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FORAGES FOR DEER: A REVIEW

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1. Introduction

In common with sheep, beef and dairy systems, deer farming in New Zealand is recognized for its year round grazing systems with a strong reliance on perennial ryegrass (*Lolium perenne*)/ white clover (*Trifolium repens*) pastures. Deer productivity is the outcome of the feed supply and management of perennial pastures, and deficits in these pasture based livestock systems are filled with either forage crops or conserved feed when pasture supply falls below animal demand.

The distance from our export markets, plus an environment suited to pastoral production has resulted in a focus on efficient production systems (Hodgson et al., 2005). On farm per animal performance targets keep increasing as farmers target efficient systems of animal performance with the requirement to meet product specification and improve the timing of supply for improved financial returns.

This review will outline what is known currently about the performance of deer on both perennial pasture and other forages in order to determine if further research is needed or whether the first principles of intake, animal and forage management can be applied to these new forages.

This review will not cover the agronomy or cultural practices of specific forages as in most cases they are well covered elsewhere.

The objective is to:

- Outline the basic principles that drive intake in deer.
- Define the response of deer to different forages including intake, preference, liveweight and carcass gain.
- Consider rumen physiology and digestion - particle size, condensed tannins.
- Outline the Influence of forage characteristics on intake - bite rate, bite size, eating and rumination time.
- Describe anti-nutritional factors ‘in’ forage (condensed tannins, endophyte (*Neotyphodium lolii*) and any influence on the above. In this instance anti-nutritional factors ‘on’ the forage such as any effects of facial eczema spores etc. will not be considered.
- Demonstrate the importance of forage management especially any differences between perennial ryegrass/white clover pastures and other forages e.g. brassicas, lucerne etc.

2. Farm Systems

Deer are farmed across New Zealand on a wide range of farm classes, from South Island high country to North Island intensive finishing properties. The feed supply and forage systems utilised by deer farms is therefore widely variable. The forage requirements for deer farms also vary considerably, and the fit of the foraging habits of deer with the types of forage that may be available becomes central to developing efficient forage systems for the future.

Table 2.1: Beef+Lamb NZ farm classes*

Sheep and beef farm survey 2012-13 farm class		
1	South Island	High country
2	South Island	Hill country
3	North Island	Hard hill country
4	North Island	Hill country
5	North Island	Intensive finishing
6	South Island	Finishing breeding
7	South Island	Intensive finishing
8	South Island	Mixed finishing

**See http://beeflambnz.com/farm-classes/ for further description of each class.*

In the South Island high country farms are extensive, dominated by tussock and browntop (*Agrostis capillaris*) and improved pastures are limited to cultivatable rolling hill or flats. Over sowing and topdressing practices may be used to introduce new or improved cultivars. Matthews (1999) estimated that 80% of the feed on these farms is produced on 20% of the area.

North and South Island hill country farms can have large areas of lower fertility low yielding pastures (2-8T DM/ha/yr) depending on rainfall but a greater area is available for improved pastures than the high country farms described above.

Both North and South Island intensive properties, by comparison, have higher fertility, dominated by perennial ryegrass and white clover; more cultivatable area with potential for more forage crops to be grown. Pasture production ranges from 10-16 T DM/ha/annum with adequate rainfall or irrigation. In addition forage crops such as brassicas can produce up to 15-20T DM/ha/annum for winter supplementary feed.

The deer industry has shifted to less productive land classes as pressure from dairy expansion and intensive sheep farming increased ((Copland and Stevens, 2012), Statistics NZ 2012). The result is often a better fit with the environment as hind breeding operations suit the extensive high country with weaner finishing on more intensive properties. The question arises as to whether the forage research undertaken fits the

current systems and whether the best forage options are well understood for the different farm systems.

3. Intake in Deer

3.1 Principles

The potential intake of all animals is driven by their own physiological requirement to survive, grow, reproduce, lactate, and meet the potential determined by their genetic makeup. Whether the animal is able to reach their potential is then determined by their health and the feed supply. In our farmed systems farmer management impacts strongly on both animal health, liveweight gain potential, and the amount of feed offered throughout the year.

In deer, intake is also influenced by their marked seasonal variation in appetite and voluntary food intake which also impacts on their potential liveweight gain. These seasonal cycles are due to the effect of photoperiod (changes in day length) as described by Suttie et al. (1983), with intake increasing as day length increases. Conversely deer intake is lowest in winter when day length is short. In addition the intake of stags declines markedly during the rut, (Lincoln 1971), even when feed was unrestricted, (Suttie et al., 1983), and then increases rapidly after the rut (Suttie et al., 1983).

Research by Webster et al. (2000) showed that the voluntary feed intake of young deer is seasonal even when fed ad-libitum on high quality pellets and that the liveweight gain for red stags was about 300 g/day in spring and 150-160g/day in winter. These trials, where weaners were fed ad-lib, removed the limitation of feed supply from pasture imposed on the animal in winter thus supporting that there is seasonal influence on their intake.

Understanding these influences on intake and their interaction with both the foraging behaviour of red deer and the response of forage supply to those requirements will help in the design of future forage systems across the range of farm systems for deer.

3.2 Diet selection

The selection of a diet by red deer to meet its nutritional requirement is a combination of their foraging behaviour, forage preference and feed availability. Deer have been classed as mixed feeders (Hofmann, 1985) or intermediate between true browsers (moose and roe deer) and grazers (cattle and sheep) which gives deer the benefit of nutritional flexibility. The main adaptations, moving from browsers to grazers, include a reduction in diet selectivity, an increase in food intake, rumen size and mean retention time as well as a greater capacity for the digestion of roughage.

3.2.1 Foraging behaviour

In relation to body size, the mouth parts of red deer are smaller than those of sheep and the bite size of deer is also slightly smaller than those of sheep (Mitchell et al., 1991), reflecting their partial browsing nature. This also translates into a tendency to graze for longer when compared to sheep on similar swards (Kay and Staines, 1981), again

reinforcing their preference for higher quality components of the sward as a mechanism to lower potential grazing time to meet their energy intake.

Fraser and Gordon (1997) demonstrated the nutritional flexibility of red deer when measuring intake on *Lolium perenne* sown swards, indigenous grassland and native vegetation. The deer selected a diet that maintained an intake that was comparatively consistent even when the composition and quality of the feed on offer changed with season.

Research has shown that sward height is a good predictor of bite depth and weight ((Hodgson, 1985); (Illius and Gordon, 1987)), and is therefore related to the rate of herbage intake. If herbage availability is not limited then the rate of intake is a function of the processing time (eating and digesting), determined by bite size and feed quality (amount of fibre). Mitchell et al. (1991), using artificial swards, found deer bite weights were greatest when swards were above 6 cm, independent of the different bulk density of the swards.

Foraging behaviour also varies depending on the physiological status of the hind. Gedir and Hudson (2000) reported that wapiti hinds altered grazing time and both bite rate and size depending on stage of pregnancy or lactation reaching a maximum for all during late lactation when energy demand was greatest. Red deer alter rumen fill and function to meet their nutritional requirements depending on season and feed supply ((Barry et al., 1991); (Freudenberger et al., 1994); (Howse et al., 1995)).

Mulley (2003) reported on a study of feeding behaviour of red deer hinds. They found a diurnal pattern of high feeding activity at dawn and dusk, and again between midnight and 2am. In addition animals fed at shorter intervals every 2-3 hours during the day.

Loudon et al. (1984) found the bite rates of hinds were lower (33 v 56 bites/min) and grazing time's higher (11.7 v 6 hr) on native hill pasture compared to improved perennial ryegrass pastures. Wickstrom et al. (1984) found consumption rate and bite size were lower on grass pastures compared to a shrub/forb community of similar biomass. Biting ranged from 15-60 bites/min and was inversely related to bite size.

They also found that the rate of travel during foraging related to the availability of forage i.e. less travel when there was more feed available. Wild ungulates have been reported to spend 40-60% of each day finding and consuming food. Gedir and Hudson (2000) defined this further; the foraging activity of wapiti hinds was greatest in late lactation (up to 94% of their active time was spent foraging) compared to 66% in early gestation.

Wickstrom et al. (1984) also measured the cost of eating as 26% over the standing costs i.e. the energy required to eat compared to that required for standing and moving around.

3.2.2 Forage preference

Research (Hunt and Hay, 1990) showed that deer exhibited strong preferences for red clover (*Trifolium pratense)*, chicory (*Cichorium intybus)* and *Lotus corniculatus* over perennial grasses. Chapman et al (2009) compared four annual forages for preference by white-tailed deer and to complement perennial pastures. They found that all four forages produced suitable yields for grazing. They found the deer exhibited dietary preferences for the four; from highest to lowest: Berseem clover (*Trifolium alexandrium*)

> field pea (*Pisum sativum)* > turnips *(Brassica rapa)* > Oilseed rape *(Brassica napus).* In addition, the deer were able to utilise more of the highly preferred legumes.

Further research by Hunt (unpublished data) also found that grasses were more acceptable in winter than in summer and that 'Matua' prairie grass (*Bromus willdenowii*) and tetraploid Italian ryegrasses were as palatable as legumes to the deer at times. However, Semiadi et al. (1995) found that prairie grass and Yorkshire fog (*Holcus lanatus*) were least preferred in summer by red deer.

This suggests that in winter, when animal demand can be met by a lower intake, the deer will eat what is easily available. In spring and summer higher pasture growth rates plus more legume will allow the deer to select a higher quality diet and exhibit any dietary preferences.

There has been some research into the foraging behaviour of deer, but little has been applied to the relationship with feeding strategies for farmed deer. Nicol et al. (2007) assessed the potential of understanding this knowledge when integrating deer with other livestock species. They concluded that there were several opportunities to capture the benefits of differences in selection to improve the overall utilisation of feed resources on-farm but identified integrated grazing management, animal behaviour interactions, production responses and environmental impacts as potential research subjects that need to be investigated before effective grazing systems could be designed.

Future research would also need to include strategies around drought management, calving and supplementary feeding management and the impact of behaviour on intake.

