively constant nutritive value, the young deer showed rapid growth over spring and summer, low growth over winter and intermediate growth in autumn. This comprises the seasonal rhythm of growth and voluntary food intake (VFI) in temperate deer (Kay 1985; Barry et al. 1991) and is entrained to photoperiod. The constraints of this seasonality to venison production in New Zealand include late calving and slow winter growth. However, despite the problems caused by seasonality, 75% of young stags grazing PRG still attained the target slaughter weight. This illustrates that effective deer production can be obtained from this forage by extending the 10 cm surface height criteria for grazing (Ataja et al. 1992) to autumn, winter and spring.

Relative to PRG, RC was of higher OMD, had a higher total N concentration, and produced greater levels of growth in young deer, all the weaner stags grazing RC reaching the desired slaughter weight by 1 year of age. Best responses to RC were obtained during summer (+80-100 g/day; Experiments 1 and 2) followed by autumn (+50 g/day; Experiment 3) and spring (+20 g/day; Experiment 3). Therefore, RC could best be used as a specialist crop on a deer farm for nutrition of lactating hinds (summer) and for autumn nutrition of weaner stags.

Less information is available on the use of C than RC for deer production. We have encountered agronomic problems with C, including declining plant density over 2 years and a tendency for reproductive development in summer. Further work is needed on the value of C for deer production. It can be concluded that RC offers considerable potential as a special purpose forage for deer production.

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# Digestion and rumen metabolism of forages by red deer, goats and sheep

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## ABSTRACT

Digestive efficiency was compared in Red deer, goats and sheep fed chaffed lucerne hay (Experiment 1). Goats digested fibre more efficiently than sheep and had the greatest rate of rumen ammonia production. Red deer showed the capacity to increase VFI from winter (W) to summer (S) without depressing apparent digestibility, through slowing the rate of rumen particulate outflow. Fractional outflow rate (FOR) of water from the rumen and the ratio FOR water/FOR particulate matter were both considerably greater for deer than for sheep and goats. It was concluded that this would enable deer to digest soluble ration components more efficiently, while allowing effective selective retention of fibre, and explains the absence of rumen bloat when deer are fed red clover (RC). The lower rumen FOR and greater fibre digestibility in deer fed RC compared with perennial ryegrass-based pasture (Experiment 2) suggests that the higher VFI found for RC in the field is due to more rapid disintegration of plant components in the rumen rather than to increased rumen outflow rate.

KEYWORDS: deer, digestive efficiency, goats, Red deer, rumen metabolism, rumen outflow rate, sheep

## INTRODUCTION

Pastoral livestock production in New Zealand (NZ) has traditionally depended on the farming of sheep and cattle. However, other ruminant species are now increasing, populations of farmed deer and goats now being, respectively, 1.4 and 2.5 million. An objective of the present investigation was to compare digestive efficiency and rumen metabolism in deer, goats and sheep during winter and summer when fed the same forage diet.

A second objective was to compare digestion and rumen metabolism in Red deer fed either perennial ryegrass (*Lolium perenne* L.)-white clover (*Trifolium repens* L.) pasture (PRG) or red clover (*Trifolium pratense* L.) (RC), as a means of explaining the greater productivity of deer in the field on RC (Barry et al. 1993).

## MATERIALS AND METHODS

Two experiments were conducted, with animals kept indoors in metabolism cages. All animals were castrate males fistulated in the rumen and all were fed at hourly intervals from overhead feeders.

### Experiment 1

Five Red deer, 7 goats and 8 sheep were fed lucerne chaff *ad lib.* for 6-week periods during winter (W) and summer (S). The hay contained 31.2 g N and 435 g fibre/kg plant organic matter (OM). Voluntary feed intake (VFI) and apparent digestibility were determined over 8-day periods, by feeding at 1.15 times the previous day's dry matter intake (DMI). Rumen pool size (liquid + DM) was determined by bailing, at the end of each feeding period. Rumen fractional outflow rate (FOR) was determined by the continuous infusion and total sampling procedure (Faichney 1975), using Cr-EDTA as the liquid phase marker and lignin as the particulate phase marker. Samples of rumen fluid for volatile fatty acid (VFA) and ammonia concentration were removed from the rumen at 1000 h and 1500 h on 3 days during each period. Rumen ammonia irreversible loss (IRL) was determined from continuous rumen infusion of $^{15}NH_4Ci$, added to the Cr-EDTA during the last 42 h of infusion, with samples of rumen fluid for $^{15}NH_3$ enrichment being taken at rumen bailing.

### Experiment 2

The PRG and RC used contained respectively 179 and 124 g DM/kg fresh weight, 29 and 44 g N/kg DM, and 479 and 303 g fibre/kg DM. Both forages contained approximately 0.25 of white clover. Both feeds were cut fresh each day, at 0900 h, and fed to the deer during late spring-early summer. Eight deer were used, in a changeover design involving 2 periods, with 4 deer fed each forage in each period. Initial DM content was determined by rapid microwave drying and equal amounts of DM of the two feeds were offered. Apparent digestibility, rumen pool size, rumen FOR and rumen ammonia concentration were measured as described in Experiment 1.

