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# Integrated livestock management ….. challenges and opportunities of farming deer with other livestock

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## ABSTRACT

A recent survey indicated that approximately 67% of deer farmers integrate sheep and/or cattle on their deer unit to better match feed demand with the seasonal pattern of pasture growth, maintain pasture quality, particularly during lactation and to control weeds. Integrated stock policies also allow for improved financial risk management and provide flexibility to adjust stock numbers in response to market signals and feed supply. There is evidence from the sheep and beef industries that productivity can be increased from the integration of sheep and cattle compared to a single species system. There is limited information for the integration of sheep and cattle with deer so an assessment of the 'challenges and opportunities for co-grazing deer with other livestock' must inevitably rely on extrapolation of knowledge from the co-grazing of sheep, cattle and goats of which there is an extensive literature.

This paper identifies the key knowledge needed to meet the challenges and identify the opportunities of grazing deer with other livestock.

**Keywords:** Deer, sheep, cattle, mixed grazing, integrated livestock management.

## INTRODUCTION

Integrating various livestock species and classes of stock is a common feature of a high proportion of New Zealand deer farms. An early adopter of this practice reported to this Society in 1991 (Cowie, 1991) and a recent survey (Griffiths *et al.*, 2006) of deer farmers found that 67% of respondents integrated deer with sheep and/or cattle on their deer unit.

A number of potential benefits for adopting an integrated livestock policy have been identified. These are:

- The opportunity to better match feed demand with the seasonal pattern of pasture growth.
- More flexibility to adjust stock numbers in response to feed supply and market demand.
- The chance to utilise differences between animal species and, to a lesser extent, stock classes in their diet preferences, and their ability and motivation to exercise these preferences to influence pasture composition (clover content), pasture quality, reduce weed infestations and, through these, improve animal performance.
- Improved financial risk management due to risk spread across several markets
- Better labour management/efficiency throughout the year
- Potential benefits, but also some increased risks, to aspects of animal health.
- Reduced environmental impact.

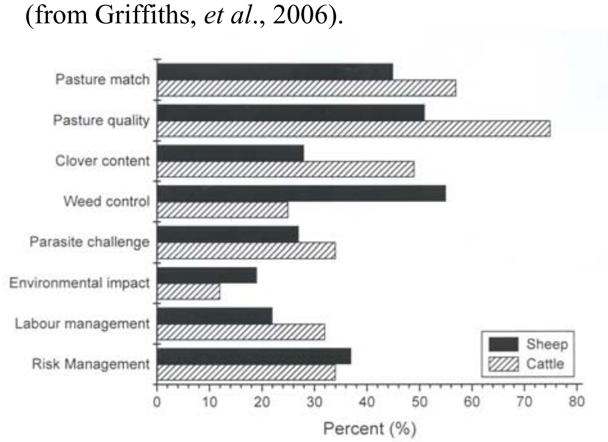
This paper will summarise the recent survey and consider the evidence for each of these opportunities. The emphasis will be on the co-grazing of deer with other livestock. But due to the very limited experimental evidence for such practices, especially under intensive farming conditions, any assessment of the challenges and opportunities for co-grazing deer with other livestock must inevitably rely on extrapolation of knowledge from the co-grazing of sheep, cattle and goats, for which there is an extensive literature (Cosgrove & Hodgson, 2003).

### Summary of integrated livestock management survey

Deer farmers clearly identified all of these opportunities in the recent survey (Griffiths *et al.,* 2006) but the relative importance that farmers who adopted integrated livestock management credited to each, varied depending on whether the integration was with cattle or sheep. Of the farmers who responded, 50% farmed deer, sheep and cattle, 17% farmed deer and cattle, 15% farmed deer and sheep and only 15% farmed deer alone. A greater number of respondents integrated cattle with deer as opposed to sheep with deer. On farms with an integrated stock policy and running deer-sheep-cattle, 56% integrated both sheep and cattle on the deer unit, approximately 32% integrated cattle only on the deer unit but not sheep and 12% integrated sheep but not cattle on the deer unit.

Respondents from farms practising integrated stock policies strongly perceived they were more effective in generating the potential benefits compared with respondents that did not integrate other stock with their deer. On farms with an integrated stock policy, a greater proportion of respondents considered cattle, compared with sheep, to be more effective in matching feed demand/supply, improving pasture quality and increasing clover content in pastures (Figure 1). There was a strong perception that sheep were more effective than cattle at managing weed infestations (Figure 1). Less than one third of respondents (28 and 34% for sheep and cattle respectively) considered sheep and cattle were highly effective at reducing an internal parasite challenge to deer. There was only a small proportion of respondents (<20%) that considered sheep and cattle to be very effective at reducing environmental damage. The data suggested that benefits in labour management were more favourable with integration of cattle as opposed to sheep. There was little difference in the magnitude of the perceived benefit of better risk management from integrating sheep or cattle on deer units.