3.2.3 Feed availability

In farm systems the natural foraging behaviour and preference of the red deer are influenced by the amount of feed on offer. The outcome of foraging behaviour is the intake of the animal. In a pastoral forage system intake is strongly influenced by the amount of feed on offer to the animal, often expressed as kgDM/hd/day. Intake may also be influenced by factors such as pasture type and quality, deer genotype and sex, weaning date, seasonality and time of year.

Several researchers report recommended pasture allowances of 5.5-6 kg DM/day/100kg liveweight for maximising liveweight gain ((Adam and Asher, 1986), (Judson and Nicol, 1997)). However (Judson and Nicol, 1997) observed that a 30% higher allowance of 8kg DM/100kg liveweight was required to achieve the maximum liveweight gain in hybrids compared to red deer in spring, but not in winter when allowance did not affect the growth rate of either genotype.

A further study by Stevens and Corson (2011) indicated that the performance of NZ red, elk crossbred and Eastern European red deer were similar in autumn regardless of being offered allowances of 5 and 9 kg DM/d. However, all three genotypes grew faster when offered 7.5 kg DM/d compared with 4 kg DM/d in winter, though the Eastern European red deer grew slower than the NZ red or elk crossbred deer. In spring, the liveweight gain of NZ red deer did not respond to increasing allowance from 6.5 to 9 kg DM/d, while Easter European red deer increased liveweight gain by 50 g/d and Elk crossbred deer increased liveweight gain by 100 g/d in response to the higher pasture allowance.

In addition Stevens (1999) looked at differences between farms in pre-weaning liveweight gain of fawns and concluded that much of the difference could be explained by the amount of green leaf in the pasture, or pasture quality. He found that as the proportion of green leaf increased from 40 to 90% of the feed on offer calf liveweight gain almost doubled from 265 to 500 g/day.

Niezen et al. (1991) investigated 3 allowances (6, 12 and 18 kg DM/d) of red clover during lactation and found that while calf liveweight gain declined with reducing allowance, they were still higher than a medium allowance of ryegrass white clover pasture, and high and medium allowances of red clover produced results that were not significantly different.

A review on pasture and forages for deer by Nicol and Barry (2003) summarised the relationship between liveweight gain in young deer and pasture allowance (kg DM /head /day) and post grazing pasture height in four seasons from a range of farms. The results show the expected seasonal pattern with daily liveweight gain in autumn (115-169 g/day), with spring (206-243 g/day) almost twice that of winter (65-91 g/day), while summer gains (144-206 g/day) were intermediate. By comparison research data for the period was slightly higher in all seasons i.e. autumn (158 g/day), winter (101 g/day), spring (225 g/day) and summer (174 g/day).

Using feed allowances (kg DM/head/day) provides a way to compare different feeds. It is important to understand how the response to allowances change between seasons, forage species and stock class but it isn't a useful measure for farmers to readily use.

3.2.4 Implications of diet selection

The physical parameters that influence bite size and bite rate set the boundaries for the intake of red deer. The preference for particular forage has two parts: the first is whether the preferred forage is available, the second is that the preference is generally formed by the need to select a relatively high quality diet to meet nutritional needs, within the boundaries set by bite size and bite rate. Feed allowance then influences whether the feed is available and/or available in great enough quantity to meet the requirements of the animal. Understanding the first principles of these interacting factors provides the framework for developing management systems to maximise the productivity of red deer using a range of forages.

3.3 Feed quality

The quality of the feed supply has a direct effect on feed intake (Section 3.2) and can be measured by direct laboratory assessment or by indirect visual assessment. Laboratory measurements include metabolisable energy (ME), digestibility, fibre, and protein. However, other factors such as forage species, legume content, and the amount of stem and dead matter also affect intake because of the diet selection exhibited by the red deer.

The seasonal response of deer also influences its response to feed quality. A relatively low energy requirement in winter can be met by a diet of lower feed quality. However, as their intakes rise in spring they respond quickly to higher quality feed. This information has been incorporated into the QGraze software and the Pasture Quality for Deer Workshop series and handbook, published in 2005. The QGraze software was modified

for deer to include research results on the seasonality of feed intake, the influence of feed quality and feed quantity as well as the effects of genotype.

This was validated against data from Ataja et al. (1990), Hoskin et al. (1999), Judson and Nicol (1997), Kusmartono et al. (1995; 1996), Min et al. (1997), Semiadi et al. (1993), Soetrisno et al. (1994), Stevens and Corson (2003), Suttie et al. (1983), and Webster et al. (1997), Webster et al. (1998), Webster et al. (2000), Webster et al. (2001). The resultant relationships were documented in Vetharaniam et al. (2009). The data in Figure 3.1 demonstrates the general relationships between the liveweight gain of young red deer and both pasture quality (Fig. 3.1a) and quantity (Fig. 3.1b), that have been derived from the research to date.

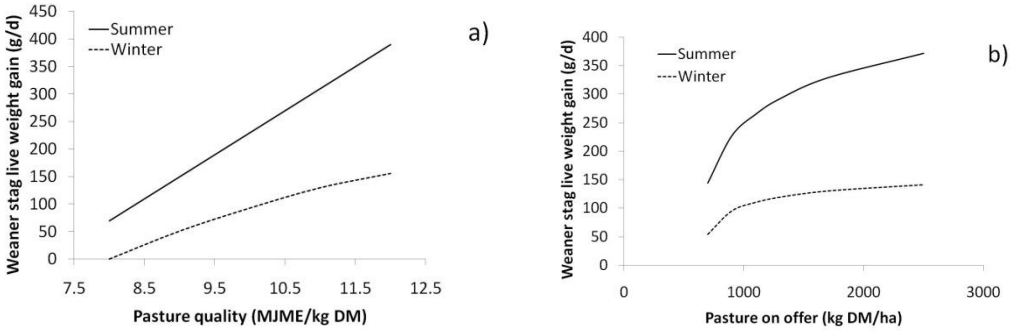


Figure 3.1 An example of the theoretical liveweight gain profiles of young red deer stags on pastures of different quality (a) and quantity (b) from the QGraze software.

The opportunity is to capture the higher intakes in spring, summer and autumn by providing enough feed; either pasture or crops, of high quality.

3.4 Grazing management

Grazing management is the application of the above principles by the farmer to achieve an optimum performance goal. This is influenced by the balance between feed supply and demand, and the expectations, knowledge and experiences of the manager. The optimum outcome of grazing management is often a compromise where not all productivity goals can be achieved.

The principles of pasture production show that animal growth (liveweight gain), feed intake and the rate of grass growth (kg DM/ha) all increase as pasture height increases (Hodgson, 1990) until it reaches a maximum after which quality and intake decline.

In addition the targeted amount of pasture to be left in the paddock after grazing can influence the animal's intake. Thus grazing management has a key influence on both the feed quantity and quality offered and the potential intake and hence growth rate of the animal.

Bircham and Hodgson (1983) showed that the intake of sheep was restricted below a sward height of 5-6cm. For deer, Ataja et al. (1992) showed that liveweight gains of yearling red deer were significantly higher on a 10 cm than on a 5 cm sward, mainly due to the higher voluntary feed intake. Similarly Hamilton et al. (1995) found significantly lower liveweight gains for yearling deer grazed on 4 cm swards but no difference

between 6, 8 and 10 cm swards. This suggests that when the sward height is too low the animal has difficulty in foraging for long enough to provide an adequate intake.

Nicol et al. (2000) summarised the effect of pasture allowance and pasture height and found that the highest output, expressed as liveweight gain per ha, was achieved at a pasture height of 6-8cm when set stocked, or when the pasture residual was 6-8 cm under rotational grazing.

Nicol and Barry (2003) concluded that for deer, at any given allowance (kg DM on offer/hd/day) or pasture height, liveweight gain will be higher than average where pastures are leafy and have a higher legume content and lower where pasture quality and composition is poor. Their summary of earlier work concluded that in all season's liveweight gain increases with higher pasture availability (up to 6-8 kg DM/hd/day or a post grazing residual of 1500-1600 kg DM/ha or post grazing height of 8 cm). However they note that increasing pasture availability in winter does not compensate for the seasonal difference in liveweight gain for deer.

The sward height requirements outlined are consistent whether the pastures are being rotationally grazed or set stocked. Seasonal differences in intake impact on the management of deer throughout the year and are represented in Figure 3.1b.

All researchers noted the difficulty in maintaining swards heights for maximum liveweight gain. The importance of pasture management was reflected by Barry et al. (1993) who noted that the proportion of animals reaching the desired slaughter weight from pasture progressively increased from 41% in 1989 to 90% in 1991 in Massey University trials due to improved pasture management including higher pasture covers and rotational grazing.

This means that liveweight gains reported from research may be limited by management constraints and that grazing management may also compromise the utilisation and stocking rate of the pastures. More importantly farmers often struggle to meet these guidelines when balancing feed supply and demand through the year. The critical importance of grazing height and pasture residual to both animal performance and pasture growth is frequently underestimated. These need to be balanced with the physiological requirements of different stock classes to improve the outputs from forage production systems.

3.5 Liveweight gains

Good liveweight gain in red deer utilises similar management principles on farm as sheep and beef systems of ensuring provision of high quality pasture when the animals have potential for growth (both hinds during pregnancy and lactation and weaners).

However deer do have unique traits, as outlined above that will impact on their liveweight gain including the impact of seasonality, weaning and calving management, and the importance of pasture height for intake. In addition their response to low temperature in winter means that deer often have to partition more of their intake to keep warm, however at the same time their drive to eat is reduced. This means that their winter liveweight gain may be below optimum (Webster et al., 2000).

In addition Webster et al. (2000) found that there was a decline in the efficiency of energy use for liveweight gain for red deer as the ME concentration of the diet declined

in winter. This implies that the animals need more food for maintenance when fed a lower ME diet (i.e. effect of lower feed quality).