### Laboratory methods

All samples of feed, digesta and faeces were freeze dried and ground (1 mm sieve), before laboratory analyses. Total N was determined by the Kjeldahl procedure and total fibre and lignin by either sequential extraction (Bailey 1967; Experiment 1) or by the detergent fibre system (Experiment 2). Chromium was determined by X-ray fluorescence spectrometry and $^{15}N$ by mass spectrometry.

## RESULTS

### Experiment 1

Deer increased their VFI and rumen pool size by 30% (P=0.06) and 51% (P<0.01) respectively from W to S, without depressing digestibility (Table 1). Goats showed evidence of a 20% increase in VFI from W to S (which did not attain significance), accompanied by a 27% increase in rumen pool size (P<0.01) and a decrease in DM digestibility (P<0.01). Sheep showed no seasonal changes in VFI or DM digestibility.

Goats digested total fibre of the diet more efficiently than sheep during W (P<0.01), when VFI for the two species were similar. However, there were no differences in fibre digestibility during S, when VFI was much greater for goats. Deer tended to digest total fibre more efficiently than sheep, but the difference attained significance (P<0.10) only during S.

Table 1 Voluntary intake, rumen pool size, apparent digestibility and rumen fractional outflow rate (FOR) in Red deer, goats and sheep fed lucerne chaff *ad lib.*

| | Season | Deer | Goats | Sheep | s.e.m. |
|---|---|---|---|---|---|
| Voluntary DMI ($g/kgW^{0.75}/day$) | S | 62.5 | 68.7 | 52.2 | 3.20 |
| | W | 46.7 | 57.4 | 54.8 | 4.24 |
| Rumen pool size ($g/kgW^{0.75}$) | S | 289 | 340 | 275 | 17.5 |
| | W | 191 | 268 | 307 | 13.4 |
| Apparent digestibility: Dry matter | S | 0.57 | 0.56 | 0.54 | 0.0044 |
| | W | 0.55 | 0.62 | 0.56 | 0.0078 |
| Fibre | S | 0.45 | 0.43 | 0.41 | 0.0065 |
| | W | 0.40 | 0.45 | 0.37 | 0.080 |
| Rumen FOR: Cr-EDTA (%/h) | S | 15.8 | 10.8 | 10.4 | 0.54 |
| | W | 16.3 | 9.6 | 10.3 | 0.56 |
| | S/W | 0.97 | 1.13 | 0.99 | 0.062 |
| Lignin (%/h) | S | 2.77 | 3.66 | 3.32 | 0.163 |
| | W | 3.47 | 3.47 | 3.29 | 0.142 |
| | S/W | 0.81 | 1.04 | 1.03 | 0.050 |
| Cr-EDTA / Lignin | S | 6.0 | 3.1 | 3.2 | 0.31 |
| | W | 4.8 | 2.8 | 3.1 | 0.11 |

S, summer; W, winter

Rumen water FOR, as marked by Cr-EDTA, was much faster in deer than in sheep and goats (P<0.01). during both S and W. The ratio of rumen particulate FOR in S/W was lower for deer than for the other species (P<0.05), showing that rate of particulate outflow in deer slowed during S. The ratio FOR Cr-EDTA/FOR lignin was consistently greater for deer than for sheep and goats (P<0.001), showing that water left the rumen at a greater rate relative to particulate matter in deer.

Whereas sheep showed no seasonal changes in rumen ammonia concentration or acetate/propionate (Ac/Pr) ratio, deer showed higher values for both ammonia concentration (P<0.01) and Ac/Pr (P<0.05) in S compared with W (Table 2). Goats showed no seasonal change in ammonia concentration, but showed a small increase in Ac/Pr in S compared to W. Rumen ammonia IRL during W was in the order goats>sheep>deer, the difference between goats v. sheep and goats v. deer attaining significance (P<0.05).

Table 2 Concentration and irreversible loss of ammonia and acetate-propionate ratio in the rumen fluid of deer, goats and sheep fed lucerne chaff *ad lib.*

| | Season | Deer | Goats | Sheep | s.e.m. |
|---|---|---|---|---|---|
| Ammonia concentration (mg N/l) | S | 172 | 158 | 161 | 5.5 |
| | W | 110 | 165 | 172 | 6.3 |
| Ammonia IRL (mg N/g N intake) | W | 535 | 692 | 607 | 35.9 |
| Acetate/propionate ratio | S | 4.20 | 3.76 | 4.01 | 0.085 |
| | W | 3.62 | 3.37 | 3.76 | 0.061 |

S, summer; W, winter

### Experiment 2

At similar VFI, rumen pool size (P<0.1) and rumen FOR of both Cr-EDTA (P<0.05) and lignin (P<0.01) were lower for deer fed RC than PRG (Table 3), whilst apparent digestibility of DM (P<0.05) and of fibre (P<0.05) were greater for deer fed RC than PRG. Rumen FOR of Cr-EDTA was very high, as observed for deer in Experiment 1, and the ratio FOR Cr-EDTA/FOR lignin was greater (P<0.01) in deer fed RC. Rumen ammonia concentration was very high, especially in deer fed RC.