**Figure 1**: Proportion of deer farmers that perceived sheep and cattle as being highly effective in improving aspects of pastoral farming (from Griffiths, *et al*., 2006).




There is clearly strong support for the potential opportunities of integrated livestock systems among deer farmers. Each of these perceived benefits will now be considered in detail.

## Potential benefits from integrated livestock management

### *Integrating feed demand and supply*

The concept of combining the feed demand of more than one grazing species or stock classes is that the combined feed demand will better match seasonal pasture growth than either enterprise on its own. There are a number of examples during the annual production cycle of deer where such opportunities exist.

The first and most obvious imbalance between seasonal pasture supply and demand of breeding hinds on flat, or easy hill country, arises from the late-spring calving season. In these situations pasture production vastly exceeds hind requirements during most of spring (Nicol & Barry, 2003), leading to a high risk of poor pasture quality subsequently for lactating hinds in summer. On farms where pasture conservation is neither possible nor required, integration of other stock classes provides an opportunity to utilise this high quality spring pasture and increase the likelihood that pasture cover can be maintained within suitable limits (Stevens & Corson, 2003) so that pasture quality is maintained for lactation. Incorporating cattle or non-lactating sheep on deer units with breeding hinds in early spring (Sept/Oct) not only increases feed demand on a deer unit, but reduces the demand on the rest of the farm in early spring when lactating ewes dominate the overall feed demand and have priority for highest quality feed. The ability to move cattle or hoggets onto deer units gives greater opportunity to fully meet the pasture requirements of ewes and lambs. Deer farmers responding to the survey (Griffiths *et al.,* 2006) specifically identified the following opportunities:

- Lambs can be finished on the deer unit taking advantage of the spring flush and reducing pressure on the sheep unit
- Hoggets can lamb in the calving paddocks maintaining feed quality for calving hinds
- If hinds and calves are moved-on at the earliest opportunity, cattle can be utilised to clean-up fawning paddocks to improve feed quality over the lactation period

Other classes of deer can also be used to help capture the early spring growth. Feed budgets show that the integration of breeding hinds with the finishing of their offspring early in the season (Oct) better fits the average pasture growth pattern (Nicol & Barry, 2003).

These additional classes of stock can be progressively withdrawn from deer units to reduce the feed demand and leave sufficient feed resource for lactating hinds and their calves. Cowie (1991) reports using bulls for this purpose and it has been recently shown that there is little difference in terms of pasture composition and hinds and calf liveweight change between using ewes or yearling cattle for this purpose (Nicol *et al.,* 2007). This is mainly because the time period involved (2-3 months) and the proportion of the grazing pressure as the alternative species (no more than 50%) is insufficient to significantly affect the composition of the pasture.

A further opportunity for feed demand-supply integration arises from the relatively low energy requirements of breeding hinds during winter. This has the potential to (a) 'free-up' valuable high quality winter feed for classes of stock with higher winter requirements such as young deer, cattle and sheep and (b) gives the opportunity for other stock, such as breeding cows, to be added to hinds in a winter rotation to increase the grazing pressure to 'clean-up' pastures on deer units over the winter.

It is not only breeding hind production systems that give opportunities for incorporating other stock classes. For example, specialist finishers of young deer, particularly if they concentrate on an early slaughter pattern (Sep/Nov), can develop a summer pasture surplus, which if not managed well, results in poorer pasture quality for the next intake of weaner deer (Mar/Apr). Finishing cattle or store lambs can be used in summers of high rainfall, and above average pasture growth, to prevent excessive pasture cover and maintain pasture quality.

It is common practice to set stock velveting stags at a low stocking rate during the roar to provide stags with a large 'personal space', so as to minimise agonistic between-stag interactions. Because the feed intake of stags is low during this period (Drew, 1993), this strategy often results in pasture being under-utilised. Potential exists to integrate another class of stock, *e.g.* cattle, to increase the grazing pressure without increasing the density of stags. Where this was tried in an informal trial (Ridgeway, M. pers. comm.), it was noted that the stags paid no attention to the cattle and stags grazed with cattle lost a similar amount of liveweight during the roar to those grazed alone.