Webster et al. (2001) found that red deer did not eat enough of a silage based diet in winter to meet their potential energy demands. However adding concentrates to the diet improved both intake and liveweight gain.

A report by Stevens and Wall (2013) summarised the results of benchmarking studies on farms from the 1980s to the present (Figure 3.2). Significant improvement in average daily liveweight gains had been made. During spring the average daily liveweight gain had increased from approximately 200 g/d in the early 1980's to an average of approximately 290 g/d in the late 2000's. In lactation the liveweight gain of calves has increased from approximately 300 g/d to between 400 and 450 g/d over the same time.

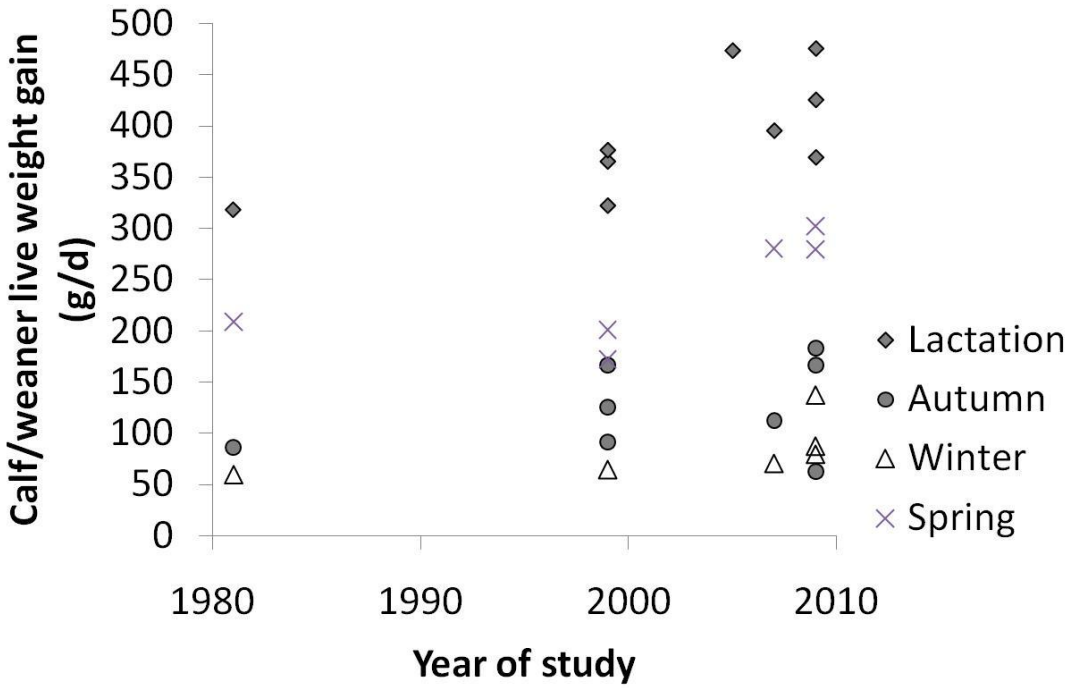


Figure 3.2 Calf/weaner liveweight gains reported in: Biology of Deer conference (1983), Richmond Wrightson, DeerMaster, and Massey University studies (1999) and Deer Focus Farms (2009) (from Stevens and Wall 2013).

3.5.1 The impact of genetics

Stevens et al. (2003) summarised that the driver of liveweight gain in elk x red (crossbred) weaners compared to red weaners was the higher body size (liveweight) of the animal not the genotype difference per se. This was because their feed intake (expressed as a percentage of their body weight) was the same for both the hybrids and the red deer. This research highlighted the importance of heavy weaners going in to winter to enable good slaughter or mating weights the following spring.

Stevens and Corson (2011) also investigated the impacts of genotype on weaner growth in autumn, winter and spring. This showed that crossbred weaners grew faster in winter and spring than red deer weaners. Weaners from Eastern European red deer grew

slightly slower during winter than NZ red deer weaners, but were intermediate between NZ red deer and crossbred weaners in spring.

4. Grasses

4.1 Perennial pasture

As has been previously outlined in Nicol and Barry (2003), the seasonal production curve of the traditional perennial ryegrass/white clover sward is a poor match for the feed requirements of deer. Peak pasture production occurs in mid-spring while hinds calve in late spring early summer. Therefore, as the feed demand of the deer herd increases over summer and autumn, and when potential liveweight gain in young deer is highest, the pasture quality and quantity is declining. The opportunity to advance calving in deer naturally, to better fit the pasture curve, is limited.

Figure 4.1: The annual feed requirements (kg DM/head/day) of breeding hinds (6.5/ha), weaner stags (13/ha) and velveting stags (7.5/ha) in relation to a typical seasonal pattern of pasture growth. (Nicol and Barry, 2003).

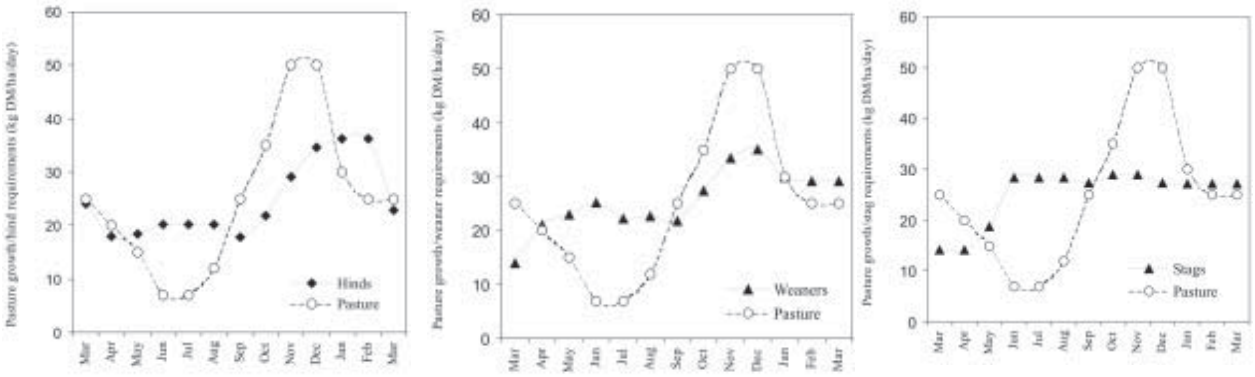
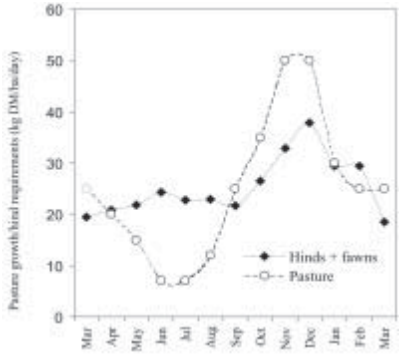


Figure 4.2: The feed demand (kg DM/day) of breeding hinds (5.5/ha) and their offspring (85% weaning) through to slaughter in Oct/Nov in relation to a typical seasonal pattern of pasture growth. (Nicol and Barry, 2003).



Research has shown that better hind nutrition and management increases the opportunity to calve earlier ((Asher and Mulley, 2003); Scott et al 2012) and with less calving spread which improves management options and the ability to get better performance from pasture (Archer et al 2008). In addition the use of foetal aging of pregnant hinds at scanning will allow farmers the additional management option of splitting calving mobs by calving date to improve pasture management and grazing flexibility.

4.2 Perennial ryegrass

Perennial ryegrass (*Lolium perenne*) is important in forage-livestock systems. It is the most widely sown temperate grass in New Zealand where high palatability and digestibility make this species highly valued for dairy, sheep and deer forage systems. It grows well in a wide range of conditions; is easy and fast to establish, easy to manage; has a high yield potential and provides good animal performance; generally has reasonable persistence and usually forms a compatible mix with white clover.

Perennial ryegrass requires moist, fertile conditions and is able to withstand treading and hard grazing.

4.2.1 Ryegrass endophyte

Di Menna (2012) described ryegrass staggers as a seasonal mycotoxicosis of grazing livestock characterised by tremors, in coordination and a staggering gait almost unaccompanied by physical lesions. Deaths occur only as a consequence of accident or starvation. Outbreaks, in summer and autumn, occur only on pasture in which endophyte-infected (*Neotyphodium lolii*) perennial ryegrass (*Lolium perenne*) predominates and usually on which animals are grazed intensively.

Much of the deer production research from pastures was completed in the 1990s and at the time the interaction with ryegrass endophyte was less well understood. Many of the results do not define the endophyte status of the ryegrass pasture used and therefore the results should be considered carefully.

The current ryegrass cultivars contain new strains of endophyte such as NEA, NEA2, AR1 and AR37, and ENDO5. These strains produce different levels of alkaloids, and provide different levels of insect control. Importantly, because the interaction between an endophyte and its host plant differs between ryegrass cultivars, so the same endophyte may produce different effects in different ryegrasses. For further explanation of the cultivar/endophyte /insect interaction see a recent summary of endophyte and perennial ryegrass in Stewart et al (2013).

Not all deer are affected to the same degree by ryegrass staggers. Red and fallow deer appear only moderately susceptible to ryegrass staggers while Wapiti are highly susceptible (Mackintosh et al., 1982). Staggers can cause deer to have low growth rates, poor conception rates and low velvet production. They are also vulnerable to misadventure and can die of shock.

Deer response to endophyte has not been specifically researched although Hunt and Hay (1990) observed no difference between high and low endophytic ryegrasses in their preference work, as both were equally least preferred by deer. Stevens et al. (1992) also found no effect of standard endophyte in the ryegrass pasture on deer growth rates.

There are also grazing animal differences reported, as wapiti have been identified in one instance with staggers on NEA2 pastures, and use of AR37 is not recommended for horses and deer (Stewart et al. 2013).

4.2.2 Animal performance from perennial ryegrass

Research into maximum potential liveweight gain from pasture has been limited, and the reported growth rates have often been determined from the slaughter weights or when compared to specialist crops. As suggested above much of the early research did not define the endophyte status of the ryegrass. However it is unclear how much of an effect this would have on liveweight. Early data was also strongly affected by grazing management as research in the early 1990s showed that higher pasture cover and allowance resulted in high growth rates (Soetrisno et al., 1994).