## DISCUSSION

Relative to sheep, Experiment 1 showed the greater fibre digestion and rumen ammonia IRL (i.e., production rate) in the goat. Components of these are probably the longer eating time, faster rate of chewing during eating, more efficient particle breakdown during eating and greater salivary N secretion during eating in goats than sheep (Domingue et al. 1991). These characteristics probably make goats more efficient utilisers of low quality fibrous feeds than sheep.

Unlike the goat, Red deer seem to have evolved a mechanism for increasing VFI in S without depressing apparent digestibility, through reducing rumen particulate matter FOR (i.e., actually increasing mean particulate retention time from 28.8 to 36.1 hrs). The high ratio of rumen FOR Cr-EDTA/FOR lignin in deer means that they have a better system for selective retention of insoluble material (i.e., fibre) in the rumen and for washing soluble material out of the rumen into the intestines. This may have developed as part of their evolution between a grazer and a concentrate selector (Hoffman 1985) and illustrates that in a farming system deer may be efficient users of both the fibre and soluble components of the forage. As such, they should be efficient utilisers of high digestibility feeds, containing high contents of soluble protein and carbohydrate.

Rumen frothy bloat is caused by the development of a stable foam from a high content of forage soluble proteins (Mangan 1959). The very rapid FOR of water from the rumen relative to particles probably explains why forages such as RC, which are well known to induce bloat in cattle, do not cause bloat in deer.

As outflow rates from the rumen were in fact slower for deer fed RC than PRG, it is evident that the greater voluntary intakes observed during lactation (Niezen et al. 1992) and during post-weaning growth (Semiadi et al. 1992) in deer grazing RC cannot be explained in terms of rumen outflow rate. Rather, the greater apparent digestibility of RC may indicate faster degradation of plant components in the rumen, causing reduced rumen digesta load, and hence allowing an increase in VFI.

The very high rumen ammonia concentration in deer fed RC indicates extensive microbial degradation of soluble proteins. It seems that forages containing low concentrations of condensed tannins, such as *Lotus corniculatus*, which reduce rumen proteolysis of plant proteins in sheep (Barry 1989) should be evaluated for their digestive characteristics in deer, with a view to increasing the protein to energy ratio of absorbed nutrients.

**Table 3** Digestibility and rumen fractional outflow rate (FOR) in Red deer fed fresh perennial ryegrass-white clover and red clover at the same level of dry matter intake

| | Perennial ryegrass-white clover | Red clover |
|---|---|---|
| Voluntary DM intake ($g/kg\ W^{0.75}/d$) | 49.1 ± 1.2 | 52.9 ± 0.8 |
| Rumen pool ($g/kg\ W^{0.75}$) | 251 ± 18 | 228 ± 19 |
| Apparent digestibility: | | |
| Dry matter | 0.74 ± 0.007 | 0.80 ± 0.005 |
| Fibre | 0.67 ± 0.022 | 0.75 ± 0.011 |
| Rumen FOR (%/h): | | |
| Cr-EDTa | 15.1 ± 0.7 | 13.3 ± 0.9 |
| Lignin | 4.3 ± 0.6 | 2.5 ± 0.3 |
| Cr-EDTA/lignin | 3.8 ± 0.45 | 5.5 ± 0.37 |
| Ammonia (mg N/l) | 215 ± 23 | 321 ± 25 |

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# Role of pasture composition and grazing management in affecting the incidence of bloat on farms


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## ABSTRACT

Farm operations, pasture composition and pre- and post-grazing herbage mass were monitored from May 1990 to November 1991 on 16 pairs of dairy farms. Each pair included one farm with a history of bloat despite routine use of chemical preventatives (bloat-prone) and one farm which did not routinely use chemicals to prevent bloat and rarely observed bloat (bloat-free). The incidence of bloat during spring was low in both years. From August to November bloat-free farms had less ryegrass (*Lolium*) (58% v. 66%) and more other grass species (25% v. 17%) in pasture, and higher pre- and post-grazing herbage masses than bloat-prone farms in both years. There were no differences between bloat-free and bloat-prone farms in white clover (*Trifolium repens*) content of pasture, soil fertility, production or stocking rate. The differences in pasture species and grazing levels indicate different management practices for the two groups, but an association with bloat could not be reliably assessed because of the mild bloat challenge during the trial period.



**KEYWORDS**: bloat, dairy cows, herbage mass, *Lolium* pasture composition, *Trifolium repens*


## INTRODUCTION

Bloat costs New Zealand dairy farmers about NZ$20-25 million each year in dead cows, lost production and chemicals to prevent bloat. Bloat typically occurs in spring and autumn, but seasonal severity varies between years, and farms vary in the severity and timing of outbreaks within a season. The factors contributing to variations in the severity of bloat between neighbouring farms have not been