***Sourcing stock for integrated grazing on deer units***

There are two sources of cattle or sheep for introduction to deer farms. On mixed livestock farms which include a deer unit, the stock required are generally sourced from the rest of the farm. For example, it is common practice to concentrate stock in late spring on areas of the farm (such as a deer unit) where it is important that pasture quality is maintained. This is done at the expense of other parts of the farm (higher altitude, less well developed areas) where pasture accumulates for use later in the season. The alternative of purchasing the cattle or sheep required is seldom attractive on economic grounds as it often involves buying stock at times of the year when they are expensive and re-selling after relatively short (few months) periods of time. Taking in stock on a 'pay for grazing' basis is less risky in this case.

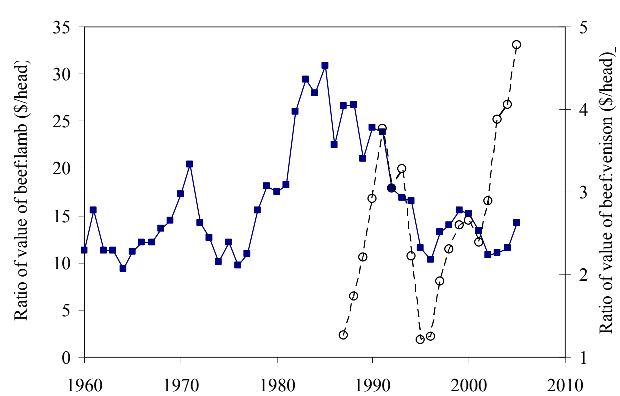
As described above, the concept of integrating other stock classes on deer units is to *improve* the overall balance of feed demand and pasture supply. However, this practice is not without risk and requires good discipline by managers to ensure, for example; that the extra stock do not remain on the deer unit longer than desirable, or the subsequent performance of the deer may be sub-optimum.

The formal feed demand/supply profiling of integrated livestock management is mainly the preserve of feed budgets and models and more of these need to have the potential to incorporate deer as an option on part of the farm. It should be noted that our simple calculations suggest that significant proportions (at least 30% of stock units (SU)) are required in any class of stock to significantly influence the average feed demand. In this regard it is interesting to note that at least one deer farmer reports that their deer farms incorporate 25% of the SU as cattle (Moloney, 2003).

***Financial risk and labour management***

The proverb of 'not putting all your eggs in the one basket' has often been used as a tenet of integrated livestock systems. Long-term cyclical changes in the value of livestock products tend not to be synchronised (Figure 2) thus fluctuations in annual farm income will be modulated in integrated livestock systems. Demands for farm labour for any one livestock enterprise show seasonal peaks and troughs but not necessarily at the same time (*e.g.* weaning of lambs November/December, weaning of fawns February/March; drafting of young deer Oct-Nov, drafting of lambs Jan-Mar). Consequently, integrated livestock systems often provide for a more seasonally equitable labour demand.

**Figure 2:** A time series of the relative value of beef:lamb and beef:venison ($/head basis) (Source, MWNZES, 2007).



### *Livestock integration and animal health*

Mixed-species grazing is likely to increase the potential risk of detrimental effects on some aspects of deer health, but such threats can be minimised with education and understanding of the seasonal nature of the threats and adopting a risk management plan. Benefits may also accrue due to a lack of cross-infection of some disease organisms. Alternative species bring benefits to the farm operation but the threat or risks from an integrated stock policy, or policies, should not be overlooked (Mackintosh & Wilson, 2005).

Table 1 shows the proportion of respondents to the recent deer farmers survey that considered the various animal health risks to be a high threat to the farm operation (Griffiths *et al*., 2006) . It is clear that farms not practising integrated policies perceived most of the threats to be much higher than respondents who did integrate sheep and/or cattle on their deer unit. Amongst the farms operating integrated stock policies a greater proportion of respondents perceived Johne's disease as the highest risk. However, when respondents answered questions on the magnitude of impact that a perceived risk would have on their farm operation, tuberculosis was considered the risk that could have the greatest impact. The finding that the perceived threat from malignant catarrhal fever , which is a sheep borne disease and has historically been of concern to deer farmers (Mackintosh & Wilson, 2005), was not widely considered a high risk probably reflected the dominance of cattle integration with deer.

**Table 1:** The proportion of deer farmers that perceived various animal health issues as being of high risk to their farm operation (from Griffiths *et al.*, 2006).

| Animal health issue | Integrated farms (%) | Without integration (%) |
|---|---|---|
| Tuberculosis (TB) | 9 | 37 |
| Johne's disease | 24 | 43 |
| Malignant catarrhal fever (MCF) | 12 | 39 |
| External parasites -ticks | 13 | 33 |
| Internal parasites | 10 | 32 |

Overall, the animal health risks of integrated grazing were not seen by deer farmers as a major disadvantage of integrated livestock systems and would appear to be clearly outweighed by the perceived advantages