Liveweight gains on perennial ryegrass/white clover pasture for deer calves during lactation have been reported between 330 (Niezen et al., 1993) and 400 g/day (Adu et al., 1997) and although the clover content was specified (5-10%) the ryegrass cultivar and endophyte status wasn't.

Red deer stags from weaning to 12 months grew between 152 g/day and 207 g/day in autumn; and 280 to 340 g/hd/day in spring (Min et al., 1997), Soetrisno et al., 1994) on perennial ryegrass pasture containing 10-12% clover. Kusmartono et al., (1996) reported that red deer weaners grew at 260 g/hd/day in spring. Hybrid weaners grew about 25-47 g/hd/day faster in spring and 11-43 g/hd/day in autumn on the perennial pastures in the same trials (Kusmartono et al., 1996, Min et al., 1997) which indicates that there is an effect of deer genotype.

4.3 Italian and Annual ryegrasses, and Short Rotation (hybrid) ryegrass

There is a continuum of ryegrass species varying from the most persistent (perennial ryegrass) through to the least persistent (annual ryegrass, *Lolium multiflorum*). Short rotation or hybrid ryegrasses (*Lolium x boucheanum syn. L. hybridum)* are generally derived from crosses between perennial ryegrass and Italian ryegrass, to combine the best features of both parent species. Cultivars in this category are variable, ranging from types midway between perennial and Italian ryegrass in characteristics, through to types more similar to Italian ryegrass.

Cultivars typically persist from 2-5 years, depending greatly on conditions. Their feed quality is very good, generally a little higher than perennial ryegrass in similar circumstances. Many cultivars contain endophyte as described for perennial ryegrass, which improves their persistence.

These two types of ryegrass are described together because they are used in similar situations. They are erect, large leaved ryegrasses which are cool season active and produce heavy yields of high quality forage. They are highly valued for their winter and early spring production. The major functional difference between these two types is persistence.

Hunt and Hay, (1990) found that although legumes and herbs were preferred over all grasses the hybrid ryegrass was preferred over perennial ryegrass, timothy, tall fescue and prairie grass. Ataja et al., (1992) found slightly higher stocking rates and winter

growth rates for young deer grazing annual ryegrass (Moata) due to the higher voluntary feed intake on these pastures.

Little/no work has been done on specific recently improved Italian or annual ryegrasses.

4.4 Tall fescue

Tall fescue (*Festuca arundinacea*) is a productive perennial grass that is best suited to high fertility and deep, heavy or wetter soils. Its extensive root system means it tolerates both drought and periodical waterlogging. It also withstands acid, alkaline and saline soils and poor drainage.

Tall fescue cultivars are often split into two groups based on their seasonal growth i.e. summer active which include cultivars that grow vigorously in summer and moderately in winter while the summer dormant group contains cultivars with little summer growth but strong winter growth. The summer active types are used more in New Zealand, and are useful in dry conditions as a special purpose summer pasture, growing well in all seasons, especially summer and autumn.

Cultivars vary in their flowering time, even more than perennial ryegrass. Early heading types grow well in August/September but their quality declines earlier than later heading types as seed heads develop.

Tall fescue is an alternative to ryegrass-based mixtures in drier regions, and where subtropical grass invasion is an increasing problem.

Grazing control in spring should be frequent, to prevent excessive seed head development, as stemmy pastures produce poor quality feed. Seed heads are difficult to remove by grazing.

Stevens et al., (1992) investigated improving spring and summer pasture availability and quality and compared tall fescue/red clover with high and low endophyte (*Neotyphodium lolii* Standard) pastures. They found that liveweight gain was similar on all treatments (296-332 g/hd/day) in spring and (196 -256 g/hd/day) in summer. Summer growth rates were 21-35% lower than in spring with the greatest drop in the tall fescue only treatment. He attributed this difference, although not significant; to the rapid decline in digestibility of tall fescue leaf as it ages. This was noted as the deer began to select or patch graze the new tall fescue leaf as the summer progressed.

4.5 Other grasses

The main alternate pasture species available are cocksfoot (D*actylis glomerata*); a range of brome grasses including prairie grass (*Bromus willdenowii*) and timothy (*Phleum pratense*).

Cocksfoot is a drought tolerant species and recent breeding has focused on improved palatability. Prairie grass and grazing brome are best suited to fertile, free draining soils and are reasonably winter active in the warmer areas. Timothy is best suited to heavier soils in cooler regions. It is a high quality grass and very palatable to stock which reduces its life in a pasture. It is best suited to lax grazing or supplement (silage, summer or winter specialist feed) paddocks.

No work has been reported specifically for deer performance from these cultivars. All may have roles as companion species in future deer systems that use lucerne, plantain,

or chicory as specialist crop components of the farms system. D Moot (Lincoln University) is currently researching mixed sward systems that include Lucerne as the legume component. However, as none of this work involves deer grazing, further work in this area could be of value.

5. Legumes and herbs

The limitation of perennial pastures means that there is an opportunity for farmers to use specialist forages to fill the feed gaps. In some environments these feed gaps are for dry matter in summer and autumn that is of high quality and may be provided by forages such as chicory (*Cichorium intybus),* plantain *(Plantago lanceolata),* red clover *(Trifolium pratense*) and lucerne (*Medicago sativa)*.

5.1 Red Clover

Red clover (*Trifolium pratense*) is a tap rooted perennial that produces shoots from a crown, is highly productive but often short lived (3-5 years) under a grazing system. It can be sown either as a pure stand or as a mixed sward. However red clover is dormant over winter and grazing should be avoided or limited to reduce the damage to the plants crown which reduces the plants persistence.

Red clover is usually rotationally grazed with a 3-5 week break between grazing depending on the time of year. As it is highly preferred deer will selectively graze the red clover effectively reducing plant numbers and again plant persistence.

Soetrisno et al., (1994) showed that weaner red deer grazing red clover grew more than those grazing perennial ryegrass white clover. This was similar to Niezen et al., (1993) who reported a higher fawn growth rate in summer from hinds (433 vs 333 g/day) grazing on red clover forage compared to perennial ryegrass/white clover.

Table 5.1: Weaner Liveweight gain (g/day) (adapted from (Soetrisno et al., 1994))

	Autumn		Winter*		Spring	
	stags	hinds	stags	hinds	stags	hinds
Red clover	237	197	94	38	346	260
Per rg/wc	207	159	95	40	281	188

*All deer grazed on ryegrass in winter but kept in treatment mobs

The higher growth rates were attributed to the higher nutritive value, higher total nitrogen, and higher organic matter digestibility which all contributed to a higher voluntary feed intake.

Soetrisno et al., (1994) also reported stag and hind performance on red clover compared to ryegrass white clover pastures at the Massey deer unit over 3 years (1989-1991). This included a higher percentage of stags reaching target slaughter weight of 92kg, higher carcass weight (kg - 59.9 vs 54.5 in 1990; 58.9 vs 53.5 in 1991) and a higher dressing out percentage (55.4 vs 53% in 1990; 56,2 vs 52.4% in 1991) higher mean liveweight at the end of November (stags - 108kg v 101 kg in 1990, 105 vs 99 in 1991; hinds – 87 vs 84 in 1990, 83 vs 77 in 1991).

The stand management used in these trials was rotational grazing over autumn and spring with a rotation length around 28 days. Deer were grazed on ryegrass only in winter so the liveweight gain results in Table 5.1 are for the red clover treatment deer grazed on ryegrass /white clover pasture (plus a pasture hay supplement) in winter (ie a ryegrass response).

5.2 Chicory

Chicory (*Cichorium intybus)* is a perennial tap-rooted forage herb with the potential to produce high yields (>20T DM/ha), perform in dry summer conditions and provide higher quality forage than summer pasture.

Evaluation of chicory, both as a feed source and as part of a forage system, has been done here as well as in Australia, USA, South America and Europe. Chicory has been reported as one of the forages most preferred by deer (Hunt and Hay, 1990)

Chicory yields have been reported on dairy farms in the Manawatu (20-22T DM/ha over 20 months from October establishment) and 17.9T DM/ha in the Waikato. Ryegrass pastures (dairy systems) in the same regions produce 14 – 22.6 T DM/ha/yr or 29 – 35.6 T DM/ha/20 months.

Research has shown that chicory has a higher organic matter digestibility (OMD) (Hoskin et al., 1995; Min et al., 1997) than ryegrass, and plantain (Sanderson et al., 2003) while voluntary feed intake (VFI) was higher than pasture in autumn but similar in spring.

Hoskin et al., (1995) found for deer fed fresh cut forage indoors (pure chicory compared to perennial ryegrass) the chicory contained lower levels of dry matter, higher levels of ash, and had a higher ratio of readily fermentable: structural carbohydrate than perennial ryegrass. Relative to perennial ryegrass, the rumen fluid of deer fed chicory had a lower pH.

Total time spent eating and chewing during feeding/g dry matter intake were similar for deer fed the two forages, but deer fed chicory spent much less time ruminating (33 v. 270 min/day) and had fewer rumination boluses (38 v. 305/day). It was concluded that the low rumination time may indicate rapid disintegration of chicory in the rumen to <1 mm critical particle size.

Sanderson et al., (2003) also found concentrations of all minerals, except for Ca, were 17 to 48% higher ($P< 0.05$) in chicory than in plantain. They concluded that both chicory and plantain were of high nutritive value and could be valuable additions to mixed pastures but that their efficacy would be limited by their lack of persistence in pasture.

Similar to Hoskin et al., (1995), Kusmartono et al., (1995) showed that relative to deer grazing perennial ryegrass and white clover pasture the deer grazing chicory had a higher voluntary feed intake, slightly lower grazing time and a substantially lower rumination time. In this trial the hybrid weaners grew faster than the red deer and were heavier at the end of all seasons. Liveweight gain for both hybrids and red deer was greater on chicory than perennial ryegrass/white clover pastures during autumn.