### *Reduced environmental impact*

Deer farming is recognised as a potential cause of some undesirable environmental impacts such as erosion, reduced water quality and nutrient transfer but the industry has been proactive in establishing protocols to minimise such an impact (Deer Farmers Landcare Manual). Farmers claim (Griffiths *et al.*, 2006) that integrated livestock management has benefits to the environment, although specific details were not recorded. Deer exhibit extremely strong group cohesion and thus rest in intensive groups, often only on selected areas in the paddock. Basically, little is known of the impact that the introduction of alternative species has on deer behaviour. A British indoor study found that deer preferred to be in close proximity to sheep rather than cattle (Abeyesinghe & Goddard, 1998) but comparative information under field conditions is unavailable. Anecdotal evidence in New Zealand suggests that feral deer are more likely to be found in areas being grazed by cattle than sheep. Any modification of the behaviour of deer in integrated livestock systems may have positive impacts on the environment through for example, less concentrated deposition of urine and dung, less fence pacing and less wallowing, but these benefits remain speculative at this stage.

## Mixed grazing - complimentarity and competition

Better matching the feed demand of more than one class of stock can be viewed as the 'broad picture' of integrated livestock management. However at the more detailed level, the outcome of integrated or mixed grazing is ultimately determined by the dietary preferences and grazing strategies and the extent to which management allows these traits of animals to be expressed and exploited. It is this interaction of the animals and their grazing environment that determines whether the outcome of mixed grazing will be complimentarity or competition.

In this context the definition of complimentarity is when the productivity of at least one of the stock classes improves so as to increase total output per hectare. Mixed grazing can also induce competition between classes of stock resulting in higher productivity of one class at the expense of the other. Competition results from a redistribution of the grazing resource so one species 'wins' and the other 'loses'. Failure to acknowledge that either complementarity or competition may be the outcome of mixed grazing can result in disappointment in the outcome of integrated livestock management.

This section considers examples of complementarity and competition and the factors that determine which outcome is likely. Hypotheses are developed as to how integrated grazing with deer might compare with that of sheep, cattle and goats.

Complimentarity usually reflects an increase in the utilisation of the grazing resource such as the closer grazing of cattle dung pats by sheep than by cattle alone (Forbes & Hodgson, 1985). Deer are almost as effective as sheep in grazing around cattle dung pats (Trotter *et al.,* 2006) suggesting a potential for complementarity between these two species. Deer farmers should be quite confident that pasture grazed by deer and cattle will become no more heterogeneous or "patchy" than those grazed by sheep and cattle.

Another good example of complimentarity is the combination of goats and sheep in the control of gorse in grass-clover pastures (Radcliffe, 1985; 1986). Goats browse the spiny stems and bark of gorse, and when grazed in combination with sheep, low rounded bushes are formed with good, nutritious pasture between bushes for both sheep and goats to exploit. Given that deer are classed as both a grazing/browsing species (Hoffman, 1985), they may, like goats, assist in controlling woody weeds. Similarly, sheep set-stocked at 3 stock units/ha, provided effective control of ragwort without seriously affecting cattle production in a bull beef system (Betteridge*,* 1994). Given that ragwort is not preferred by deer, sheep can be used on deer farms as with beef cattle in the above example. Comments from respondents to the deer farmer survey indicated that ragwort control was the sole reason for the presence of sheep on many properties (Griffiths *et al.*, 2006). Further examples of complimentarity affecting weed control are provided in Bourdôt *et al*. (2007).

On the other hand, a nice example of competition is the poorer quality of the diet of cattle grazed with sheep which contained more seed head (+16%) and stem (+4%) and less clover (-13%) and grass leaf (-2%) than their diet when grazed alone (Nicol & Collins, 1990).

***Diet preferences and grazing strategies***

To be able to predict the outcome of mixed grazing, an understanding of the differences between species in their dietary preferences and selection, and how these aspects of the biology of the animal are influenced by the grazing environment, is required. Diet preference refers to the diet chosen by an animal when operating under minimum environmental constraints (Hodgson, 1979; Newman *et al*., 1995). Diet selection reflects the ways in which physical and environmental constraints modify the animals dietary preferences. All animals show a preference for some dietary components over others. These preferences can be 'absolute' as in a herbivore versus a carnivore , but more often diet preferences are 'partial'; one component of the diet is preferred more than another but not exclusively (Parsons *et al*., 1994). Sheep, cattle and goats all exhibit a partial preference for white clover over perennial ryegrass. When offered simple choices between large adjacent monocultures of white clover and perennial ryegrass, they select a diet of 60-80% white clover, and continue to eat some ryegrass (Newman *et al*., 1992; Parsons *et al*., 1994; Penning *et al*., 1995a; b; Cosgrove *et al*., 1996). This is despite livestock being able to obtain a diet of pure clover at no extra foraging cost.