Hoskin et al., (2006) found the liveweight gain of weaners on chicory was 40-48% greater than other forages in spring. However Kusmartono et al., (1996) found red weaners grew at a similar rate on chicory compared to perennial ryegrass/ white clover pasture in spring while hybrid weaners grew 14% faster and Min et al., (1997) reported an 18% advantage for red weaners and 11% for hybrids for chicory in spring. They both found a greater advantage (36-56%) to chicory in autumn. Both Niezen et al., (1993) and Kusmartono et al., (1996) reported a 16% higher growth of calves during lactation in summer.

Both chicory and red clover are dormant over winter and hence grazing over this time needs to be avoided to prevent damage to the plant crowns which will reduce the life of the stand. For this reason sowing them in a mixed sward will also reduce plant life in the pasture due to both overgrazing and winter damage.

5.3 Plantain

Plantago lanceolata L., known as narrow leaf plantain or ribgrass, occurs naturally in many pastures and has had a long history of use as a minor forage plant in Europe.

The first two cultivars bred for use in New Zealand were Grasslands Lancelot and Ceres Tonic. Grasslands Lancelot was selected for bushy growth habit and the ability to tiller strongly under close sheep grazing while Ceres Tonic was selected for a very erect habit and very large leaves. Tonic remains erect under a wide range of conditions while Lancelot tends to become prostrate under close grazing. The two cultivars are quite different in morphology and seasonal productivity, both from one another and from the common flatweed type (Stewart, 1996). Tonic has higher winter growth rates even though it is less densely tillered and is now the more commonly sown cultivar.

With other imported plantain cultivars available on the market it is important to recognise that Tonic is still the only winter active plantain (winter dormant types are now present) therefore it is no longer accurate to generalize about plantain as all current research and farm acceptance has developed using Tonic (A Moorhead pers comm).

Plantain crop yields of 11 T DM from October establishment to May (8 months); 17.4-19 T DM/ha June to May (11 months) and 28.7-30 T DM/ha total over 20 months have been reported for dairy farms in the Waikato and Manawatu (Lee, 2012). However, long term persistence and yield are still relatively unknown.

Plantain is tolerant of a range of soil types and pHs (4.2-7.8). It is more drought tolerant than ryegrass, similar to cocksfoot and is also heat tolerant. In mixed pastures plantain is highly palatable to sheep, cattle and deer and is likely to be selectively grazed in preference to perennial ryegrass. In contrast seed heads and old leaves are much less palatable and likely to be left to reseed.

Plantain contains high levels of calcium, magnesium, sodium, phosphorus, zinc, copper and cobalt, at least as high as perennial ryegrass/white clover based pastures and usually higher and the research is summarised in Stewart, (1996). Plantain also has some biologically active compounds such as antimicrobials, tannins and sugars that may have impacts on animal performance. Trials on the anthelmintic effects of the tannins in plantain have not shown any reduction in parasite levels although lower level of dags on lambs has been observed.

Trials have shown that lamb liveweight gain on pure plantain is similar to endophyte free ryegrass while results from mixed swards are more variable depending on the time of year and companion species. Further research indicated that there is a compromise between stocking rate and liveweight gain as higher individual growth rates are achieved in taller plantain stands (11cm vs 6 cm) as shorter covers limit intake. The recommendation is to graze between 8cm to 5cm (with sheep) to maintain plantain quality and high animal intakes. Plantain quality declines as leaves age and as seed heads form so grazing interval is used to manage this. Higher lamb liveweight gains for herb/legume mixes compared to plantain alone have been reported, which may be because plantain is low in nitrogen or high in fibre at some times.

Hoskin et al., (2006) found that the feeding value of plantain (as fed to weaner deer) was 14% greater in autumn compared to pasture but was similar for the rest of the year. In addition they found that grazing plantain enhanced the copper and vitamin B12 status of weaners in autumn, and their selenium status in spring and autumn.

Originally plantain was sown as part of a pasture mix but in the last few years has been increasingly sown as a stand-alone crop (with legumes) so farmers can optimise their management of stands. More on-farm research into plantain/legume and plantain/chicory stands is being done to evaluate animal performance and stand management.

5.4 Lucerne

Lucerne (*Medicago sativa)* is a deep rooted perennial legume. It is drought tolerant, productive when there is adequate moisture and provides high quality forage for stock.

In summary lucerne is different from a grass pasture in how it grows and recovers from grazing, its seasonal production and quality and most importantly its overall grazing management and integration into a farm system. For further information on current New Zealand research on lucerne growth and grazing management - lincoln.ac.nz/dryland and farmingsheep.co.nz. A summary of a Lucerne management field day is in Deer Industry News: Issue 50 (Oct/Nov 2011).

As suitable forage for a deer system most of the understanding is from previous work with sheep (D Moot and D Stevens pers comm) and farmer experience grazing deer. As a high quality legume forage it has a similar profile to red clover and chicory in terms of animal preference.

Deer need time to adjust to the change in diet, similar to introducing them to a brassica diet. Animals need about 10 days for the rumen to adjust after a grass diet, but can eat a mixture of both grass and lucerne during this time. Limited on-farm data regarding lactating calves and their hinds suggest that growth rates of 450 g/d may be able to be achieved, but there is no research to support this claim.

Ideally the animals should stay on a lucerne diet for at least 6-8 weeks to benefit from the time to adjust period. Deer should be rotationally grazed on the lucerne rather than set stocked. The grazing management programme required for lucerne needs to be well understood before planning to introduce lucerne to the farm system. Where it is a suitable option a large enough area of lucerne needs to be established to allow for a rotational grazing system to be set up. This will allow optimum performance of both the lucerne crop and the deer.

Animal health issues are not a serious problem although fibre and salt will help avoid potential issues with red gut and Na deficiency.

5.5 Lotus spp

There are two common lotus species, *Lotus corniculatus* (birdsfoot trefoil) and *Lotus pedunculatus* that have been bred as grazing forages for NZ but difficulties with establishment, herbage production and persistence in a pasture have limited their use. They are often promoted for use due to the nutritional benefits of condensed tannins (CT). Research has shown improved liveweight gains and possible reduced gastro intestinal parasite burdens may be linked to CT levels in the herbage.

Adu et al., (1998) reported significant increases in daily liveweight gain and weaning weight for calves raised by hind's grazing a *Lotus corniculatus* diet compared to those grazing perennial ryegrass and white clover. They found the gains were similar to red clover and chicory diets (reported by Kusmartono et al., 1996 and Niezen et al., 1993) fed during lactation. This implies that the greater CT concentration had little effect on the liveweight gains of the calves. The hinds in this trial also gained more weight on the lotus than those on perennial ryegrass/ white clover pasture. The results also reflected the higher quality of the lotus compared to the perennial ryegrass pasture in summer as the perennial ryegrass pasture had high levels of dead material (47%) compared to 6% in the lotus.

6. Brassicas

In cooler regions the key requirement is for high yielding crops such as swedes (*Brassica napus*) and kale (*Brassica oleraceae* spp.) or fodder beet (*Beta vulgaris*) that provides maintenance feed from small areas of the farm. This enables pasture covers to recover over winter and respond in spring to provide the high quality forage required.

Forage brassicas and fodder beet are both sown as supplementary feed for animals. The two are different species although often treated similarly by farmers.

Brassicas are commonly sown to provide high quality feed during periods when pasture growth or quality is poor, such as winter and mid-summer. One advantage, when done well, is the ability to produce a high DM yield off a small area of the farm.

Brassicas are also grown in summer in some areas to avoid potential health risks associated with pasture such as facial eczema and ryegrass staggers.

These forage crops encompass a wide range of different plant forms including bulb (turnips and swedes); leafy (rape); swollen stem (marrow stem kale); and long stem (kale). These all have different fits within the farm system.

Deer are fed all types of brassica crops depending which fit best into the farm system, however very little research has been reported from these forages. The different brassica species are introduced briefly below.

6.1 Swedes

Swede crops (*Brassica napus* spp. *napobrassica* or *rapifera*) are a traditional winter feed, especially in Southland and Otago, and in the central North Island (Percival et al., 1986). Swedes perform best in cool climates with adequate moisture, but do not like waterlogging. Swedes are usually sown in November or December, extending to January further north, with crop maturities of 150-250 days, depending on cultivar.

Swedes grow rapidly, and the long growing period from an early sowing can result in yields of up to 20 T DM/ha being accumulated, with crops of 15 T DM/ha common on good soils. Crops are typically 20-30% leaf, and 70-80% bulb.

Swedes are commonly grazed from early to late winter, with bulbs usually keeping well through the winter unless diseased; with the swede leaf yield commonly declining during winter because of adverse weather and disease damage.

6.2 Kale (Chou Moullier)

Kale (*Brassica oleracea* spp. *acephala*) is the most cold tolerant of the brassicas yet is also drought tolerant making it a desirable crop in many areas of New Zealand. For these reasons kale yields can vary widely, from 18-20T DM/ha to 10T DM/ha in drought regions. For good yields crops require high nutrient and water inputs.

Kale is a stemmy crop and the stem is important in determining both yield and quality of a kale crop. Leaf yield is reasonably consistent between tall and short cultivars. However it is important to recognise that the leaf and top third of the stem will be of high quality (ME 12) and the remaining stem of lower ME.

Kale should be break fed to reduce wastage, with utilisation of the crop an important factor in expected animal performance from kale. A high expected crop utilisation can

limit animal performance. If weight gain is the objective the utilisation of the crop has to be lower, i.e. more stem left behind.

6.3 Rape

Rape (*Brassica napus* spp. *biennis*) is a hardy, leafy, quick growing crop used in a range of ways. Grazing can begin 60-90 days after sowing. The most common use is sowing rape as a finishing crop i.e. to finish lambs or to grow out ewe lamb replacements in summer, particularly in summer dry East Coast regions; or in a deer system, to finish weaners. Sometimes these crops are also used for flushing ewes in early autumn.