There are only limited data on the relative dietary preference of deer for grass and clover. Hunt & Hay (1990), using a photographic method, showed that red deer hinds, yearling red deer stags and fallow deer spent more time grazing legumes compared with grasses, and in particular, low-oestrogen red clover compared with other legumes. However, definitive work on the relative proportion of clover and grass in the diets of deer has not been done. If deer do have a lower relative preference for clover than other species, then pastures grazed by deer might retain a higher clover content due to reduced effects of selective grazing on plant competition (Cosgrove & Edwards, 2007).

Dietary preferences can be based on plant species as illustrated above, but also for plant parts. Sheep, cattle, deer and goats select green leaf in preference to dead leaf and leaf in preference to stem (*e.g.* reproductive or pseudostem) (Hendricksen & Minson 1980; Guy *et al*., 1981; Hughes *et al*., 1984; L'Huillier *et al.,* 1984; Gordon 1989a; b). It is generally considered that this example of preference is for higher digestibility or ME value.

The ability of animals to exercise their diet preferences is determined by the availability of pasture plants and plant parts and by the anatomy of their mouth parts. Animals with large broad mouths (cattle) are physically less capable of making fine selections of material from their grazing environment than those species with narrow (sheep) and pointed (goats) mouths (Illius & Gordon 1987). The use of the tongue by cattle to 'sweep' pasture into the mouth to increase bite size further reduces the potential for selection from the pasture. On the other hand, a long narrow tongue as in giraffe can be an asset to diet selection. An example of this anatomical effect is the higher seed head and stem component of the diet of cattle than sheep (Grant *et al*., 1985) on similar pastures. This does not represent a lower preference for leaf by cattle but simply an inability to select it out due to larger mouthparts. Also, even though sheep and cattle prefer a 70:30 clover-grass ratio in their diet, their diet from a mixed ryegrass clover pasture seldom reaches more than 50% clover (Newman *et al*., 1992). It is too difficult (mouth is too big) and time consuming (selection takes time and energy) to select the preferred diet without compromising overall forage intake (Edwards *et al*., 1996; Champion *et al*., 2004).

The mouth parts of deer in relation to body size are smaller than those of sheep, and deer also have a small intake per bite (Mitchell *et al*., 1991) which may explain why they tend to graze longer than sheep on similar swards (Kay & Staines, 1981). However, the absolute breadth of the incisors of deer is greater than sheep (Illius & Gordon, 1987) and this is likely to mean that deer cannot be quite as selective as sheep for the preferred components of the sward.

Goats are an interesting species from this point of view. They have the physical features (small pointed mouths) to allow them to be very selective, but generally the diet selected by goats from similar pastures to that grazed by sheep is of slightly (3-5%) lower digestibility (Collins & Nicol, 1987). Studies on the diet selected by goats suggests that they often use their small mouths to 'sample' a wide range of dietary components but at other times focus heavily on a single component. Furthermore, it has been shown that goats will not penetrate so far into the sward to maintain a high clover content in their diet as sheep (Concha & Nicol, 2000) and this results in a higher clover content in goat grazed pastures.

There has been some suggestion that deer are 'horizon grazers', (graze progressively from the upper levels of the sward), but this has not been confirmed in good comparative studies. We can only surmise that because the mouth size and breadth of the dental arcade of deer is intermediary between cattle and sheep, that deer will be also intermediary in their ability to select preferred dietary components from a mixed species pasture.

### *Dietary overlap and dietary diversity*

Dietary overlap and dietary diversity are another two factors which influence the outcome of mixed grazing. Dietary overlap refers to the amount of commonality between the preferred diet of different animals. Do they all want the same or are they after different components? Obviously, the opportunity for competition is greater when there is a lot of dietary overlap as there is with sheep and cattle. Goats have a wider range in their dietary preferences and therefore give more opportunity for complimentarity (see gorse example, earlier). On the other hand the dietary preferences of cattle and sheep are very similar resulting in more competition. In this case, the species capable of being more selective often beats the less selective animal species for the preferred items.