Rape can be grown on lower fertility soils than other brassicas, and is a good option for drier areas as it is drought tolerant. However it also responds well to irrigation or rainfall.

Yields up to 8T DM/ha can be achieved with good management. Rape is leafier than kales but the stem declines in quality the same as for kale as the plant ages.

Stevens and Corson, (2010) compared a range of forage supply options, including rape, to lactating hinds in the Manawatu. All forage options, including the rape, performed similarly with calf liveweight gains of approximately 500 g/d from birth to mid-January, and 400 g/d from mid-January to weaning in early March.

6.4 Leafy Turnips

Generally, leafy turnips (*Brassica rapa* syn. *B. campestris*) do not produce a bulb, and suit spring and summer sowing, for summer and autumn feed production. They have been widely grown for lamb finishing in higher rainfall districts but in drier districts rape is used instead because it has greater drought tolerance. These crops perform best on soils of medium to high fertility and can be fed to stock at any stage.

Stevens and Corson, (2006) reported the performance of hinds and calves during summer on Pasja, a variety of leaf turnip. They measured lower intake and liveweight gain of both hinds and calves on Pasja, but a much higher stocking rate. Calves gained 16.9 kg compared with 19.1 kg from pasture between mid-January and early March, at a stocking rate of 17.4 hinds and calves on leaf turnips compared with 5.0 hinds and calves on pasture. Hinds lost 4 kg of live weight on the Pasja while hinds on pasture gained 4 kg over the same period.

6.5 Bulb Turnips

Turnips (*Brassica rapa* spp. *rapa* or *rapifera;* syn. *B. campestris*) have been used as a forage crop in New Zealand for many decades and an extensive range of cultivars with yellow flesh (often called ‘hard’) and white flesh (‘soft’) is available. The hard types with yellow flesh have good keeping qualities and are adapted to cool moist climates, but produce lower yields than the diploid and tetraploid soft turnips with white flesh which have been more widely used in recent years.

The sowing period for turnips starts in spring (typically October) for summer production, and extends through until February or even March in warmer areas, for winter production. Some farmers use mixtures of turnips and rape. Another practice is to include bulb or leaf turnips at about 0.3 kg/ha with grass sowing, especially with short term ryegrasses.

6.6 Feeding forage brassicas

Well managed brassica crops normally provide excellent fodder for livestock with few problems. Their high feed quality encourages high intake to provide excellent animal performance. However, as with many plant species, there can be potential problems with brassicas and understanding these is crucial to minimising them.

Ruminant animals take some time to attain maximum voluntary intake when presented with a change of diet, an effect dictated by the population of microflora within the rumen. When the diet of a ruminant changes dramatically, from high to low fibre, or low to high feed quality and vice versa, rumen microbes must likewise adapt to the new conditions. The time this takes will vary depending on what type of brassica is being introduced, the cultivar and the stock type grazing the crop.

To limit the effects of diet change stock should be gradually adapted to the new crop by using a runoff paddock of pasture for 7 days or more, ensuring that the diet is only partly brassica based (Barry, 1978; NZSAP, 1980). Animals should also be relatively full when first introduced to the crop.

Stevens and Corson, (2003) also looked at the transition from winter diets, including swedes, to spring pasture and concluded that although the impact was small, improved management of the transition reduced the potential liveweight loss of deer.

7. Fodder Beet

Fodder beet (*Beta vulgaris*) isn't related to the winter brassicas but to sugar beet, silver beet and beetroot. As such it requires the agronomic care associated with a vegetable crop to perform well. Fodder beet use has expanded more recently due to the ability to grow a high yielding crop, assisted by better weed and pest control, agronomics and management. Apart from the high yield potential it also provides farmers an alternative break crop in their brassica or cropping rotation.

Fodder beet yields in excess of 25-30T DM/ha have been reported. Yield is directly related to length of the growing season therefore for high yields early sowing is required. Matthew et al., (2011) reported farm yields of 19-35T DM/ha in the Hawkes Bay but also state that good yields are not a foregone conclusion. Research trials report similar yield ranges in Canterbury (Chakwizira et al., 2013). More likely yields are 18-20 T DM/ha (typically 5T DM leaf and 15T DM root) however the final harvested yield can vary widely around this (Stewart et al 2013).

Fodder beet cultivars also vary in the dry matter percentage (10-20% Gibbs, 2011) as well as the amount of root above ground which is an important consideration in the feed allocation of the crop. Chakwizira et al., (2013) reported that the fodder beet bulb was 73% to 80% of the DM yield of the crop, with mean bulb DM of 17% and leaf DM ranging from 8% to 17% DM depending on site. These differences will be an interaction between the cultivar chosen, the soil moisture and fertility status and the sowing date therefore DM needs to be measured for each crop to enable correct feed allocation.

Clark et al., (1987) reported that crude protein (CP) levels in the bulb were 6.2%. DairyNZ (2010) provide similar figures for fodder beet bulb and give values for leaves of 23% CP, 30% NDF and 10-12% sugars. Beet leaves and roots also contain approximately 10 times the level of the minor nutrients; Na, Cu and Zn, compared to kale (Dairy NZ, 2010). Chakwizira et al., (2013) also found that the crude protein and fibre levels of the diet were lower than the minimum recommended for dairy cows in late pregnancy and early lactation. This data indicates three potential problems with fodder beet as a ruminant feed: low CP, low fibre and high soluble sugar levels.

7.1 Feeding and managing fodder beet

The recent research by DairyNZ (http://www.dairynz.co.nz/file/fileid/47026) provides the most up to date resource on the animal nutrition and feeding of fodder beet. They highlight that feeding fodder beet requires more care than swedes and kale. Animals require at least a 10-14 day transition period on to the crop compared to 7-10 for brassicas or lucerne.

Gibbs (2011) has evaluated fodder beet as a diet and established that the digestibility is comparable to a high quality ryegrass white clover diet (12-13MJME) if fed as a mixed leaf and bulb diet. This provides a high quality diet, where most of the energy is sugar. To prevent issues such as acidosis this needs to be fed with fibre. The recommendation for dairy cow grazing over the last 5 years has shifted from 20% of the diet as straw to closer to 50% supplement as higher quality baleage. This allows the animal enough protein and fibre in their diet, however it is noted that it also significantly increases the true cost of the crop as a winter feed.

For dairy cows it is recommended that fodder beet provide less than 2/3 of the diet. The bulbs do not provide adequate protein for ruminants, including deer (NRC 2002).

Farmer experience with fodder beet and deer has been variable. Matthew et al., (2011) reported a deer farmer feeding beet with baleage to 120 rising 2 year stags gained 9 kg body weight between 27 May and 27 July (61 days) on 1 ha of fodder beet, or about 147g/day. However he also reported one farmer had deer refusing fodder beet bulbs fed *in situ*.

Anecdotally farmers have reported good winter performance over about 60 days from hinds, stags and weaners wintered on fodder beet. After this time performance can drop off and may be due to the low protein or calcium concentrations (Stevens personal communication).

The potential to grow more DM per unit area has been a key driver in the increase in the use of fodder beet crops however now there is growing recognition that the crops need to be managed for minimal environmental impact.

Feeding supplements and break feeding are both an issue with a high yielding crop. A very high yield can mean a very small daily break allocation and a high stock density. Spreading this out to a 2 or more day break improves the stock density (and dirtying of the crop) but makes it more difficult to ensure an even feeding of leaf and bulb. Feeding greater than 30% of the diet as a supplement, such as baleage, increases these issues with deer. Other options can include planting crops side by side for a better balanced diet, such as kale or forage cereals (see Zino Bros. Focus farm).

Awareness of the issues related to the impact of high stock density on fodder beet is important. The most obvious are soil damage such as pugging, increased nutrient inputs (including that from supplement), phosphate runoff in sediment and high nitrate leaching potential.

8. Fodder trees

Both poplar and willow have been used as drought forage for sheep, cattle and deer. There has been a little New Zealand research on these forages for stock focusing mainly on sheep and cattle, including nutritive value, dry matter yield, palatability and as well as management of the tree blocks (Charlton, 2003).

International research shows that foraging deer add a considerable amount of tree and shrub species to their diet. Their intake appears to be determined by forage architecture (height, leafiness, branch length, and shade) and bite size and frequency (ease of prehension). This correlates to deer being an intermediate forager and as such highlights an opportunity open to explore further.

The feed value of poplar and willow is between 65-70% dry matter digestibility and the crude protein level around 15%. The leaves also contain condensed tannins (higher in willow) and phenolic glycosides. Willow leaves are also high in zinc and magnesium however sodium levels can be low therefore salt blocks should be provided. Cattle will eat trimmings up to 10mm in diameter and sheep up to 5mm in diameter and both will strip off and eat the bark (NZ Poplar and Willow Research Trust Fact Sheet 02, 2013. http://www.poplarandwillow.org.nz/pages/publications/)

It is reported that stock need little conditioning on to fodder trees but this may be due to their use as a drought feed.

Willows produce more fodder than poplars, as leaves small stems and bark. In addition mature poplars and willows shed a large quantity of leaves in autumn and early winter that can be a valuable feed source.

Nugent et al (2001) reported that the native trees species, *Griselinia* and *Coprosma* sp., were highly preferred by wild red and fallow deer however the nutritive properties are unknown.

9. Forages – implications for use and research

A significant body of research has been done for some of the forage options that are available. Much of this research reinforces the first principles of intake and digestion that underpins diet selection and subsequent animal performance. Therefore, much of this research is relevant to any similar species that are available as potential pasture/forage candidates.

The table below (Waghorn et al., 2007) compares some derived feeding values of common pasture forages as fed to lambs. The feeding values represented here are a combination of feed intake and nutritive value. The relative results of the legumes and herbs are similar and higher than the grasses, except for the tetraploid Italian ryegrass. Following the results from preference work (Hunt and Hay, 1990), it would be fair to assume that the rankings would be similar if fed to deer.

Table 9.1: Feeding value of temperate pastures based on liveweight gain when fed *ad libitum* to growing lambs relative to white clover (100) from Waghorn et al (2007).

Group	Species	Ranking	No of trials
Legumes and herbs	White clover	100	15
	Chicory	95	1
	Lotus corniculatus	87	4
	Lotus pedunculatus	84	6
	Lucerne	82	12
	Red clover	70	7
Grasses	Tetraploid Italian ryegrass	83	1
	Timothy	67	5
	Perennial ryegrass	52	16
	Browntop	46	2

Often, variations that exist can be explained by morphological differences (such as amount of stem or dead material), or by the concentrations of various anti-quality factors (such as endophyte toxins or tannins). In the case of tetraploid Italian ryegrass the changes in cell wall to cell contents ratio and feed quality components improves digestibility and intake.

However, there are some notable forages that still require research. These include an expansion of our knowledge of different grass cultivars and species as only perennial and Italian ryegrass and tall fescue have had any research reported for deer, and the inclusion of more research on lucerne, brassicas and fodder beet. In addition cereal forages, including barley and oats, triticale and ryecorn, both as greenfeed, and as silage, remain untested.

There has been no research on the use of mixtures of species as an opportunity to provide a more balanced diet. However, the interaction with diet selection by deer and the final outcome of forage growth would need to be understood. This has implications both for mixing species within a pasture (cocksfoot/red clover), and for developing a whole farm forage system where the species are separated spatially (perennial pasture and lucerne).

The impacts of transition from one diet to another are still relatively unknown in red deer. This may be an important limiting factor in forage use. Currently, recommendations from other ruminant species are used, but some anecdotal evidence suggests that these practices may not be appropriate. Examples of this may be lucerne, brassicas and fodder beet, but may also apply to red clover, chicory and plantain. Providing an understanding of these requirements may further improve the gains that these forages may add to the farming system.

Incorporation of forages into the range of farming systems is a next step in developing productive forage systems. The development of new forage systems needs to consider stock classes (weaners, hinds, stags and sheep and cattle), the farm environment (climate and soil fertility), and farm managements (e.g. weaning systems). For example, fodder beet, with its low protein content, may be most suited for stags or hinds at maintenance, rather than growing weaners; forage systems to provide feed for a high country farm may be different to an intensive finishing property.

Changing animal performance by better forage use has flow-on effects throughout the farm system. For example, higher weaning weights and increased autumn liveweight gain in weaners increases winter feed requirements and can create a compromise with winter hind stock numbers. This then introduces a further requirement to balance increased winter feed costs with the potential to get early weaner liveweight gains from mid-August until slaughter.

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10. Appendix One: Web briefs

Web brief overview

The Forages for Deer review has highlighted several topics that are yet to be provided on the DINZ Productivity hub.

The following are recommendations for additions to the hub. The recommendations provide suggested placement on the website, and some small amount of rearrangement of some content already on the website for clarity.

Under the Feeding tab it is suggested that:

The following 3 pages are added to the Feeding Deer section

Diet selection

The diet selected by deer is a combination of their foraging behaviour, forage preference and feed availability.

Red deer are best described as a mixed feeder, or somewhere between a browser and a grazer. This determines the diet they can select, the amount of food they can eat, rumen size and function as well as the amount of roughage they can eat. A true grazing animal (sheep) is ideally suited to grazing grass and legume pasture while a true browser (moose, roe deer) selects foliage (leaves, young tips, seeds etc.). Red deer therefore exhibit some of both which gives them the benefit of some flexibility in their diet.

This also means that deer have a smaller mouth, and therefore a smaller bite size, relative to their body size. In practice this relates to a longer grazing time compared to sheep on a similar pasture as well as a preference for the higher quality parts of the pasture to reduce the potential time spent grazing. In addition taller swards (greater than 6cm) allow deer to meet there feed requirements more readily.

Deer have also been shown to increase grazing time, bite size and rate depending on their physiological state (pregnancy, lactation) and the feed supply. During late lactation, when their energy demand is greatest, a hind will spend about 30% more time grazing than in early gestation. The type of forage also impacts on the deer's diet as bite size and rate will differ between native hill pasture, improved perennial ryegrass pasture and a shrub/forb pasture. Forbs are any herbaceous plant in grassland that isn't a grass. On hill pasture the deer are likely to take fewer bites and compensate by grazing longer to meet their requirements. Similarly bite size may be lower on grass pasture compared to a shrub/forb pasture. Chicory, red clover, plantain and lucerne as well as fodder trees may be included in a shrub/forb mixture.

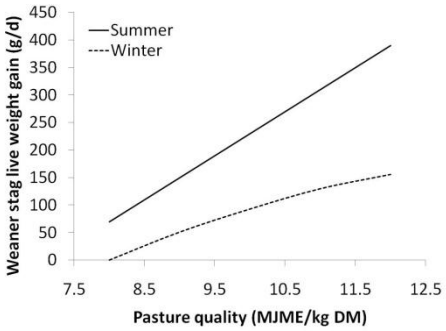
Therefore the preference deer have shown for red clover, chicory and lotus over grasses can be explained by their higher quality and how easily they can be selected and eaten.

Developing effective and efficient forage systems needs to consider the behaviour of the deer outlined briefly here.

Feed quality

What is feed quality? The quality of the feed available is made up of plant components (ME, protein, fibre) and pasture components (species, age, legume content, stem and dead material etc.). The diet selection and seasonal variation in appetite of deer are also important.

A lower energy requirement in winter can be met by a diet of lower feed quality, likely to be more grass or brassica than legume. The intake of deer rise rapidly in spring and the opportunity is to provide enough feed of high quality to capture the liveweight gain (productivity) benefits.

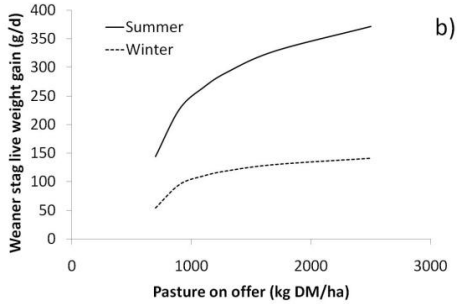


An example of the theoretical liveweight gain profiles of young red deer stags on pastures of different quality from the QGraze software.

Grazing management

Grazing management by the farmer needs to incorporate many factors to achieve high performance targets for deer. This also includes balancing the best management for both the pasture and the animal. The key management principle to keep in mind for deer is pasture height as this offers the animal the opportunity to graze readily, but this must be balanced with maintaining quality.

Feed budgeting is a useful tool for ensuring that the feed supply on the farm will provide for the stocking rate and the performance targets. Adding supplement (silage or crops, grain or PKE) or using other livestock to balance the forage system can be critical.



An example of the theoretical liveweight gain profiles of young red deer stags on pastures of different quantity from the QGraze software.

Under the Feeding tab it is suggested that:

The following rearrangement of the Feed Sources section take place.

Instead of a Pasture tab there should be separate sections for Grasses, Legumes and Herbs as follows

Grasses

Perennial ryegrass

Perennial ryegrass is the most widely sown species in New Zealand, most commonly with white clover. The key benefits include the ability to grow well in a range of conditions, easy and fast to establish (reducing weed issues), easy to manage, good

herbage yields and animal performance, reasonable persistence and compatible with white clover. In addition it is able to withstand both animal treading and hard grazing.

Surprisingly there is little published data on animal performance for any of the pasture cultivars. Most data will be influence by the endophyte status of the ryegrass cultivar and the legume content of the sward.

Annual, Italian and hybrid ryegrasses

These are ryegrass cultivars that persist for 2-5 years. In general their feed quality is very good, usually a little higher than perennial ryegrass at similar stages. The plants in general are erect large-leaved and high yielding. They are cool season active therefore good for winter and early spring production, depending on region. Early research indicated that these types of ryegrass were preferred over other grasses and that weaner stocking rate and performance is better due to higher potential intakes.

Ryegrass Endophyte

Ryegrass staggers may be seen when ryegrass is infected with an endophytic fungus. It is a seasonal mycotoxicosis of grazing livestock characterised by tremors, in-coordination and a staggering gait. Deaths occur only as a consequence of accident or starvation. Outbreaks, in summer and autumn, occur only on pasture in which endophyte-infected (*Neotyphodium lolii*) perennial ryegrass (*Lolium perenne*) predominates and usually on which animals are grazed intensively.

Not all deer are affected to the same degree by ryegrass staggers. Red and fallow deer appear only moderately susceptible to ryegrass staggers while Wapiti are highly susceptible. Staggers can cause deer to have low growth rates, poor conception rates and low velvet production. They are also vulnerable to misadventure and can die of shock.

The current ryegrass cultivars contain new strains of ‘low toxicity’ endophyte such as NEA, NEA2, AR1 and AR37, and ENDO5. These strains produce different levels of alkaloids, and provide different levels of insect control. Importantly, because the interaction between an endophyte and its host plant differs between ryegrass cultivars, so the same endophyte may produce different effects in different ryegrasses.

There have been different responses to these ‘low toxicity’ endophytes, as wapiti have been identified in one instance with staggers on NEA2 pastures, and use of AR37 is not recommended for horses and deer.

Tall fescue

Tall fescue is an alternative pasture cultivar for ryegrass in drier regions and also where there are potential issues with subtropical species invasion. In spring tall fescue needs to be grazed frequently to reduce excessive seed head development and high levels of stem as this reduces feed quality. Some research in Otago showed similar liveweight gains (296-332g/day) in spring for weaners grazing either tall fescue/wc or high and low endophyte ryegrass/wc pastures. In summer liveweight gains were lower (21-35%) on all pasture but lowest on the tall fescue pastures. This is likely to be because of the rapid decline in quality of tall fescue leaf as it ages.

Other grasses

The main alternate pasture species available are cocksfoot; a range of brome grasses including prairie grass and timothy.