Again, without the basic information on how effective deer are in competing with sheep and cattle for their preferred components of pasture, we can only hypothesise that they may be less disadvantaged than cattle by grazing with sheep (mouth size closer to that of sheep) and that cattle may be disadvantaged less by grazing with deer than sheep (deer less capable of fine selection than sheep)

Dietary diversity refers to the range, or variation, in the grazing resource. Little diversity represents, for example, a leafy monoculture of Italian ryegrass or even simple two species grass-clover mixtures. Higher diversity is seen in less intensive systems, for example in summer hill country pastures where there is a range of grasses, clovers and weeds; leaf, stem, seed head and dead components and often shrubs and herbs. Low diversity environments offer little choice for either competition or complimentarity while high diversity environments offer opportunities for either outcome. For example, greater dietary diversity leads to an improvement in the diet of sheep grazed with cattle and a reduced diet digestibility of cattle grazed with sheep (Nicol, *et al*., 2005). In the context of deer, breeding hinds are increasingly being farmed on extensive hill country, so there is likely to be more opportunity for both complimentarity and competition with them in this more heterogeneous environment than in specialist finishing systems on less variable pastures.

### Impact of grazing system on mixed grazing

The grazing system imposed by the manager of integrated livestock systems can determine the outcome of mixed grazing. For example, the well known 'leader-follower' system gives the greatest opportunity for competition. The 'leaders' are given the sole opportunity to select their preferred diet, leaving what they don't want for the 'followers'. This is a most appropriate strategy when one class of stock has a higher priority for feed but results in a significant reduction in the productivity of the followers as illustrated by Boswell & Cranshaw (1978). Deer as leaders in leader-follower systems are likely to be a part of integrated livestock systems for those classes of deer (weaners), or for periods of the year (summer for lactating hinds) where deer have high priority. On the other hand, hinds in winter or velveting stags, post-velveting may be appropriate deer to 'follow', say hoggets or finishing lambs respectively.

Competition between sheep and cattle has been shown to exist under set-stocking but not under rotational grazing (Table 2) (Kitessa & Nicol, 2001). By regularly replenishing the grazing resource under rotational grazing, both species have more opportunity to exercise their dietary preferences. On the other hand, under set-stocking there is continuous competition between the species. It may be, if deer are less competitive than sheep are with cattle, that there will be less impact on cattle of set-stocking with deer (*e.g.* cattle with hinds during calving). However, where feasible, rotational grazing should be adopted to minimise the impact of conjoint grazing on the co-grazed species.

**Table 2:** The daily liveweight gain of yearling heifers grazing alone or with hoggets under set stocking or rotational grazing (from Kitessa & Nicol, 2001).

| **Cattle grazing combination** | **Liveweight gain** (kg/day) |
|---|---|
| Cattle – alone – set stocked | 0.92 |
| Cattle – with sheep – set stocked | 0.71 |
| Cattle - alone – rotationally grazed | 1.02 |
| Cattle – with sheep – rotationally grazed | 1.03 |
| SE mean | 0.072 |

The impact of the common procedure of rotating mobs of cattle through areas set-stocked with ewes and lambs or hinds and calves has not been researched but it might again be predicted that this practice of ‘taking the ‘top’ of the pasture might have less impact on cattle if they were co-grazed with deer.

The grazing system which induces least opportunity for either complimentarity or competition is sequential grazing of species alternatively in a rotation. In this case pasture is allowed to re-grow before the alternate species thus minimising any effect of the previous grazing

## Changing pasture composition by mixed species grazing

One of the objectives of mixed grazing can be to change pasture composition. For example, goats (Radcliffe & Francis, 1988) and cattle (Wright *et al*., 2001) have been used to increase the clover content of pastures. Nicol *et al*. (2007) noted in passing that the trend to higher clover content of pastures grazed by breeding hinds and heifers (compared to that in pastures grazed by hinds and ewes) persisted through the subsequent period (2 months) in which these pastures were grazed only by deer.

It is important to note that when pastures of increased legume content have been established by cattle or goats, subsequent grazing by sheep has rapidly (6 weeks) reduced the clover content (Radcliffe & Francis, 1988; Wright *et al*., 2001) due to the strong preference of sheep for clover over grass (Clark & Harris, 1985). In the absence of good information of the relative preference of deer for clover and grass (Hunt & Hay, 1990) and stronger evidence for changes in pasture composition with integrated grazing systems involving deer, it is speculative to suggest that pastures under deer grazing may support a higher clover content than under sheep grazing.

## Other factors influencing the outcome of mixed grazing

### *Pasture availability – stocking rate*

Most of the examples in the literature of complimentarity are when pasture availability has not been restricted (McCall *et al*., 1986; Nolan & Connolly, 1977). At generous pasture allowances, all animals can exercise their preferences and maintain a high feed intake. However, as pasture mass decreases, complimentarity can quickly change to competition. This is nicely illustrated by an experiment that tracked the feed intake of cattle grazing on their own or with sheep (Figure 3, de Sousa, 1994). From day 1 to day 6 of an 11 day period, during which a pasture was grazed down, the intake of co-grazed cattle was higher than when they grazed alone, but after date competition between the two species developed and the intake of cattle grazing with sheep was reduced. Critical pasture availabilities at which these change may take place are not known for mixed grazing systems incorporating deer.

**Figure 3:** The change in digestible dry matter intake of cattle grazed alone (open symbols) or grazed with sheep (closed symbols) (from de Sousa, 1994).

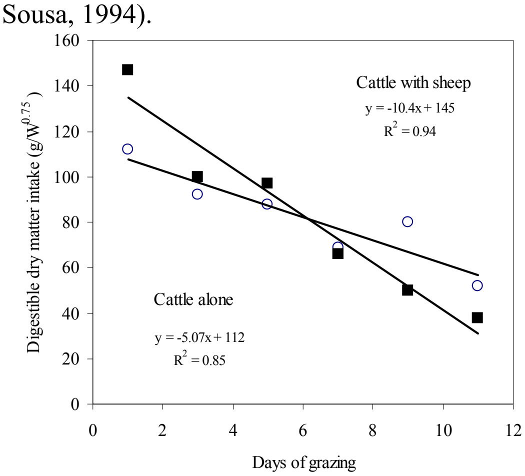


**Table 3:** The effect of the ratio of stock classes and grazing system of the liveweight of co-grazed cattle and sheep. (from Boswell & Cranshaw*,* 1978*).*

| % Total Liveweight | | Grazing system | Liveweight gain (g/day) | |
|---|---|---|---|---|
| Cattle | Sheep | | Cattle | Sheep |
| 100 | | On own | 660 | |
| 66 | 33 | Together | 580 | 128 |
| 33 | 66 | Together | 700 | 121 |
| 66 | 33 | Cattle leaders | 770 | 76 |
| 33 | 66 | Cattle leaders | 960 | 56 |
| 0 | 100 | On Own | | 55 |

***Ratio of stock classes***

The ratio of one class of stock to the other, usually expressed as their respective proportion of the stock units or total liveweight, affects the outcome of mixed grazing. Generally, the species present in the smaller proportion benefits the most from mixed grazing (there is less competition between members of their own species). This can be seen in the work of Boswell & Cranshaw (1978) (Table 3). This may be somewhat of a limiting factor to benefits from mixed grazing with deer if they are dominant in the species mix on deer farms.

**Evidence for mixed grazing with deer**

There is limited experimental data on the co-grazing of deer with other species under intensive management, but cattle, deer and sheep grazing under uncontrolled, extensive conditions has been observed. Studies of extensive systems in Scotland show sheep, deer (stags and hinds) and cattle all preferred high quality *Agrostis/Festuca* areas over taller heath based communities of lower quality (Gordon, 1989a; b; Virtanen *et al*., 2001). Where there is competition by sheep, usage of high quality areas by deer declined (Osbourne, 1984). In winter, when the *Agrostis/Festuca* areas were grazed very heavily, stags were the first to move to heath based communities. Hinds, with their smaller body size, were able to meet their nutritional requirements from the *Agrostis* greens, and remained there longer. This illustrates opportunities for both complimentarity and competition in this environment.

## CONCLUSIONS

We conclude that there are many opportunities for deer farmers to benefit from integrated livestock management but these are not without risk. In particular:

a) There are examples of potential benefits from feed demand/feed supply integration with other classes of stock for all sectors of the deer industry (breeding hinds, specialist finishing and velveting stags) although few of these are adequately quantified. It is unlikely, given their high cost, that farmlet trials to demonstrate these benefits will be forthcoming. It is important then, that feed budgeting and whole farm models are capable of incorporating deer units *within* a farm and to account for their feed demand and supply *separately* from the rest of the farm if the real benefits of integrating other stock on deer units is to be recognised.

b) It is possible to identify some of the factors which will determine the outcome of mixed grazing involving deer in terms of potential complimentarity and competition. For example,

   i. When deer are the higher priority class of stock they should 'lead' in a rotation, but there are occasions such as in winter where energy demands of hinds are low that deer can be used as followers.

   ii. Experimental evidence to date suggests that either cattle or sheep can be co-grazed with hinds over calving and early lactation.

   iii. Pastures grazed by deer and cattle are no more likely to become clumpy than those grazed by sheep and cattle.

   iv. When pasture availability is high, competition between deer and any co-grazed species is likely to be low. However, competition between deer and the other species is likely when pasture availability is limited. We hypothesise that under the latter completion between deer and cattle will be less than that between deer and sheep.