Cocksfoot is a drought tolerant species and recent breeding has focused on improved palatability. Prairie grass and grazing brome are best suited to fertile, free draining soils and are reasonably winter active in the warmer areas. Timothy is best suited to heavier soils in cooler regions. It is a high quality grass and very palatable to stock which reduces its life in a pasture. It is best suited to lax grazing or supplement (silage, summer or winter specialist feed) paddocks.

No work has been reported specifically for deer performance from these cultivars. All may have roles as companion species in future deer systems that use lucerne, plantain, or chicory as specialist crop components of the farms system.

Legumes

Legumes are an important component of NZ perennial pastures whether they are finishing properties or less developed hill country properties with tussock and oversown pastures. The predominant legume is white clover and it is incorporated in to all or most perennial pasture mixtures, both for the feed quality component and the ability to fix nitrogen.

White clover

White clover has three characteristics that make it an ideal companion species in a pasture, and in particular with perennial ryegrass. First, it is summer active, with an optimal growing temperature 5°C higher than perennial ryegrass. Second, it maintains high feed quality in late spring and summer, at the time grass plants set seed, thus helping maintain the nutritive value of grass/clover pastures. Third, white clover fixes nitrogen in pastures, improving total pasture production and helping develop organic matter in poorer soils.

White clover cultivars range from small-leaved, low growing and lower yielding to large-leaved upright types. The larger leaved white clover varieties will be better suited to grazing by deer but may be less persistent if they are strongly selected for by the deer.

White clover levels in the sward vary but are usually less than 10-20% of the forage available. However animal performance is usually higher on swards with higher levels of clover.

Red clover

Red clover is a shorter lived legume (2-4 years) compared to white clover depending on grazing management. It is a tall tap-rooted plant with large hairy leaves. It is summer active and flowers later than white clover, but has poorer winter growth. There is an opportunity to use red clover in summer dry areas especially with lax grazing or long rotations or as a silage crop. Pure stands of red clover can produce up to 17 t DM/ha/yr under favourable conditions (good fertility and moisture or irrigation).

Red clover is one of the cultivars shown to be highly preferred by deer. While white clover is stoloniferous which means it spreads and produces daughter plants, red clover produces shoots from a crown which can be damaged by grazing and treading therefore reducing the plants persistence. In addition red clover is dormant over winter so grazing needs to be avoided.

The best grazing management for deer is rotational grazing with a 3-5 week break depending on the time of year. Allowing the deer to graze for too long or too close to the ground will reduce red clover persistence. Research has shown weaners, hinds and calves and adult deer all grew better on red clover when compared to ryegrass white clover pastures.

The following should precede the current Lucerne documentation (under Legumes).

Lucerne

Lucerne is a high quality, deep-rooted perennial legume. Its yield potential will depend on the depth fertility and available water holding capacity of the soil where it’s sown. For optimum performance and ease of management lucerne is best sown as a stand-alone crop. Lucerne is different from a grass pasture in how it grows and recovers from

grazing, its seasonal production and quality and most importantly its overall grazing management and integration into a farm system.

Lucerne is highly preferred by deer, similar to red clover and chicory. Farmer experience has shown deer do very well on lucerne, including weaners and lactating hinds and their calves. A critical factor in lucerne management is the time taken to adjust to the change in diet. Deer need about 10 days for the rumen to adjust to the lucerne, but they can be fed a mixture of grass and lucerne during the adjustment period. The addition of roughage (straw) and provision of salt licks help with any health issues.

The grazing management requirements need to be well understood before introducing lucerne into the farm system. These include planting enough lucerne to keep stock on lucerne for at least 6-8 weeks once they have adjusted to the diet, and to allow for a 5-6 paddock/break grazing rotation. This will allow best management of both the deer and the lucerne stand.

Lotus spp.

Although lotus is highly preferred by deer the plant is difficult to establish and persist successfully in a pasture which has limited its use. They are often promoted for use due to the nutritional benefits of condensed tannins (CT). Research has shown improved liveweight gains and possible reduced gastro intestinal parasite burdens may be linked to CT levels in the herbage. However their ineffectiveness as a pasture plant and the difficulty in sourcing seed limits their use.

Herbs

The two main improved pasture herbs commonly used in NZ are chicory and plantain. Originally used as part of a pasture mix they are increasingly used as a 2-3 year crop in many summer dry areas.

Chicory

Chicory is a perennial tap-rooted herb able to produce high yields, perform in dry summers and provide higher quality forage than summer pasture. It has been reported as one of the forages most preferred by deer. It is more digestible than ryegrass and plantain. Chicory may be broken down faster in the rumen by deer enabling a higher intake and less grazing time. Higher liveweight gains have been reported from chicory compared to perennial ryegrass /wc in all seasons. Chicory is also dormant over winter therefore grazing needs to be avoided to prevent damage to the crown of the plant.

Plantain

Plantain has been a minor component of many improved pastures for the last 20 years. The most common cultivar is Tonic, an erect large-leaved plant that has improved winter growth rates. The imported cultivars have different morphology and may be winter dormant. Plantain is tolerant of a wide range of soil types and more drought tolerant than ryegrass. It is highly palatable to all stock and is likely to be selectively grazed in a mixed sward. Plantain also contains antimicrobials and condensed tannins that may have positive impacts on animal performance, such as reducing parasite levels.

Potential plantain yields and persistence are relatively unknown although recent DairyNZ work reported about 17-19 T DM/ha/yr.

The best management of plantain stands for deer has yet to be well defined. Better liveweight gains have been achieved on taller plantain stands (11cm v 6 cm). Grazing duration to maintain height and quality is important as the quality declines as leaves age and seed heads form. Seed heads are less likely to be grazed which will allow reseeding which is one method of improving stand life. A long period of spelling from grazing is then required to allow seedlings to develop.

Under the Feeding Tab in the Feed Sources section

The following should be added to the Crops subsection. The information on Cereal crops should have a separate sub-sub-section

Brassicas and Fodder Beet

Forage brassicas and fodder beet are both sown as supplementary feed for animals. The two are different species although often treated similarly by farmers. In cooler regions the key requirement is for high yielding crops such as swedes and kale, or fodder beet, that provide maintenance feed from small areas of the farm. This enables pasture covers to recover over winter and respond in spring to provide the high quality forage required.

These crops are commonly sown to provide high quality feed during periods when pasture growth or quality is poor, such as winter and mid-summer. One advantage, when done well, is the ability to produce a high DM yield off a small area of the farm. Brassicas are also grown in summer in some areas to avoid potential health risks associated with pasture such as facial eczema and ryegrass staggers.

These forage crops encompass a wide range of different plant forms including bulb (turnips and swedes); leafy (rape); swollen stem (marrow stem kale); and long stem (kale). These all have different fits within the farm system.

Deer are fed all types of brassica crops depending which fit best into the farm system, however very little research has been reported from these forages. The different brassica species are introduced briefly below.

Swedes and Kale

These are the most common winter brassica crops, potentially yielding 10-20 T DM/ha.

Feeding forage brassicas

Ruminant animals take some time to attain maximum voluntary intake when presented with a change of diet, an effect dictated by the population of microflora within the rumen. When the diet of a ruminant changes dramatically, from high to low fibre, or low to high feed quality and vice versa, rumen microbes must likewise adapt to the new conditions. The time this takes will vary depending on what type of brassica is being introduced, the cultivar and the stock type grazing the crop.

To limit the effects of diet change stock should be gradually adapted to the new crop by using a runoff paddock of pasture for 7 days or more, ensuring that the diet is only partly brassica based Ensuring animals are relatively full when first introduced to the crop will reduce issue of over eating causing problems.

The current section on Fodder beet should be added to this paragraph as a separate sub-sub-section within Crops.

Fodder beet

The use of fodder beet has been increasingly adopted in the dairy industry due to the ability to grow a high yielding crop on a small area. Increasingly deer farmers are also utilising fodder beet with varied success.

Fodder beet is not related to the winter brassicas but to sugar beet and beetroot. The agronomic requirements to ensure a high yield include correct soil fertility, ground preparation, an early sowing date and intensive weed control in the early life of the crop.

Although farmers report very high yields, commonly yields range between 18-20 t DM/ha. Approximately 75-80% of the DM yield is bulb. This is important when estimating yield and allocating feed. In addition, fodder beet has low crude protein levels (6-7%), lower fibre and high soluble sugar levels. To balance the diet of ruminants including deer

a high quality supplement (baleage or lucerne silage) should be used to provide fibre and some of the protein that may be required.

The transition to a fodder beet diet is longer (14-21 days) that that required for brassicas or lucerne (7-10 days) and more care is required. As the leaf is a small proportion of the yield it is not feasible to rely on this to help balance the diet. The recommendation for dairy cows is that fodder beet supplies less than 2/3 of the diet with the rest as supplement. The recommendations for deer have yet to be fully tested but should be similar to dairy cows in the first instance. Anecdotally farmers have found that after 60 days the performance of deer wintered on fodder beet can drop off and may be due to low protein or calcium in the diet.

Within Feed Sources there needs to be a new section on Fodder trees for deer

Fodder trees for deer

Both poplar and willow have been used as drought forage for sheep, cattle and deer. There has been a little New Zealand research on these forages for stock focusing mainly on sheep and cattle, including nutritive value, dry matter yield, palatability and as well as management of the tree blocks (Charlton, 2003).

International research shows that foraging deer add a considerable amount of tree and shrub species to their diet. Their intake appears to be determined by forage architecture (height, leafiness, branch length, and shade) and bite size and frequency (ease of prehension). This correlates to deer being an intermediate forager and as such highlights an opportunity open to explore further.

The feed value of poplar and willow is between 65-70% dry matter digestibility and the crude protein level around 15%. The leaves also contain condensed tannins (higher in willow) and phenolic glycosides. Willow leaves are also high in zinc and magnesium however sodium levels can be low therefore salt blocks should be provided. Cattle will eat trimmings up to 10mm in diameter and sheep up to 5mm in diameter and both will strip off and eat the bark (NZ Poplar and Willow Research Trust Fact Sheet 02, 2013. http://www.poplarandwillow.org.nz/pages/publications/)