However, better prediction of the outcome of mixed grazing with deer, particularly when co-grazed, is severely limited by lack of knowledge of the basis of diet preferences and selection of deer and the interaction of these with that of other species. Deer farmers recognised this lack of knowledge and unsolicited comments in the recent survey (Griffiths *et al*., 2006) indicated they wished to know more about

- Integrated grazing management – systems, ratio of stock classes, cattle versus sheep
- Animal behaviour interactions with mixed grazing: - behaviour in mixtures, calming effect, disturbance, distribution
- Production responses to integrated systems – animal performance and pasture quality
- Environmental impact – integrated systems and sustainability

Unless such information is forthcoming, there is a high risk that deer farmers will, in some instances, be disappointed with the outcome of integrated grazing on the performance of both their deer and the co-grazing species.

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# The effect of maternal liveweight gain of 15-month-old beef heifers on foetal weight

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## ABSTRACT

Dystocia in 2-year-old beef heifers is a major factor limiting the willingness of farmers to breed 15-month-old heifers in New Zealand. Foetal oversize relative to the size of the heifer is a contributor to dystocia. This study aimed to determine the effect on foetal weight of maternal liveweight change during joining and early pregnancy. Sixteen 15-month-old Angus heifers were allocated to moderate (444 ± 30 g/day) or low (109 ± 28 g/day) liveweight-gain treatments for 21 days prior to and 91 days after insemination. Gravid uteri were recovered on day 91 of pregnancy. Foetuses from the low-fed heifers tended to be heavier than foetuses from the moderate-fed heifers (215.6 ± 6.7 g and 198.4 ± 6.8 g, respectively; P=0.09). Foetal weight per 100 kg maternal weight was greater (P<0.01) in foetuses from the low treatment (58.9 ± 2.5 g/100 kg) than in foetuses from the moderate treatment (47.4 ± 2.6 g/100 kg). Weight of foetal membranes was greater (P<0.05) in the low treatment (262 ± 16 g) than the moderate treatment (213 ± 16 g). Foetal weight was correlated with cotyledon weight (r=0.59; P<0.05). Moderate compared with low maternal liveweight gain reduced foetal weight relative to maternal live weight.

**Keywords:** Foetal weight; nutrition; heifers; beef cattle; early pregnancy.

## INTRODUCTION

Breeding heifers for the first time at 15 months of age instead of 27 months of age has been shown to increase the productivity of the beef breeding cow herd by 0.7 calves per cow lifetime (Nicol & Nicoll, 1987), yet it is not widely practiced in New Zealand, with only 30% of 15-month-old beef heifers joined with a bull in 2003 (Anonymous, 2003). The expectation of a high incidence of calving difficulty in beef heifers calving at 2 years of age has been suggested as one reason deterring farmers from breeding their beef heifers at 15-months of age (Hickson *et al.*, 2006).

Birth weight of the calf was the most important single contributor to dystocia in 2-year-old beef heifers (Rutter *et al.*, 1983; Rice, 1994; Arthur *et al.*, 2000), and lighter calves were less likely to experience dystocia than heavier calves (Laster *et al.*, 1973; Smith *et al.*, 1976). Therefore, reducing birth weight of calves should decrease the incidence of dystocia in 2-year-old beef heifers and, consequently, allow more farmers to breed beef heifers at 15 months of age.

Birth weight is determined by foetal growth rate throughout gestation, which is in turn determined by a combination of genetic and environmental factors (Hickson *et al.*, 2006). Substantial research has been carried out to determine the effects of feeding level or liveweight change of the dam in late pregnancy on birth weight of the calf and the incidence of dystocia (Laster, 1974; Wiltbank & Remmenga, 1982; Spitzer *et al.*, 1995); however, little is known about the effect of nutrition in early pregnancy on foetal and placental development in cattle. In adolescent ewes, over-nourishment during pregnancy was associated with decreased foetal and placental weight at days 95 and 128 of gestation (Wallace *et al.*, 1996; Wallace *et al.*, 2002).

The aim of this study was to determine the effect of maternal liveweight gain of 15-month-old Angus heifers on foetal and placental growth and development.

## MATERIALS AND METHODS

### Treatments

Liveweight gain treatments were imposed under pastoral grazing conditions on 56 fifteen-month-old Angus heifers from 21 days (1 oestrus cycle) prior to insemination until day 91 of pregnancy (end of first trimester). Treatments consisted of moderate maternal liveweight gain (target 500 g/day) and low maternal liveweight gain (target 100 g/day). Unfasted live weights were recorded at monthly intervals throughout the treatment period. Oestrus was synchronised in the heifers using progesterone-containing controlled internal drug release devices (1.38 g progesterone; Pharmacia Limited, Auckland, New Zealand) and heifers were inseminated to observed oestrus with semen from 5 Angus bulls.

Twenty-five heifers (45%; 12 moderate, 13 low) conceived to AI and all other heifers were removed from the trial at pregnancy diagnosis 42